Interagency Ecological Program
2025 Annual Workshop

ABSTRACTS

March 4-6, 2025

DWR • USBR • USFWS • SWRCB • CDFW • USGS • NMFS • USACE • USEPA

Interagency Ecological Program

COOPERATIVE ECOLOGICAL INVESTIGATIONS SINCE 1970

Table of Contents

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Oral Presentations

Eleven out of the fourteen sessions in the IEP workshop include oral presentations.

- Session 1: Plenary I – The Law of the Delta (*Guest Speaker Karrigan S. Bork*)
- Session 2: Let's Shake Things Up: Redesigning Monitoring
- Session 3: New Monitoring and Expansions
- Session 4: Muddy Waters, Clear Goals: Restoring Wetland Ecosystems
- Session 6: Plenary II – IEP Monitoring: Informing Resource Management
- Session 7: Flow and Physical Processes
- Session 8: Fish Modeling
- Session 9: Environmental Stressors on Salmon and Smelt
- Session 11: Food Webs and Predation
- Session 12: Management and Policy
- Session 13: Phytoplankton and HABs (Part I)
- Session 14: Phytoplankton and HABs (Part II)

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

Sessions 1 and 6 are the opening plenary talks on day 1 and 2 of the workshop. Sessions 5 and 10 (not shown above) are dedicated Poster Sessions on day 1 and 2 of the workshop in rooms 2-221 B-C.

Session 1: Plenary I

The Law of the Delta

- Dr. Karrigan S. Börk*, Professor at UC Davis School of Law and Interim Director at the UC Davis Center for Watershed Sciences, ksbork@ucdavis.edu

**Plenary Speaker*

Prof. Börk will offer an overview of the myriad state and federal laws addressing water allocation in the Delta, from California water rights law to the federal Endangered Species Act. These laws provide the regulatory infrastructure for decisions about who gets what water, where, and when. The complicated tangle of laws can be difficult to unpack, but this presentation gives the nonlawyer and lawyer alike a solid foundation to understand the Law of the Delta.

Session 2: Let's Shake Things Up: Redesigning Monitoring

The Redesign of CDFW Pelagic Fish Monitoring Studies in the San Francisco Estuary

- Aroon Melwani*, Applied Marine Sciences, amelwani@amarine.com
- Steven B. Slater, California Department of Fish and Wildlife, Steve.Slater@wildlife.ca.gov
- Mike Tillotson, ICF

Presenting author

Since 2021, an interagency effort initiated by the California Department of Fish and Wildlife (CDFW) and U.S. Bureau of Reclamation (USBR) has been working to examine opportunities to improve the design of existing pelagic fish monitoring surveys in the San Francisco Estuary (Estuary) to address current management needs. The California Department of Water Resources, U.S. Fish and Wildlife Service, National Marine Fisheries Service and California State Water Resources Control Board are also participating in the process. The effort is focused on surveys administered by CDFW pursuant to a cooperative agreement with USBR: specifically, the Smelt Larval Survey (SLS), 20-mm Survey, Summer Townet Survey, and Fall Midwater Trawl (FMWT). Following an initial redesign evaluation report, progress has been made to 1) develop a standardized sample frame for design and evaluation of pelagic fish monitoring throughout the Estuary, 2) determine design-based abundance estimates with uncertainty for fish species, 3) conduct a two-year special study to compare fixed and stratified random stations sampled by the FMWT, and 4) add stations to improve the spatial balance of monitoring for the FMWT, SLS, and 20-mm studies. Ongoing work will evaluate efficiencies in sampling design to consider overlap with the San Francisco Bay Study by inclusion in the sample frame and calculation of design-based abundance estimates.

Remember that IEP Science Advisory Group review from a decade ago?

- Adam Nanninga*, U.S. Fish and Wildlife Service adam_nanninga@fws.gov

Presenting author

The USFWS Delta Juvenile Fish Monitoring Program (DJFMP) has been collecting data on out-migrating juvenile salmon and co-occurring fish in the San Francisco Estuary since 1976, with an emphasis on federally endangered winter-run Chinook Salmon. Sampling includes (1) Kodiak and mid-water trawls for strategic mid- to upper-water column sampling at the entry and exit points of the Sacramento-San Joaquin Delta and (2) littoral habitat seine surveys throughout the Delta and lower mainstems of the Sacramento and San Joaquin rivers. These long-term monitoring programs are critical for understanding the status and trends of fish populations that can inform water operation decisions. Long-term monitoring programs are periodically audited for assessments of relevance, redundancy, efficiency and scientific integrity. The DJFMP underwent an audit led by an IEP Science Advisory Group in 2013. The results of the audit highlighted the necessity that sampling methods and data processing protocols be adjusted and modernized. Since audited, DJFMP staff have been making changes to operations that have led to major improvements of the program. Here I explain how each issue brought forth during the audit has either been addressed or is in the process of being addressed. I describe programmatic improvements including (1) measuring salmonid capture efficiency for trawls and seines, (2) refining the data QA/QC process, (3) increasing genetic sampling, (4) implementing an electrofishing study for more robust nearshore sampling, (5) adjusting the beach seine program to include more sites and randomly selecting which sites are sampled weekly, (6) measuring net dimensions on trawls to ensure accurate volume measurements, and (7) field testing the use of electronic data entry to streamline the data entry process. In conclusion, the ongoing enhancements to the DJFMP not only address the critical findings from the 2013 audit but also significantly strengthen our capacity to monitor and protect vulnerable fish populations.

Evaluating the Potential for Temporal or Spatial Redundancy in Sampling Across Zooplankton Monitoring Surveys in the Bay-Delta

- Kristi Arend*, U.S. Fish and Wildlife Service kristin_arend@fws.gov
- Catarina Pien, U.S. Bureau of Reclamation
- Sam Bashevkin, California State Water Resources Control Board
- Daniel Ellis, Interagency Ecological Program
- Rosemary Hartman, California Department of Water Resources

**Presenting author*

The zooplankton community and individual populations in the Sacramento and San Joaquin Bay-Delta (Delta) have changed drastically over the past 50 years, in response to natural and anthropogenic factors. Tracking and identifying sources of these changes is vital to both understanding general food web structure and dynamics and prey resources for native fish species in the Delta. Zooplankton monitoring data in the Delta comprise multiple surveys with varying objectives that consequently differ in spatial extent, sampling frequency, intra-annual timing, and inter-annual duration. Recently, synthesized datasets have been used to evaluate changes in mesozooplankton populations over time in response to abiotic and biotic drivers, such as flow, salinity, and introduced species They also have been used to understand relationships between changes in the lower food web and fish populations. However, what limitations or redundancies the synthesized dataset may have remain unclear. This talk explores the question of redundancy and population abundance. Relying on distinct and overlapping surveys creates potential for insufficient sampling at certain scales and redundant sampling at others. This can impact what can be concluded about the status and trends of the zooplankton community and food web interactions. In this study, we sought to identify redundancies in sampling across surveys by conducting redundancy analyses for representative species from the meso-zooplankton community. We began by developing hurdle models for each representative species using zooplankton abundance data from 2004 – 2021. We then fit the same model structure to data sets of simulated reductions in temporal and spatial sampling and compared their predictions of temporal trends in abundance. This analysis can inform the efficiency of zooplankton community monitoring in the Delta.

Session 3: New Monitoring and Expansions

Evaluating a New Fishery-Independent Survey Method in Monitoring the Population of White Sturgeon (*Acipenser transmontanus*) in the California Central Valley

- Vanessa Lo*†, Pacific States Marine Fisheries Commission, vlo@psmfc.org
- Ryan McKim, California Department of Fish and Wildlife
- John Kelly, California Department of Fish and Wildlife
- Colby Hause, California Department of Fish and Wildlife
- Jacqueline Fukumoto, Pacific States Marine Fisheries Commission

**Presenting author, †Early Career Award candidate*

This presentation will not be recorded as part of the workshop recording.

This presentation describes a new fishery-independent White Sturgeon (*Acipenser transmontanus*) monitoring project that was piloted in the San Francisco Estuary in 2024. This project was a mark-recapture setline survey to estimate White Sturgeon population abundance and composition in San Pablo Bay and the Sacramento – San Joaquin Delta. The new survey involved capturing White Sturgeon using baited hooks over an 8-week period in the San Francisco Bay and Delta region. Fish that were captured were implanted with a passive-integrated transponder (PIT) tag and released back into the environment. After a 4-week break to allow the White Sturgeon to redistribute, the study area was once again surveyed over an 8-week period using generalized random-tessellation stratification (GRTS) to ensure evenly weighted distribution across all sampling zones. In all, a total of 1402 White Sturgeon were captured over the duration of the survey. This survey is being evaluated as a more robust alternative to the fishery-dependent Lincoln's harvest estimator currently used to monitor population trends in the White Sturgeon fishery in California. By identifying population abundance, composition, and distribution, this project aims to contribute valuable insights into the contemporary state of the White Sturgeon population in California and inform the most suitable actions to take when managing the fishery.

Spatially-Explicit Water Quality Data Collected Onboard the R/V Sentinel

- Craig Stuart*†, California Department of Water Resources, craig.stuart@water.ca.gov
- Sarah Perry, California Department of Water Resources
- Ted Flynn, California Department of Water Resources

**Presenting author, †Early Career Award candidate*

The Environmental Monitoring Program (EMP) has for decades deployed water quality instruments in situ at various fixed locations throughout the Sacramento – San Joaquin Delta. Data collected at these stations is relayed in near real-time to online databases, such as the California Data Exchange Center (CDEC), and informs the management and operation of California's water delivery systems. While these stations provide an essential record of baseline environmental conditions across the estuary, their fixed locations limit their spatial resolution. To provide complementary data, EMP also deploys identical YSI Multiparameter EXO2 water quality sondes during their monthly cruises onboard the R/V Sentinel. Using a through-hull flowthrough system connected to customized datalogging software (MOPED), EMP scientists record six water quality parameters (pH, dissolved oxygen, specific conductance, chlorophyll-a fluorescence, water temperature, and turbidity) every five seconds while the Sentinel is underway. Each measurement is GPS-tagged and can therefore be used to create a spatial map of surface water conditions in areas traversed by the Sentinel. Such maps have the potential to be used for various scientific and management applications, such as assessing the spatial extent of harmful algal blooms, conducting habitat suitability analyses for species of interest, and modeling the impact of climate change. To date, however, this data has primarily been used internally and has only been made available upon request. This project seeks to publish this data via the Environmental Data Initiative (EDI) repository employing FAIR (findable, accessible, interoperable, and reusable) data principles. In so doing, EMP will continue to support data users and stakeholders in addressing critical scientific and management questions in the Delta.

The Larval Entrainment Study (LES): 2024 On the Water

- Morgan Gilbert*, California Department of Fish and Wildlife, Morgan.Gilbert@wildlife.ca.gov
- Tim Malinich, California Department of Fish and Wildlife

**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 & indirect entrainment, unfavorable water quality, predation, and lack of food potentially contribute to increased mortality of the species early life stages. While export facilities record the salvage of adult Smelt, the magnitude of their entrainment as larvae is unclear and modeling efforts to examine this have not agreed on the extent of these impacts. The 2020 Incidental Take Permit for the Long Term Operation of the State Water Project identified a need for quantitative estimates of larval (<20mm) Longfin Smelt entrainment. In response, the Larval [Smelt] Entrainment Study (LES) began in 2022. Here we summarize our 2024 season, during which we sampled using a bongo sled mounted with a pair of 500 micron nets. We also moved our sampling out of West Canal onto a transect of Smelt Larval Survey stations along the Old and Middle River Corridor. This longer transect will provide important insights into the differences in Longfin Smelt abundance across the spatial extent at risk of entrainment. Information on how this broader extent compares with previous years of intensive single-site sampling will be presented. We also summarize a special study carried out during 2024, a comparison between daytime and overnight sampling which should provide insights into the diel variation of our target species. These studies will improve efforts to quantify longfin smelt presence within regions where they may be subject to entrainment by water exports.

The Delta Juvenile Fish Monitoring Program Beach Seine Expansion Project

- Jennifer Whitt*, U.S. Fish and Wildlife Service, jennifer_whitt@fws.gov
- Adam Nanninga, U.S. Fish and Wildlife Service

**Presenting author*

To quantify the relative abundance and distribution of juvenile Chinook Salmon and co-occurring fish in near-shore habitats, the Delta Juvenile Fish Monitoring Program (DJFMP) has conducted beach seining throughout the Lower Sacramento and San Joaquin Rivers, the Delta, and San Francisco Bay since 1976. The beach seine sites are stratified into six geographic regions sampled once per week. In 2013, the DJFMP underwent a programmatic review led by an IEP Science Advisory Group. The review's outcome included recommendations to measure the efficiency of capture using beach seines and to make site selection random so that calculations of absolute abundance are possible. Subsequently, DJFMP has been measuring beach seine efficiency since 2019. In 2022, the DJFMP began a beach seine site expansion project to strengthen standardized sampling procedures to eliminate selection bias and help provide a base for using the probability theory. Here, I discuss how we went about site expansion and selection and report on the preliminary success of the project. Since the beginning of the 2025 water year (August 2024), the DJFMP seining program has added 46 new sites (on top of the 58 historical sites) to the seven fresh and brackish water regions. This expansion allows the program to select eight sites randomly per seine sampling run. The Beach Seine site expansion project highlights that relatively small changes in monitoring can result in increased utility of the data collected.

Contaminant Monitoring and Assessment in the Sacramento San Joaquin Delta to Inform Ecosystem Management: A Proposed Review by the Delta Independent Science Board

- Margot Mattson*†, CA Sea Grant Fellow, Delta Science Program Adaptive Management Unit, margot.mattson@deltacouncil.ca.gov
- Inge Werner, Delta Independent Science Board
- Robert Naiman, Delta Independent Science Board
- Tanya Heikkila, Delta Independent Science Board

**Presenting author, †Early Career Award candidate*

Thousands of contaminants enter the Delta waterways primarily via urban and agricultural stormwater and irrigation runoff, industrial and municipal wastewater effluents, and atmospheric deposition. However, the sheer number of chemicals and the complexities of assessing or measuring their toxic effects in ecosystems present significant challenges for monitoring, ecological risk assessment, and management of chemicals. Previous assessment of water quality by the Delta ISB has identified a lack of clarity around how contaminant and toxicity data inform environmental management and decision making, along with a need for increased resources to support coordinated monitoring and science efforts. The Delta ISB has the legislative mandate to provide scientific oversight and assessment of monitoring and research in the Delta to support adaptive management. As such, it is strategically positioned to conduct a review on the current state of contaminant and toxicity monitoring connecting science, management, and policy considerations. Informed by previous Delta ISB reviews and recently conducted scoping discussions with key agency staff, the Delta ISB proposes a review that will address challenges regarding the incorporation of contaminant and toxicity data in adaptive management and decision making. The proposed review aims to identify current contaminant programs and assess their ability to detect ecological risks in the Delta, understand the legislation and funding mechanisms that drive monitoring, and explore evolving tools that have the potential to expand ecological significance and range of current monitoring. This presentation will provide an overview of the current scope and direction for the proposed review and solicit feedback and suggestions from the IEP community. This work directly relates to the concerns surrounding contaminants in Delta waterways as outlined by the IEP Science Strategy, and will build upon the work conducted by the Contaminant Project Work Team as described in the IEP 2024 Work Plan.

Session 4: Muddy Waters, Clear Goals: Restoring Wetland Ecosystems

A First Look at Adaptive Management Thresholds in Tidal Wetland Habitats

- Daniel Ellis*, IEP Program Management and Synthesis, California Department of Fish and Wildlife, Daniel.Ellis@wildlife.ca.gov
- Elsie Platzer, University of California Davis
- Daniel Cox, (Formerly) California Department of Fish and Wildlife; (Currently) California Department of Water Resources, Fisheries Monitoring and Technical Studies
- Gina Darin, California Department of Water Resources, Fish Restoration Program
- Keith Bouma-Gregson, U.S. Geological Survey, California Water Science Center

**Presenting author*

Over the next decade, thousands of acres of wetland habitat will be adaptively managed to provide benefits for native and listed fishes in the San Francisco Estuary. To adaptively manage those restored wetlands, managers require intervention thresholds and metrics to guide adaptive management actions, however, there are no proven management thresholds in wetland restorations. We established these metrics as successful if they could be tied to an ecological outcome with potential to benefit native fishes such as: Delta Smelt, Longfin Smelt, or Chinook Salmon, either directly or indirectly. To gauge ecological outcomes, food web support can be measured via primary production similar to studies by Cloern et al. (1987, 1991, & 20002), who estimated primary production from water quality measurements at a landscape scale. Through a collaboration with DWR, CDFW, UC Davis, and USGS, we collected in-situ measurements of primary production and water quality parameters at four sites in the North Delta Arc throughout 2024. Every two months, each site was sampled during flood tide and the subsequent ebb tide to measure changes in water constituents after interaction with the restored wetlands. This level of temporal resolution is necessary to investigate changes in measured values to specific wetland habitats. Using our findings, we will compare measurements of primary production to i) continuous datasets from YSI EXO2, ii) tide gauges, iii) discrete measures of water quality, and iv) habitat maps. We will discuss the potential value of these metrics for use as adaptive management tools for wetland restoration.

Big Notch, Big Plans: Upcoming Operations and Adaptive Management Studies in the Yolo Bypass

- Dennis Finger*, California Department of Water Resources, dennis.finger@water.ca.gov
- Brandy Smith, California Department of Water Resources
- Luke Olson, California Department of Water Resources
- Hailey Mico, California Department of Water Resources

**Presenting author*

The Yolo Bypass Salmonid Habitat Restoration and Fish Passage Project (YBSHRFPP; Big Notch), led by the California Department of Water Resources and the Bureau of Reclamation, aims to improve fish habitat and passage through adaptive management. The project seeks to enhance hydrologic connectivity between the Sacramento River and Yolo Bypass, supporting state and federally listed fish species. Key components include a gated notch at the Fremont Weir, intake and transport channels, and additional passage facilities, which collectively aim to increase floodplain rearing habitat and reduce fish stranding and migratory delays.

With an estimated completion timeframe of summer 2025, the first year of operations will focus on setting up monitoring protocols and gathering baseline data to guide adaptive management. This adaptive framework allows iterative adjustments based on monitoring results to ensure objectives are met. Monitoring efforts are organized around three primary objectives: increasing floodplain rearing habitat, improving migratory passage, and addressing operational needs. Juvenile rearing habitat and hydraulic conditions are assessed through telemetry and various fish sampling techniques, while adult salmon and sturgeon migrations are tracked to reduce delays and improve rescue operations when needed. This talk will highlight ongoing Yolo Bypass adult salmon and sturgeon telemetry studies and discuss possible future results upon project completion.

Assessing Aquatic Food Web Responses to Tidal Slough Restoration Using Low-Impact Techniques

- Joseph Merz*, Cramer Fish Sciences, jmerz@fishsciences.net
- Kai Ross, Cramer Fish Sciences
- Bobbie Flores, Cramer Fish Sciences
- Scott Blankenship, Cramer Fish Sciences
- Andrew Veary, Cramer Fish Sciences
- Jesse Wiesenfeld, Cramer Fish Sciences
- Katie Karpenko, Cramer Fish Sciences
- Cheryl Dean, Cramer Fish Sciences
- Katherine Bandy, California Department of Water Resources
- Molly Ferrell, California Department of Water Resources

**Presenting author*

To inform Bay-Delta management and habitat restoration design, we evaluated abiotic and biotic responses to the Dutch Slough Tidal Restoration Project using a Before-After-Reference-Impact (BARI) study design. Spatiotemporally coupled data on water quality, zooplankton and fish abundance, and fish diversity were collected through continuous water quality monitoring, video imagery, and eDNA sampling methods. Tidal habitat construction was completed in 2019 but remained isolated from tidal waters until levee breaching. Groundwater infiltration and active pumping facilitated vegetation establishment before the breach. Pre-breach, we observed significant differences in water quality between newly constructed channels and adjacent reference sites. A multi-trophic level aquatic food web was present in the unbreached channels. Post-breach, we detected significant changes in fish species composition. Paired mixed-effects BARI models were used to account for environmental variability across the 2021–2023 monitoring period and isolate breach and restoration design effects on key variables, including water quality gradients, chlorophyll a concentrations, zooplankton, and fish abundance. These effects were most pronounced in the longest constructed channel demonstrating wetland design benefits. Additionally, nearshore transects exhibited higher zooplankton and fish abundance compared to open water areas in all three channels. Tidal channel complexity, size, and interaction with adjacent wetlands influenced water quality, chlorophyll a, zooplankton, and fish densities and diversity. While native fish were present in the newly constructed channels, non-native fish dominated the community. Phytoplankton and zooplankton production in these channels may be exported to adjacent habitats, potentially contributing to short- and long-term ecosystem sustainability. These preliminary findings provide insights into the early ecological evolution of restored Bay-Delta tidal channels and highlight implications for adaptive management in wetland habitat design. Furthermore, our approach demonstrates the utility of low-impact sampling methods for generating robust ecological data.

Session 7: Flow and Physical Processes

Testing and Quantifying a Conceptual Model for the Response of Longfin Smelt to Outflow

- Jason Hassrick*, ICF, Fish and Aquatic Science, jason.hassrick@icf.com
- Wim Kimmerer, San Francisco State University
- Edward Gross,
- Anne Slaughter, San Francisco State University
- Toni Ignoffo,
- Teague Corning,
- Michelle J. Jungbluth, San Francisco State University
- Levi Lewis, UC, Davis,
- Andrew Kalmbach,
- Calvin Lee,
- Tim Carrara
- Nann A. Fangue, UC, Davis, Department of Wildlife and Fisheries Biology

**Presenting author*

The abundance of longfin smelt (*Spirinchus thaleichthys*) in the San Francisco Estuary has declined over 100-fold since monitoring began. California lists it as threatened, and the U.S. Fish and Wildlife Service has recently listed it as endangered. Longfin smelt abundance is highly responsive to freshwater outflow from the Delta, yet underlying mechanisms remain obscure. The decision for the endangered status of this fish highlights the need for a better understanding of the causes of variability in this population. We examine the flow-abundance relationship by testing a model that posits that larval longfin smelt and their zooplankton prey are retained most effectively when freshwater flow is high during late spring. High flow moves the longitudinal salinity gradient seaward into deeper water around Carquinez Strait, enhancing stratification and deep, gravitational circulation of landward flow. We combine modeling and data analysis with sampling for longfin smelt larvae using depth-stratified tows taken by day and night. Our study also investigates larval feeding, growth, salinity history, and the risk of predation by northern anchovy at higher salinity. Active sonar surveys indicate anchovies overlap with post-larval longfin smelt at the high end of their salinity range. Anchovy densities also overlapped with longfin smelt near the bottom by day. We hypothesize that higher flow reduces exposure time to high salinity and the associated predation by northern anchovies. Our recent catches of longfin smelt larvae show the highest catches near the bottom, implying downward movement that enhances retention. Particle-tracking modeling shows that passive particles released in Suisun Bay move seaward, but sinking particles are retained, especially when freshwater flow is high. Longfin smelt larvae (>10 mm) and their prey are most abundant at salinities of ~0.5-5, implying retentive behaviors are most effective at high flows.

Physical Characteristics of Estuary Turbidity Maximums (ETMs) in the San Francisco Estuary [***Canceled Presentation***]

- Kim Brewitt*, ICF, kim.brewitt@icf.com
- Julien Moderan, ICF

**Presenting author*

Estuarine turbidity maxima (ETM) are localized areas of concentrated suspended particulate matter and organisms created by tidal asymmetry and gravitational circulation. By acting as entrapment zones, ETMs can play a critical role in the trophic transfers between particulate organic matter and higher trophic levels, supporting secondary production and thus essential estuarine functions such as nurseries and feeding areas. Our study builds on the “physics to fish” concept developed by the USGS, which examines how interactions between physical processes and the landscape can sustain high-quality habitat. We hypothesized that in the San Francisco Estuary, ETMs are more likely to form when the 2 ppt isohaline (X2) is positioned in deeper channels and during periods of weak tides. We sampled water quality, phytoplankton, and zooplankton at three sites running longitudinally across the range where ETMs were expected to form; near X2 where ETMs would form if the channel is deep enough, and both seaward and landward of X2 outside the expected range of ETMs. We collected acoustic doppler current profiler (ADCP) data to capture differences in surface and bottom currents, as well as echosounder data to test the efficacy of using acoustics to detect mesozooplankton densities. Preliminary results from June – November in 2024 show evidence of stratification in both salinity and turbidity at sampling sites, but the periods of stratification do not match up with the pattern of weak tides. Instead, both stratification and regions of overall high turbidity show a longitudinal pattern, with the highest levels of turbidity and stratification at the furthest seaward site. As populations of pelagic fish continue to decline, understanding and characterizing other potential regions of high quality habitat and sources of trophic support like ETMs is critical.

Fate and Transport of Hydrophobic Organic Contaminants in a Terminal Slough: Impacts of Boat-Induced Turbidity

- Cristina G.B. La*† - Center for Fisheries, Aquaculture, and Aquatic Sciences, Southern Illinois University cristina.la@siu.edu
- Michael J. Lydy, Center for Fisheries, Aquaculture, and Aquatic Sciences, Southern Illinois University

**Presenting author, †Early Career Award candidate*

Hydrophobic organic contaminants (HOCs) have been detected within waterbodies throughout Northern California. The Sacramento Deep Water Ship Channel (SDWSC) within the northern freshwater reaches of the San Francisco Estuary provides vital habitat for a variety of organisms such as delta smelt, longfin smelt, and salmonids. Although deemed critical habitat, the channel is near sources of contamination, and research on exposure risks to HOCs in the SDWSC is limited. To assess risk to HOC exposure in the SDWSC, we collected sediments, zooplankton, and suspended solids from six locations longitudinally throughout the channel and analyzed each matrix for organochlorine pesticides (OCPs), pyrethroid insecticides, polyaromatic hydrocarbons (PAHs), and polychlorinated biphenyls (PCBs). Sediments were also extracted via Tenax to predict the bioaccessible fraction of sediment contamination. In addition to the baseline assessment of HOCs, we evaluated changes in contaminant concentrations, total suspended solids (TSS), and turbidity due to boat traffic by collecting samples before and after the passage of three cargo ships. For the longitudinal sampling, OCPs and PAHs were detected consistently in all samples collected throughout the channel, with 4,4'-dichlorodiphenyldichloroethylene (DDE), phenanthrene, fluoranthene, pyrene, benzo[a]anthracene, and chrysene being detected in 100% of samples. Highest HOC concentrations were associated with suspended solids. Bifenthrin was the only pyrethroid detected and limited to sediments and zooplankton, while PCB detections were limited to zooplankton and suspended solids. Consistent bioaccessible OCP, pyrethroid, and PAH concentrations and concentrations detected in zooplankton tissue highlight the potential risk of uptake for aquatic organisms. Although TSS and turbidity increased immediately after boat passage, concentrations of HOCs, while detected in all matrices, did not significantly change. While contaminant concentrations did not significantly change, boat traffic keeps HOC-associated suspended solids elevated in the channel, which increases the risk of HOC exposure to pelagic organisms.

Long-Term Continuous Flow Monitoring in the Sacramento-San Joaquin Delta

- Lex Thomas*†, U.S. Geological Survey, athomas@usgs.gov
- Elise Shea, U.S. Geological Survey
- Anna Conlen, U.S. Geological Survey

**Presenting author, †Early Career Award candidate*

The U.S. Geological Survey has been collecting continuous data in the Sacramento-San Joaquin Delta (Delta) for decades. The network has expanded from several experimental stations in the 1970s and 1980s to a robust and integrated monitoring network. Today more than 40 stations are collecting a range of water-level, discharge, and water-quality data that support critical real-time water management decisions as well as in-depth analyses. Our group collaborates with stakeholders to increase the power of the data being collected across the monitoring network. The data are transformed into information in a variety of ways, including constituent mapping, salmon out-migration survival studies, interdisciplinary tidal-marsh function studies, and hydrodynamic model calibration and validation.

Long-term datasets in conjunction with modelling efforts and process-based studies provide insight into the impacts that various habitat restoration and water management actions have had on circulation and mixing in the Delta. More changes are proposed for the future that will directly impact the basic hydrodynamic processes at work in the Delta. These long-term monitoring data provide a framework for assessing the impacts of proposed actions. Moreover, as they are integrated with additional data streams, such as biological monitoring, scientists can gain insight into the impacts that physical and chemical processes have on the distribution of native and non-native species in the Delta.

Suspended Sediment and Turbidity in the Sacramento-San Joaquin Delta, California, Influenced by an Unregulated Watershed During the Wet Water Year of 2023

- Tara Morgan-King*, U.S. Geological Survey, tamorgan@usgs.gov
- Jon Burau, U.S. Geological Survey

**Presenting author*

In early January 2023, turbidities unexpectedly and rapidly exceeded the 12 FNU delta smelt turbidity trigger in the central and south Sacramento-San Joaquin Delta (the Delta) immediately following an extreme runoff event that occurred in all Delta tributaries caused by a large atmospheric river in late December 2022. Typically, water project operators use turbidity in the Sacramento River as an early warning system to manage turbidities in the central Delta through reduction in exports because the largest suspended-sediment load typically enters the central and south Delta through Georgiana Slough (which carries about 20 percent of the Sacramento River sediment load). However, the atmospheric river induced peak flows eroded bed and near-bank sediment that accumulated during several years of drought in Delta watersheds, delivering a large amount of sediment directly into the central Delta from the Consumnes River. Thus, a combination of high sediment loads entering the Delta from all tributaries, and a particularly high load from the Consumnes River (which doubled the higher-than-average sediment load entering the Delta from the Sacramento River) caused an unexpectedly rapid exceedance of 12 FNU turbidities in the central and south Delta, ultimately resulting in an export curtailment. This was followed by a series of atmospheric rivers that continued to deliver suspended sediment to the central Delta from the Delta tributaries. Franks Tract turbidities remained elevated due to periodic above average winds and wind-wave resuspension of recent sediment inflows from the atmospheric rivers and contributed to elevated turbidities (above 12 FNU) in the central and south Delta.

The sediment load from the Consumnes and Mokelumne River systems had not been considered a significant source of sediment (and turbidity) in the water project operators' early warning system because the contribution is typically less than 5 percent of the total sediment load. However, because the Cosumnes River is unregulated, flow can increase rapidly, and it can be a significant source of suspended sediment. When sediment loads like during 2023 enter the Delta, it can be nearly impossible to avoid turbidities greater than 12 FNU in the central and south Delta using water project operations.

Long-Term Suspended-Sediment Monitoring in the Sacramento-San Joaquin Delta and San Francisco Bay

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The U.S. Geological Survey has been collecting suspended-sediment data in the Sacramento-San Joaquin Delta (Delta) and San Francisco Bay for decades. The network has expanded from several experimental stations in the 1990s to a robust and integrated monitoring network. Today, more than 25 stations are reporting suspended-sediment data based on turbidity surrogate models. Our group collaborates with stakeholders to increase the power of the data being collected across the monitoring network. The data are transformed into information in a variety of ways, including constituent mapping, interdisciplinary tidal-marsh function studies, and model calibration and validation.

Long-term datasets in conjunction with modelling efforts and process-based studies provide insight into the impacts that various habitat restoration and water management actions have had on circulation and mixing in the Delta. More changes are proposed for the future that will directly impact the basic hydrodynamic processes at work in the Delta. These long-term monitoring data provide a framework for assessing the impacts of proposed actions. Moreover, as they are integrated with additional data streams, such as biological monitoring, scientists can gain insight into the impacts that physical and chemical processes have on the distribution of native and non-native species in the Delta.

Session 8: Fish Modeling

A Framework for a Juvenile Production Estimate of Central Valley Steelhead

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Significant uncertainty remains regarding the abundance, distribution, productivity, and life history diversity of California Central Valley (CCV) Oncorhynchus mykiss due to limited data on both resident (trout) and anadromous (steelhead) life-history forms. In 2024, the Steelhead Science Plan was created to identify and prioritize monitoring and research needs for CCV steelhead with the goal of calculating a juvenile production estimate (JPE). We present two methods for estimating a tributary-level CCV steelhead JPE in the Stanislaus River, both aimed at estimating the number of two-year-old steelhead smolts migrating out in a given year while also highlighting key data collection methods to implementing the framework. The first method estimates the number of adult spawners and derives a JPE from the projected progeny, while the second focuses on estimating the number of approximately one-year-old individuals in the system and derives a JPE based on estimates of survival and outmigration rates of that subset of the population. Both approaches utilize real-world data from multiple studies on *O. mykiss* in the Stanislaus River, supplemented with data from literature on steelhead and related species. Additionally, we introduce a conceptual third method designed to use new data to refine forecasts derived from the first two methods. Finally, we discuss current limitations of a CCV steelhead JPE, including data gaps and challenges, and considerations for scaling a tributary-level JPE to the watershed level.

Long-term Changes in the Rearing Habitat of Delta and Longfin Smelts

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**Presenting author*

How the abundance and habitat of Delta and Longfin smelts have responded to the pelagic organism decline (POD) and climate change intensification (CCI) in the upper San Francisco Estuary (USFE) remain key research and management questions. We evaluated abundance-habitat associations of larval-juvenile Delta and Longfin smelts during spring to early summer 1995-2017. Our goal was to identify key potential abiotic and biotic drivers of fish abundance during three periods: Baseline (1995-2001), POD (2002-2012), and CCI (2013-2017). We used CDFW's 20-mm Survey to estimate how fish abundance (catch-per-unit volume, CPUV, log-transformed) responded to zooplankton and water quality covariates, based on nonparametric multiplicative regression. Explanatory variables included: abiotic factors (surface water temperature and salinity, Secchi depth); biomass per unit volume of potential zooplankton prey (BPUV; log-transformed; calanoid and cyclopoid copepods; cladocerans; copepodids of calanoids and cyclopoids; copepod nauplii; rotifers and harpacticoids), and spatial variables: bottom depth, latitude, longitude and areas (10 categories). During the baseline-period, CPUV of Delta Smelt was best explained by copepods (*Pseudodiaptomus, Sinocalanus*) and longitude (xR2=0.40). For Longfin Smelt, the corresponding factors were copepods (*Limnoithona, Eurytemora*), and longitude (xR2= 0.57). During the POD-period, *Sinocalanus*, the cladoceran *Ceriodaphnia* and temperature best explained Delta Smelt CPUV (xR2= 0.46). The corresponding factors for Longfin Smelt were *Limnoithona, Eurytemora*, all cladocerans and temperature (xR2= 0.59). During the CC-period, Delta Smelt CPUV was best explained by *Sinocalanus*, harpacticoids and latitude (xR2 = 0.41). For Longfin Smelt, the corresponding factors were copepods (*Eurytemora, Acanthocyclops*), and miscellaneous cladocerans (xR2= 0.54). Although some potentially important prey were detected across all periods for Delta Smelt (*Sinocalanus*) and Longfin Smelt (*Eurytemora*), CPUV of both fish species was concurrently explained by longitude (baseline-period) and temperature (POD-period). This suggests the value of the latter two explanatory variables in accounting for habitat contraction towards upstream areas over the study period.

Phenology-Informed Decline Risk of Estuarine Fishes and Their Prey Suggests Potential for Future Trophic Mismatches

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Conservation scientists have long used population viability analysis (PVA) on species count data to quantify trends and critical decline risk, thereby informing conservation actions. These assessments typically focus on single species rather than assemblages and assume that risk is consistent within a given life stage (e.g., across the different seasons or months of a year). However, if risk is assessed at too broad a temporal or spatial scale, it may overlook diverging population declines between predators and prey that disrupt biotic interactions. In this study, we used time-series based PVA for age-0 forage fishes and their potential zooplankton prey for each month of the year in the San Francisco Estuary, over 1995-2023 (N = 175 time series). We used Multivariate Autoregressive (MAR) models that estimate long-term population trends and variability (i.e., process error) for each population. We found widespread negative population trends across fish species (56.6%) and observed that critical decline risk is often higher in months when species abundances peak compared to 'shoulder' months. Although current decline risk is somewhat balanced between predators and their prey (mean 21.8% for fish and 21.4% for zooplankton), our time-series models indicate trophic levels are poised to diverge over the next 10 years, with fish generally accumulating risk faster than their prey. Additionally, zooplankton showed 11.5% higher uncertainty about their near-term critical decline risk relative to fish. These observations suggest strong, previously unreported potential for future trophic mismatches. Our results underscore the need to assess risk over finer temporal scales within and across trophic levels to better understand vulnerability, and thus inform conservation of imperiled species. Our approach is transferable and highlights the benefits of time-series based PVA to understand risk of food-web collapse in the face of climate-induced phenological shifts.

Identifying a Possible Relation between Population Dynamics of White Sturgeon and Hydrology

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Recent studies have shown that the population of White Sturgeon (*Acipenser transmontanus*) in the Delta has been in decline during recent years due to sporadic successful reproduction events and overharvesting. This, in addition to intense harmful algal bloom events during 2021 and 2022, have led to the White Sturgeon population to become a candidate for CESA classification under threatened. Previous population dynamics models have considered the sporadic nature of White Sturgeon reproduction to be a completely random event. However, survey efforts have shown that catch of White Sturgeon larvae in the Delta occurs mainly during wetter years, which leads to a possible relationship between hydrology and likelihood of successful recruitment that directly affects population dynamics.

In this work we perform statistical modeling to elucidate the relationship between hydrology and likelihood of successful reproduction. We identify this relationship and use it to study the population given future hydrology scenarios under climate change. We hope this can be used to manage the species more effectively into the future.

Recovering High-Frequency Plankton Dynamics from Low-Frequency Samples

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Analyzing data with mismatched time scales can be challenging, and it is often conceded that data on the coarsest scale will dictate the resolution of the analysis. Environmental data is often collected by sensors at high frequency, yet due to practical constraints populations are typically only sampled at annual or monthly intervals. When the organisms being sampled (e.g. plankton) have dynamics operating on a time scale much shorter than their sampling frequency, this high-resolution data has the potential to provide invaluable information about the under-sampled ecological dynamics. I present an extension of empirical dynamic modeling (EDM) that leverages high-resolution environmental data to uncover important and potentially nonlinear drivers of an infrequently and unevenly sampled population. I demonstrate this technique on seasonally sampled CalCOFI fish larvae data, using daily satellite measurements to uncover environmental effects on fish larvae operating on daily and weekly time scales. I also hope to include results using data from the Interagency Ecological Program by the time of the workshop.

Session 9: Environmental Stressors on Salmon and Smelt

Advances in California Central Valley Salmon Science: Implications for Landscape Scale Management in a Changing Climate

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**Presenting author*

Central Valley Chinook Salmon stocks are in decline due to multiple interacting stressors, including climate change, flow management, infrastructure, predation, habitat, hatcheries and harvest. We examined current scientific information to update the story of “what’s going on with CV salmon”. This story starts with a description of “what was”… how salmon interactions with their ecosystem and humans prior to European colonization resulted in a resilient diversity of ecotypes capable of utilizing a mosaic of habitats across the landscape. We then describe “what is now”… how reduction in the diversity of geographic and environmental opportunities for salmon, coupled with management that selects for a narrow range of specific ecotypes, has brought California salmon to the current status of low abundance and high vulnerability. Finally, we use “what was” and “what is now” to guide a vision of “what could be”… and what we need to do to bring back diverse and abundant CV salmon populations. This vision emphasizes the need for habitat, flow, harvest, and hatchery management that allow salmon to maximize both abundance and spatial-and-life-history diversity (SLD). To achieve this vision, we suggest three principles to guide recovery actions: 1) Promote SLD through expansion of diverse and connected freshwater and estuarine habitats – including access to habitat above dams, on floodplains, and in the estuary, and provision of functional flows to cue diverse rearing, migratory, and spawning behaviors across the landscape. 2) Exercise discretion in actions focused on preserving distinct ecotypes – it does not make sense to work to preserve or promote ecotypes without promoting the habitat they evolved to exploit (e.g. trying to manage winter-run/spring-run as valley floor spawning and rearing populations). 3) Support a thriving human-salmon connection – harvest and consumption of salmon is essential to a human-salmon connection, as is a continuing education and awareness of salmon as part of the fabric of the community and Central Valley watershed.

Going Viral: Presence and Abundance of Pathogens in Ocean Caught Chinook Salmon Prior to Freshwater Entry

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Chinook Salmon are exposed to a multitude of stressors as they migrate to and from the ocean. These hurdles can increase the amount of energy adult salmon need to migrate, and impact spawning success. In addition, California is at the southernmost range for Chinook Salmon, meaning populations are pushed towards their upper thermal limit, leaving them more susceptible to infection. The goal of this project is to develop a better understanding of what pathogens adult salmon are exposed to prior to freshwater entry. This data will add to a larger project to simulate energy use of fall-run Chinook Salmon during migration. To evaluate pathogen presence, gill biopsies were collected from adult fall-run Chinook Salmon in the Pacific Ocean off of San Francisco during the summer of 2022, a dry year, and the summer of 2023, an exceptionally wet year, before they entered freshwater. Using Fluidigm, a real-time qPCR system, we targeted 47 different pathogens (i.e., bacteria, viruses, and parasites) known to be infectious to salmon. Preliminary data on the presence and abundance of these pathogens has shown Candidatus *Branchiomonas cysticola* and *Ichthyophthirius multifiliis* to be the two most commonly detected pathogens in the collected gill samples. In addition, we detected the presence of at least one pathogen in 91% of all gill samples. This project will help build a better picture of Chinook Salmon migration and correlation with environmental conditions, with implications for fisheries, conservation, and restoration efforts.

Assessing sublethal effects of 4,4′-DDE in juvenile Chinook salmon (*Oncorhynchus tshawytscha*) using internal body residues

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**Presenting author*

Chinook salmon (*Oncorhynchus tshawytscha*) populations have been declining, with water contamination being a contributing factor. Therefore, there is a need for the evaluation of potential population level effects of common contaminants in aquatic environments. Chinook salmon exist at the top trophic level within their ecosystem, making them especially susceptible to compounds that are persistent in the environment and exhibit biomagnification. One of these compounds is 4,4'-dichlorodiphenyldichloroethylene (DDE), a degradation product of legacy pesticide dichlorodiphenyltrichloroethane (DDT). To determine potential effects on Chinook salmon populations, the objective of the present study was to assess sublethal effects of DDE on outmigration success in juvenile Chinook. The endpoints assessed were survival, growth, swim performance, routine swimming, shoaling behavior, and anxiety behavior. Juvenile Chinook salmon were exposed to aqueous DDE doses formulated to achieve internal body residues matching environmentally relevant concentrations and up to 500 times higher. The analyzed endpoints were assessed based on internal body residues, to provide a more direct evaluation of DDE effects on juvenile Chinook salmon. Utilizing internal residues accounts for all potential routes of DDE uptake in the environment, which is advantageous over aqueous concentrations. The analyzed internal DDE residues ranged from 0.72 – 2049 nmol/g lipid. Results from this study showed that internal DDE residue did not affect survival, growth, swimming performance, or anxiety behavior. Shoaling behavior increased as the internal DDE residue increased, and conspecifics spent significantly more time in proximity to each other across all treatments. Shoaling behavior is common in juvenile Chinook salmon, therefore it's increase does not provide strong evidence of a potential effect on outmigration success. Overall, results observed in this study indicate that DDE alone does not pose a significant threat to Chinook salmon populations. Internal DDE residues show minimal effects on juvenile Chinook salmon as it relates to survival, growth, and outmigration success.

Evaluating the Impact of Pesticide Mixtures on Juvenile Chinook Salmon Behavior Using Body Residues

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Pesticides are extensively used across agricultural, industrial, and residential areas, often entering nearby aquatic ecosystems through runoff and spray drift, especially during storm events. The Sacramento-San Joaquin Delta is notably impacted, with elevated levels of bifenthrin, fipronil, and DDE frequently detected in surface waters and sediments. These pesticides are linked to various adverse effects on aquatic species, from sublethal impairments to lethal outcomes. Chinook salmon (*Oncorhynchus tshawytscha*), which migrate downstream through these contaminated rivers, are particularly vulnerable. This project aimed to assess the combined impacts of three frequently detected pesticides in the Delta, bifenthrin (BIF), fipronil (FIP), and 4,4'-dichlorodiphenyldichloroethylene (DDE) on Chinook salmon behavior. We hypothesized that sublethal pesticide levels would be high enough to affect overall fish key behavior traits such as routine swimming and social behavior. To test this hypothesis, juvenile Chinook salmon were exposed for 10 days to four treatments: control, treatment 1 (0.125 µg/L BIF + 4.0 µg/L FIP), treatment 2 (0.500 µg/L BIF + 8.0 µg/L FIP), and treatment 3 (0.125 µg/L BIF + 4.0 µg/L FIP + 0.45 µg/L DDE). The aqueous concentrations were designed to reflect body residues in the wild, from environmentally relevant concentrations and higher. Exposure to these mixtures impacted multiple behavioral traits when compared to control fish. Fish in treatment 1 showed mild hyperactivity, with increased movement and swimming speed compared to controls, while those in treatments 2 and 3 exhibited significant hypoactivity. Additionally, fish across mixture treatments displayed reduced social interactions, as evidenced by an increased average distance between individuals. These sublethal effects are likely to impair the migratory success of juvenile Chinook by elevating predation risk, along with numerous physiological and developmental issues known to result from exposure to these pesticides.

Larval Delta Smelt: Recent Observational and Experimental Results

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The San Francisco Estuary (SFE) is the exclusive habitat for the endangered Delta Smelt, *Hypomesus transpacificus*. While the species is well-studied both in captivity and the wild, the larval stage is relatively understudied. We aim to (1) expand the current understanding of the health condition, distribution, and diet of wild-caught, larval Delta Smelt while (2) examining the response of larval Delta Smelt to salinity and temperature in laboratory experiments. First, eighty-three larval Delta Smelt were collected from 2019-2022 from the region with the highest abundance in the wild, the Sacramento River Deep Water Ship Channel (DWSC). We observed ubiquitous signs of starvation throughout the DWSC. CPUE peaked in the wettest year of 2019, in the middle (most turbid) portion of the DWSC, and at turbidities >20 NTU. Larval gut contents were dominated by the calanoid copepods *Sinocalanus spp*., followed by *Pseudodiaptomus spp*. and *Eurytemora spp*. The results indicate food limitation stress in the wild population of Delta Smelt larvae, consistent with other pelagic species in the SFE. Second, newly-hatched Delta Smelt larvae were exposed to a range of temperatures (13-22°C) under fresh (0.125 ppt) or brackish (4 ppt) conditions. We found that larval growth and survival exceled in warm (22°C), brackish water, while lower growth was observed in all freshwater treatments. High growth potential of larvae displayed in this study matches growth rates in the wild and improves understanding of the habitat requirements of Delta Smelt larvae.

An Assessment of 6PPD-Quinone Acute and Sublethal Toxicity on Endangered Smelt in the Sacramento-San Joaquin Delta

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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. 6PPD-quinone, a toxic breakdown product of the widely used tire additive N-(1,3-Dimethylbutyl)-N'-phenyl-p-phenylenediamine (6PPD), has emerged as a significant ecological concern. This compound has been detected in water samples from San Francisco region creeks at concentrations near or exceeding the LC50 for Coho Salmon, raising concerns about its impact on local aquatic species. The presence of 6PPD-quinone in the Sacramento-San Joaquin Delta represents a potential risk to endangered species such as Longfin Smelt (*Spirinchus thaleichthys*) and Delta Smelt (*Hypomesus transpacificus*).

For the first time, the acute and sublethal toxicity of 6PPD-quinone was assessed on these two Smelt species. Larvae and juveniles of both smelt species were exposed to evaluate mortality and sublethal endpoints, including behavior, thermal tolerance, and swimming performance, to explore potential neurotoxicological and cardio-respiratory effects of 6PPD-quinone. Acute toxicity results revealed no mortality in either species, even at concentrations orders of magnitude higher than those detected in the environment. However, sublethal exposure studies indicated significant behavioral changes, such as altered locomotion and anxiety-like responses, supporting evidence that 6PPD-quinone acts as a neurotoxicant. These findings suggest that while acute mortality from environmental levels of 6PPD-quinone may not pose an immediate threat, sublethal effects could impact critical behaviors and physiological functions essential for survival and reproduction. This research provides valuable insight into the potential risks of 6PPD-quinone to Delta and Longfin Smelt and underscores the importance of further investigation into sublethal effects. The results will help inform conservation strategies for these endangered species and contribute to understanding the broader ecological implications of tire-derived contaminants.

Estimating Survival of Chinook Salmon Eggs and Measuring Hyporheic Conditions During Incubation in the Sacramento River

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Dam construction on rivers throughout the Central Valley has restricted Chinook Salmon from accessing historically available spawning habitat. Winter-run Chinook Salmon spawned in higher elevations of the Sacramento River watershed during summer months, avoiding warm water temperatures inhospitable to successful egg incubation. However, they are now confined below Keswick Dam on the valley floor. Despite concern about poor conditions during egg incubation limiting reproductive success, data on in-situ survival of eggs and associated environmental conditions within the hyporheic zone are not available. In Fall 2023 an in-situ study of egg-to-fry survival on the lower Sacramento River near Redding, CA was implemented. Ten artificial redds were created at each of three sites and implanted with an incubation chamber containing a temperature logger and approximately 150 fertilized fall-run Chinook Salmon eggs from Coleman National Fish Hatchery. Intergravel velocity, permeability, and dissolved oxygen measurements were collected at three redds per site on a biweekly basis throughout the incubation period. Results from the first year demonstrated a significant difference in egg survival to-hatch that varied by site. Temperature and dissolved oxygen varied among sites but did not exceed tolerance thresholds suggesting they did not drive observed patterns of survival. The second year of our study includes a deep-water site below Keswick Dam in addition to the previous study sites. Findings from this study will provide critical information on observed survival while demonstrating the effectiveness of proposed methods, so that similar methods can be used in a more extensive study with endangered winter-run Chinook Salmon in 2025 to better inform temperature management plans.

Session 11: Food Webs and Predation

Missed Connections: Identifying Key Food Web Interactions for Management in the Bay-Delta Estuary

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San Francisco Bay and the Sacramento-San Joaquin Delta form a complex estuarine system that poses many management challenges due to human alteration and competing goals for ecological and human needs. Management for species regulations has focused on the direct impact of individual or combined drivers, such as flow and temperature, on the abundances of single species. However, ecosystem-based management that spans habitat and spatial boundaries, such as for anadromous fish migration, requires consideration of food-web interactions that can also shift abundances of species. Despite a large amount of research being conducted in the Bay-Delta region, the science addressing species interactions is often spread across agencies, groups, and jurisdictions. This review synthesizes what is known about species interactions in the Bay-Delta, with a focus on both direct and indirect food web interactions, to determine 1) the spatiotemporal spread of science conducted on food web interactions, 2) which species interactions may be important/overlooked, and 3) how an understanding of species interactions can aid management. We hypothesize that missed connections across species, such as ocean-estuarine trophic connections, may lead to suboptimal management and inaccurate projections of how species in the Bay-Delta system will respond to environmental changes, especially climate. We conducted a reproducible review by searching for primary literature with fixed search strings in multiple literature databases. Our inclusion criteria are empirical and modeling papers detailing species interactions in the Bay-Delta ecosystem. We highlight species interactions that span geographic regions and may be particularly significant to quantifying energy flows for management, and identify specific drivers that may affect key species interactions. The results of this synthesis can be used to update or create new conceptual models of the ecosystem, and to develop a more comprehensive method of managing species in the Bay-Delta in a future of climate change.

Quantifying Component Mortality Rates of Juvenile Steelhead Trout (*Oncorhynchus mykiss*)

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Federally threatened Central Valley Steelhead (*Oncorhynchus mykiss*) have undergone significant population declines because of elevated water temperatures, poor water quality, limited habitat availability, and predation by non-native species. Juvenile recruitment is essential to recover adult abundances, yet previous studies have estimated that juvenile survival is as low as 5% with little empirical data to support main drivers of mortality. Thus, our study aimed to partition juvenile Steelhead mortality among component sources using Predation Detection Acoustic Tags (PDATs). We deployed a passive acoustic array along the San Joaquin River to detect Steelhead smolts tagged with PDAT transmitters. From March–May 2024, we tagged 200 juvenile Steelhead and manually tracked them for eight days following release. We observed five fish states using both passive and active detections: (1) alive, (2) aquatic predation, (3) stationary tag, (4) outmigration, and (5) unobserved. We plan to use these observations in a multistate capture-recapture model to quantify component mortality rates of juvenile Steelhead from three different sources: fish predation, avian predation, and natural mortality. Our preliminary results indicate a 20% (n=40) mortality rate by predation (i.e., predation detection sensor was triggered), and 50% survival (n=99). Out of the 40 identified predation events, only one tag exhibited temperatures consistent with an avian predator. The preliminary results of this study indicate that piscivorous predation represents the highest source of outmigration mortality for juvenile Steelhead, and that survival is higher than previously recorded. We hypothesize that increased water height and flow due to recent rain events in the Central Valley Delta may result in increased Steelhead survival. The results of our study will provide some of the first empirical estimates of juvenile Steelhead predation rates exemplifying the utility of PDAT tags while providing valuable information for management strategies aimed at increasing juvenile survival within this system and others.

Examining the role of predation and habitat on Chinook Salmon smolt survival in the Sacramento River

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The Sacramento River in California's Central Valley is home to four distinct ecotypes of Chinook Salmon (fall, late-fall, winter, spring runs), all of which have declined precipitously since the mid-1800's. Poor juvenile outmigration survival has been identified as a major concern for population stability in the region, and past research has suggested that this may be due to high levels of non-native predators encountered by Chinook smolts as they migrate downstream. However, variation in smolt size and migration timing among ecotypes can expose migrating fish to differing environmental conditions and levels of predation, which can present distinct risks for outmigration survival. In this study, we analyzed ten years of acoustic telemetry data (2012 – 2021) from all four runs of Chinook Salmon in the Sacramento River to identify the areas and environmental conditions which have the greatest relative impact on juvenile survival for each ecotype in discrete river segments along the migratory corridor. We used Cormack-Jolly-Seber mark-recapture models in a Bayesian framework and modeled survival as a factor of predation using the mean free-path length model (XT model), which estimates a relative index of predator densities throughout a reach based on the distance traveled and travel time of migrating prey (i.e., Chinook smolts). XT model parameters were informed by spatially explicit and time-varying habitat covariates for each river reach, combined with covariates for individual fish size and seasonal/annual variation in flow patterns. Results from this study can help inform water management actions and river restoration efforts in the Central Valley that support greater survival for migrating salmon smolts by providing estimates of the primary drivers of predation risk/mortality in Sacramento River, and how these factors vary through space, time, and among Chinook Salmon ecotypes.

Estimated Population Level Impacts from Piscivorous Predation on Juvenile Chinook Salmon in the Stanislaus River

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**Presenting author*

In response to the Water Infrastructure Improvements for the Nation (WIIN) Act (2016), we collaborated with NOAA Fisheries and California Department of Fish and Wildlife to develop and implement a suite of predation related studies and impacts on juvenile Chinook salmon (*Oncorhynchus tshawytscha*) in the Stanislaus River. These studies were used to elucidate the ecology and trophic dynamics of native and nonnative predatory fishes with the goal of identifying potential management strategies to mitigate predation related losses. From 2018 through 2023, we used boat electrofishing to sample fish and collect data over 64 kilometers of the Chinook salmon migration corridor. A combination of abundance estimates of predators, diet composition, water temperature modeling, and estimates of juvenile Chinook salmon availability were used to estimate the population-level impact of predation by striped bass (*Morone saxatilis*), black bass (Micropterus sp.), and Sacramento pikeminnow (*Ptychocheilus grandis*). Model error was estimated using resampling routines of the data, then a one-way sensitivity analysis of input variables was conducted to assess the sensitivity of results to potential error in input variables and investigate how certain variables may inform the development of management strategies to reduce predation impacts on juvenile Chinook salmon. From 2019 to 2023, we estimated that 20% to 60% of available salmon could be consumed by the three predatory fishes examined. Estimated impacts were typically lowest in wet water years in 2019 and 2023 and highest in dry water years in 2021 and 2022. Model results were most sensitive to water temperatures, one consumption model parameter for black bass, and estimated abundance of juvenile Chinook salmon from the Oakdale rotary screw trap. The models and sensitivity analyses represent a preliminary step to assess efficacy of management strategies that might be employed to benefit juvenile Chinook salmon via reduced predation impacts in the Stanislaus River.

How four introduced copepod species interact in the San Francisco Estuary: accommodation in a low-productivity environment

- Wim Kimmerer*[1], Estuary & Ocean Science Center, San Francisco State University, kimmerer@sfsu.edu
- Michelle Jungbluth[1], Ann Slaughter[1], Toni Ignoffo[1], Kiona Parker[1], Amy Wong[1]

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*Presenting author

The San Francisco Estuary (SFE) is home to nine copepod species, most introduced 3-4 decades ago. We analyzed potential interactions among four of these introduced species that are abundant during spring-summer in the Low-Salinity Zone (LSZ), the rearing habitat for larval delta and longfin smelt. Since 1987, grazing by the introduced clam *Potamocorbula amurensis* reduced summer phytoplankton biomass and productivity in the LSZ by ~10-fold. The resulting chronic food limitation, together with consumption of copepod nauplii by clams, restricted copepod abundance to low levels during summer of every year since 1987, and produced a “food desert” for young smelt. *Eurytemora carolleeae*, introduced to the Estuary before monitoring began, was highly abundant year-round in the LSZ until it declined sharply in 1987, and it is now abundant only in spring. The other three copepod species are subtropical and most abundant during summer: *Pseudodiaptomus forbesi* (detected in 1988) at salinity less than ~2, and *Limnoithona tetraspina* (1993) and its predator *Acartiella sinensis* (1993) in salinity of 0.5–10. Since 1993 abundance patterns of these four copepods overlap in season and salinity, superficially suggesting competition. However, this is a case of “apparent competition”, because competition for food is ruled out by the distinct diets and incomplete spatial overlap among the four species. Rather, abundance of each species is influenced by a combination of temperature, freshwater flow, feeding by clams on microplankton and copepod nauplii, and predation. The ability of estuarine copepod species to co-occur may generally be explained better by considering the broader hydrodynamic, thermal, and predatory environment than by competition.

Exploring food-web subsidies from Shasta-Keswick reservoirs as a potential management strategy for highly-altered downstream ecosystems

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Presenting author, *†Early Career Award candidate*

Freshwater ecosystems downstream of large dams are often degraded and dependent on reservoir releases for agriculture, hydropower, flood control, and environmental mandates. Resource management efforts have steered towards reconciling reservoir operations with ecosystem health, where releases are managed to benefit downstream ecosystems. This process has mostly been framed within the context of environmental flows and water quality objectives (e.g., water temperatures). Recent research has shown that reservoirs can also be an important source of food web subsides (e.g., nutrients, basal carbon, zooplankton) to downstream ecosystems. Such subsidies can be advected through reservoirs and boost downstream lotic ecosystem productivity. However, unlike discharge and temperature, actively managing such subsidies has received little attention. Here, we focus on the Shasta-Keswick dam complex in northern California, to understand the tradeoffs of subsidy management within an altered and ecologically significant section of the Sacramento River (e.g., spawning and rearing locations of two federally-listed species). We robustly sampled and simulated nutrient and productivity dynamics within the Shasta-Keswick Reservoir complex and analyzed how alternative operations of its selective withdrawal device can affect food-web subsidies and overall downstream ecosystem productivity. Particular attention is given to the early life stages of endangered winter-run Chinook salmon, from egg incubation to juvenile rearing, to better understand the operational tradeoffs between coldwater temperature releases and exported food web subsidies. Ongoing analysis suggests that this novel management strategy may have important implications for ecosystem resilience under a changing climate, providing additional flexibility to manage imperiled species.

Session 12: Management & Policy

COEQWAL: Water Allocation and Planning Data for Everyone

- Eric Danner*, NOAA Fisheries, eric.danner@noaa.gov
- Ted Grantham, University of California Berkeley
- Wietske Medema, University of California Berkeley
- Laurel Larsen, University of California Berkeley

Presenting author

Drought, floods, and widespread environmental degradation are exposing significant vulnerabilities in California's water management system, and decisions over how water is allocated (i) rely on models that consider a limited range of climate and operational scenarios, (ii) are constrained by an entrenched system of water rights, and (iii) are inaccessible to the public. Building a resilient water future requires new water planning tools that advance sustainable, inclusive, and equitable water stewardship. To meet this need, we are developing COEQWAL (COllaboratory for EQuity in Water ALlocations), a user-driven framework for water planning that leverages existing planning models for California's major water supply systems. Our goal is to empower end-users, including those historically excluded from decision making. COEQWAL will identify user-defined objectives and design alternative operational scenarios using CalSim3, the water resources planning model used to operate infrastructure throughout California's Sacramento-San Joaquin River System. This co-production process will occur through engagement with researchers and community partners, including underserved communities, environmental organizations, Tribal Nations and communities, agricultural groups, municipalities, and water agencies. We will produce a novel open-access library of data and scenarios for water system operations under a wide range of climate futures that will be of significant interest to the IEP and the larger Delta science community. For research or planning efforts that involve future water supplies to the Central Valley, Delta salinity dynamics, environmental flows (including Delta outflows), and water allocations in a changing climate, scenarios from the COEQWAL data platform will be an invaluable resource. We will evaluate tradeoffs and synergies among objectives and share results using state-of-the-art visualization tools. Our goals are to advance the underlying science, improve existing planning models, bring into the public domain water allocation information that has previously been inaccessible or nonexistent, and catalyze participatory water resilience planning at local, regional, and statewide scales.

Decision Uncertainty and Research Prioritization for Delta Smelt Summer-Fall X2 Action

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- William E. Smith, U.S. Fish and Wildlife Service
- Brian D. Healy, U.S. Geological Survey
- Cameron Koizumi, U.S. Bureau of Reclamation
- Matthew Nobriga, U.S. Fish and Wildlife Service
- Shawn Acuña, Metropolitan Water District of Southern California
- Brian Crawford, Compass Resource Management
- Kristin K. Arend, U.S. Fish and Wildlife Service
- Michael C. Runge, U.S. Geological Survey

**Presenting author*

Water management has been an area of focus and controversy in California, USA. Construction of numerous reservoirs and water diversion facilities throughout the state, while critical to the state's economy, have contributed to the decline of many native species. The endangered Delta Smelt (*Hypomesus transpacificus*) is endemic to the Sacramento-San Joaquin Delta (Delta), the heart of California's complex water conveyance system. To aid the recovery of Delta Smelt, an action to increase freshwater outflow through the Delta in the fall has been implemented in wet years since 2011, requiring a large amount of water either released from storage or made unavailable to export for human consumptive uses. Evaluating the trade-offs between different water uses is made even more difficult by uncertainties in the predicted fish response. Using examples from different iterations of a Delta Smelt individual-based model that spans the species' life cycle, we showcased how uncertainties surrounding environmental flow actions can be assessed through a structured decision-making framework. We also demonstrated when and where there was value of information in resolving structural uncertainty, and how the value of information was affected by the objective weights. Our study serves as an example of scientific uncertainty, even if large, may not be relevant to a decision maker, and how value of information analysis can be used to guide future conservation conversation in an overallocated system such as California.

Science Action Agenda Progress Summary

- Kim Luke*†, Delta Stewardship Council, kim.luke@deltacouncil.ca.gov
- Rachael Klopfenstein, Delta Stewardship Council

**Presenting author, †Early Career Award candidate*

The Science Action Agenda (SAA) prioritizes and aligns science actions to inform management, identifies knowledge gaps, promotes collaborative science, and builds science infrastructure for the Sacramento- San Joaquin Delta (Delta). The SAA is a four- to five-year agenda, with the most current iteration (2022-2026) presenting 25 priority science actions.

Currently, the Delta Stewardship Council's (Council) Delta Science Program is conducting a midpoint progress summary of the 2022-2026 SAA. The goal of the midpoint summary is to determine what progress has been made on the 25 priority science actions — part of the "evaluation" phase in the adaptive management cycle. This midpoint summary provides a gauge on the return on investment of the Science Program's and its partner's funding, which is guided by the SAA, and helps to inform how funding should be prioritized for the remaining duration of the SAA. Our lightning talk will present preliminary results from the midpoint progress summary and highlight the status of a few of the priority science actions.

The SAA helps to fill knowledge gaps and identify synergies with other agencies' science strategies, including IEP's Science Strategy. This presentation will benefit the IEP community by sharing information about the SAA and highlighting the status of Science Actions relevant to Delta ecological monitoring and research.

Machine Learning for Natural Resource Management

- Kai Ross*, Cramer Fish Sciences, kai.ross@fishsciences.net

*Presenting author

Machine learning (ML) has become a transformative tool in natural resource management, offering innovative approaches to complex problems through predictive modeling, classification, and pattern recognition. Aligning with the IEP's commitment to being relevant, responsive, and adaptive in providing data and information on the Bay-Delta aquatic ecosystem, ML techniques can enhance comprehensive, ecosystem-level assessments, facilitate rapid analyses, and help automate time intensive tasks. However, this requires managers and practitioners to understand both the benefits and limitations of applying ML techniques. This talk provides an introduction to ML, explaining its core principles and how it can be applied effectively in the natural resource sector. We will discuss the use of predictive models such as Random Forest, Generalized Additive Models (GAMs), and Lasso regression to make predictions and help determine variable importance. Additionally, we will highlight pattern recognition applications, including bird song identification, text-based optical character recognition (OCR), and automated landscape classification through geospatial object-based image analysis (Geobia). Finally, we will expand that to the topic of computer vision, where ML enables advancements in fish counting and tracking, zooplankton identification, and substrate size estimation in aquatic habitats. The talk will also weigh the benefits and challenges of using ML for natural resource management, highlighting advantages such as rapid, consistent outputs and the ease of integration into data processing pipelines, while discussing limitations, including the need for robust training data and potential errors in edge cases.

Multi-Year Regional-Scale Efficacy Comparison of Two Herbicides for Treatment of Invasive Floating Aquatic Vegetation in a California Estuary

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- Jereme Gaeta, California Department of Fish and Wildlife
- J. Louise Conrad, California Department of Water Resources

**Presenting author*

Invasive aquatic macrophytes are a major threat to estuarine ecosystems globally. This study examined the efficacy of a treatment program for treating invasive floating aquatic vegetation (FAV) using two herbicides, glyphosate and 2,4-D over two five-year periods. The study combined multiple image datasets, spray location data, and herbicide application information to examine the efficacy of the treatment program at the scale of the full ecosystem. The objectives of the study were to determine i) if probability of FAV presence at a site decreased as herbicide concentration increased, ii) if this decrease was still apparent a year after treatment, iii) if efficacy depended on the kind of habitat that was treated and, finally, iv) if the two herbicides differ in efficacy. The results show that probability of FAV presence reduces as concentration of herbicide application increases. Both herbicides are only effective above specific concentration thresholds and their efficacy does indeed vary among habitat types. More results will be available as the study progresses in the next couple of months.

Session 13: Phytoplankton and HABs (Part I)

Harmful Algal Toxins are Widespread in Shellfish Across the San Francisco Estuary

- Ellen Preece*[1,2], California Department of Water Resources, Ellen.Preece@water.ca.gov
- Tim Otten[3], Janis Cooke[4], Raphe Kudela[5], Keith Bouma-Gregson[6]

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**Presenting author*

Harmful cyanobacteria blooms are a growing threat in estuarine waters as upstream blooms are exported into coastal environments. The cyanotoxin microcystin (MC) can persist and accumulate within the food web. Filter-feeding invertebrates may biomagnify toxins up to 100X ambient concentrations. As such, shellfish can be used as an environmentally relevant and highly sensitive sentinel for MC monitoring. To date there has been little research on cyanotoxin bioaccumulation in estuaries. The Sacramento-San Joaquin Delta (Delta) aquatic food web has undergone a profound change in response to widespread colonization of aquatic invasive species such as Asian clams (*Corbicula fluminea*) in the freshwater portion of the Delta. These clams are prolific—blanketing areas of the Delta at densities up to 1000 clams/m2, and are directly implicated in the pelagic organism decline of threatened and endangered fishes. We studied MCs accumulation in Delta Asian clams and signal crayfish (*Pacifastacus leniusculus*) over a two-year period. We found MCs accumulate in Asian clams across all months and at all study sites, with seasonal maxima occurring during the summer. Although MC concentrations rarely exceeded public health advisory levels, the persistence of MCs year-round still poses a chronic risk to consumers. We found crayfish at times also accumulated high concentrations of MCs. We expanded our study to also measure MCs and the potent neurotoxin, domoic acid, further along the freshwater to marine continuum, by collecting crabs (*Rhithropanopeus harrisii* and *Metacarcinus magister*) and shrimp (*Crangon franciscorum*) in more saline waters. These organisms also accumulate MCs that may have originated in upstream Delta waters as well as domic acid from the marine diatom *Pseudonitzschia*. Summertime concentrations of both MC and domoic acid exceeded public health advisory levels at most sites. Our results highlight the utility of shellfish as sentinel organisms for monitoring in estuarine areas.

Using Genome Resolved Metagenomics to Assess the Taxonomic, Metabolic, and Toxigenic Diversity of Cyanobacteria in the Delta

- Keith Bouma-Gregson*, U.S. Geological Survey, kbouma-gregson@usgs.gov
- Andreja Kust[1,2], Theodore M. Flynn[4], Vivian Klotz[4], Judy Westrick[5], Nicholas Peraino[5], Spencer Diamond[1,2], Jillian F. Banfield[1,2,6,7]

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**Presenting author*

Cyanobacterial Harmful Algal Blooms (cyanoHABs) pose a significant threat to water quality, ecosystem health, and public safety within the Sacramento-San Joaquin Delta, a vital waterway supporting diverse ecological and human needs. Recent increases in the diversity and abundance of potentially toxigenic cyanobacteria in the Delta have raised concerns about the emergence of novel cyanotoxin producers and their implications for water quality, ecosystem health, and public safety.

Through monthly sampling across ten Delta sites over eight months in 2023, we combined genome-resolved metagenomics with chemical toxin analyses to uncover the potential of cyanobacteria to biosynthesize cyanotoxins, to detect actual toxins present, and to identify specific functional genes within cyanobacterial genomes. We recovered over 50 metagenomic assembled genomes (MAGs), including genomes from *Microcystis*, *Aphanizomenon*, *Dolichospermum*, and *Planktothrix*. We only found microcystin biosynthesis genes within Microcystis genomes, suggesting they are the only microcystin producer in the Delta. Beyond the well-known cyanotoxin producer Microcystis, we found that *Planktothrix* genomes contain biosynthesis genes for bioactive compounds with unknown environmental effects, while *Aphanizomenon/Dolichospermum* genomes contain biosynthesis genes for geosmin, a taste and odor compound that degrades drinking water quality.

Biosynthetic gene cluster (BGC) analysis revealed novel pathways for the biosynthesis of previously unidentified compounds, suggesting a broader range of potentially harmful substances than currently recognized. Biosynthetic gene cluster (BGC) analysis revealed novel pathways for the biosynthesis of previously unidentified compounds, suggesting a broader range of potentially harmful substances than currently recognized.

These findings highlight the potential insights gained with genome-resolved methods and underscore the need to understand the diversity of molecules produced by cyanoHABs.

More than Meets the Eye: Using Metabarcoding for Cyanobacteria and Phytoplankton Monitoring in the Delta

- Silvia Angles*, California Department of Water Resources, Silvia.Angles@water.ca.gov
- Andreja Kust, University of California Berkeley
- Alexa Camilleri-Evans, California Department of Water Resources
- Ted Flynn, California Department of Water Resources
- Daphne Gille, California Department of Water Resources

**Presenting author*

Traditional microscopy-based methods to characterize cyanobacteria and phytoplankton, while valuable, often have limitations in terms of sensitivity, specificity, and time-efficiency. These limitations can hinder accurate assessment of cyanobacteria and phytoplankton communities, especially when dealing with low-abundance species or morphologically similar taxa. Metabarcoding offers a promising approach to overcome these challenges. This study explores the application of metabarcoding to monitor cyanobacteria and phytoplankton communities in the Delta. By targeting specific genetic markers, we aim to identify cyanobacteria and phytoplankton taxa, including potentially toxic species. By analyzing environmental DNA (eDNA) extracted from water samples collected in the Delta during 2023 and 2024, we will compare metabarcoding data with traditional microscopy data to assess the sensitivity of metabarcoding in detecting diverse phytoplankton and cyanobacteria taxa. Additionally, we will investigate the spatiotemporal patterns of these communities and assess changes in their composition.

Comparative Analysis of Primary Production and Nutrient Cycling in Shoal and Channel Regions of the San Francisco Bay and Sacramento-San Joaquin Delta

- Alexander R. Ryan*†, U.S. Geological Survey, arryan@usgs.gov
- Emily T. Richardson, U.S. Geological Survey
- Jacob D. Brinkman, U.S. Geological Survey
- Katy O'Donnell, U.S. Geological Survey
- Brian A. Bergamaschi, U.S. Geological Survey

**Presenting author, †Early Career Award candidate*

Research on nutrient cycling and primary productivity in the San Francisco Bay and seaward portion of the Sacramento San Joaquin Delta (Bay-Delta) has traditionally occurred within the main channel, leaving shoals — shallow areas constituting about 65% of the Bay-Delta — understudied. Data collected during U.S. Geological Survey high-resolution mapping surveys suggest that shoals may support more favorable conditions for phytoplankton growth, contributing to elevated nutrient cycling and primary productivity. Phytoplankton biomass was generally higher in shoal environments than shallow environments — often much higher. The dearth of data in shoals, compared to the main channel, limits our understanding of the Bay-Delta's complex aquatic ecosystem.

We address this knowledge gap by analyzing water quality and phytoplankton data collected across the Bay-Delta from Suisun Bay to the lower San Francisco Bay comparing and contrasting shoal and channel habitats. We aim to provide a holistic view of the Bay-Delta's lower trophic food web, highlighting the need to integrate shoal regions into regular Bay-Delta assessments to fully understand this dynamic ecosystem.

Session 14: Phytoplankton & HABs (Part II)

Investigating Phytoplankton Community Dynamics During the August 2022 *Heterosigma akashiwo* Bloom in San Francisco Bay, California

- Schuyler Nardelli*†, U.S. Geological Survey, snardelli@usgs.gov
- Keith Bouma-Gregson, U.S. Geological Survey
- David Senn, San Francisco Estuary Institute
- Erica Nejad, U.S. Geological Survey
- Emily Richardson, U.S. Geological Survey
- Brian Bergamaschi, U.S. Geological Survey

**Presenting author, †Early Career Award candidate*

San Francisco Bay, California, is a nutrient-enriched estuary with the potential to support acute harmful algal blooms (HABs). Although HAB taxa are present in historical data, high-biomass HAB events are rare, likely due to a combination of tidal mixing, light limitation from high turbidity, and benthic grazing pressure. However, in August 2022, record-high chlorophyll concentrations (200-400 µg/L) measured in San Francisco Bay were associated with a bloom of *Heterosigma akashiwo* that led to widespread low dissolved oxygen and fish mortality. *H. akashiwo* had been detected with 18S rDNA methods in 37% of phytoplankton samples since 2015 but had never formed a bloom of this magnitude. We investigated the bloom dynamics from a community perspective, using protist community composition (18S rDNA) and environmental (light, nutrients, temperature, salinity, etc.) data collected via surveys aboard the R/V Peterson and R/V Aiken 2-3 times per month from 2015-2022. Preliminary results show that there was an anomalously large diatom bloom in June, which led to a mostly small-celled, heterotrophic community in July with an abnormally low abundance of dinoflagellates. The absence of dinoflagellates, which could include predators of *H. akashiwo*, plus optimal environmental conditions (high light, warm temperatures, ample nutrients, reduced flushing) may have provided opportunity for *H. akashiwo* to proliferate in August. The abundance of dinoflagellate species in the genus *Gyrodinium* (predators of *H. akashiwo*) also increased as the bloom collapsed. Study results improve our understanding of the community drivers of the August 2022 HAB event, provide an "early warning" of conditions that could precede a bloom, help managers assess the likelihood of a HAB event of this magnitude occurring again, and provide a basis for assessing whether actions can be taken to prevent large HAB events in the future.

Vertical Mixing in Dead-End Channels of the Delta

- Sienna White*†, University of California Berkeley, siennaw@berkeley.edu
- Tia Böttger, U.S. Geological Survey
- Keith Bouma-Gregson, U.S. Geological Survey
- Lisa Lucas, U.S. Geological Survey
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Harmful algal blooms are frequently observed in low energy, dead-end channels of the Sacramento-San Joaquin Delta during the summer. These dead-end channels and sloughs are characterized by their high nutrient loading, diurnal stratification, and long residence time. We hypothesize that phytoplankton growth in these dead-end channels is limited by access to the photic zone (not nutrient limitation), and that this access is modulated by the presence (or lack thereof) of vertical mixing.

In order to investigate vertical mixing in a dead-end channel, we conducted fieldwork in the Stockton Shipping Channel during August 2024 and sampled vertical distributions of phytoplankton alongside hydrodynamic parameters. We used these data to generate vertical profiles of turbulent dissipation over several days at both the mouth (Turning Basin) and end (University Plaza) of the channel. We find that diurnal winds are the dominant driver of dissipation, generating vertical profiles with dissipation gradients of several orders of magnitude. In our discussion, we focus on comparing the behavior and magnitude of these dissipation profiles to those produced by an idealized one-dimensional hydrodynamic model forced by temperature, winds, and water level. Specifically, we investigate if a one-dimensional model can accurately simulate the mixing characteristics of this dead-end channel and replicate measured vertical profiles of both dissipation and phytoplankton. We close by using our model to review what conditions could produce vertical mixing profiles that give Microcystis access to the photic zone. These findings have critical implications for the specific physical characteristics (weather, inflow, tides, etc.) that may incite harmful algal bloom events in the Delta.

Investigating Drivers of Phytoplankton Dynamics in the South Delta

- Nick Framsted*†, U.S. Geological Survey, nframsted@usgs.gov
- Crystal Sturgeon, U.S. Geological Survey
- Jared Frantzich, California Department of Water Resources (NCRO)
- Brooke Rosenow, California Department of Water Resources (NCRO)
- Tamara Kraus, U.S. Geological Survey
- Keith Bouma-Gregson, U.S. Geological Survey

**Presenting author, †Early Career Award candidate*

Cyanobacterial harmful algal blooms (CHABs) have received much attention throughout the Sacramento-San Joaquin Delta (Delta) due to their negative effects on wildlife, water quality, and risks to public health. Studies of CHABs in the Delta, and elsewhere, have identified important drivers that favor CHABs, such as long water residence times, low turbulence, high nutrient availability, high light availability, and warm temperatures. The southern part of the Delta, an important region encompassing both the State and Central Valley Water Project export pumps and many local agricultural diversions, is characterized by long residence times, weak tidal mixing, and warm water temperatures. Despite conditions indicating that this region could potentially support CHABs, most CHAB-related studies have focused on the central and north Delta. In this study, we compiled CHAB-relevant data from the Department of Water Resources (DWR) North Central Region Office, DWR Operations and Maintenance, DWR Environmental Monitoring Program (EMP), and other entities active in the south Delta to investigate the effects of flow and water quality parameters on phytoplankton dynamics. Phytoplankton and cyanotoxin data are available for 2019-2023, thus this period is the focus of our analyses. Preliminary results suggest that CHABs are relatively uncommon in the south Delta river channels. Diatoms and green algae dominated during bloom events and toxigenic species made up only a small portion of the community. This finding was unexpected considering that many of the CHAB drivers we analyzed are favorable to CHABs. Further analyses will explore the drivers of phytoplankton dynamics in this region. Understanding the controls of CHABs in this region will be increasingly important as climate change and management actions continue to alter the hydrodynamics and water quality of this region.

Response of Phytoplankton to the Regional San Upgrade – Wet Years Versus Dry Years

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- Richard Dugdale, Estuary and Ocean Science Center, San Francisco State University
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- Alex Parker, California State University Maritime Academy
- Patricia Glibert, University of Maryland Center for Environmental Science

**Presenting author*

This study was aimed at understanding how the phytoplankton (leading to fish-food) in the northern San Francisco Estuary/Delta would respond to the EchoWater upgrade to the Regional San Wastewater Treatment Plant and shows the importance of monitoring different flow scenarios. The upgrade completed in April 2021 with biological nutrient removal eliminated the ammonium and reduced the total nitrogen being discharged. This presumably also resulted in less in-river nitrification (i.e. ammonium oxidation to nitrate), so reducing the nitrate levels for phytoplankton growth. We had conducted pre-upgrade down river cruises from Regional San to Carquinez Bridge in spring and fall of 2012 to 2016, measuring nutrient and chlorophyll concentrations, and primary productivity rates. These transects were repeated from 2021 to 2024 – post-upgrade. Both sets of transects were collected in wet and dry years such that dry pre and post and wet pre and post data can be compared. Preliminary analysis shows that the transects in March of dry years (2014 and 2022) showed much greater response than in wet years (2016 and 2023) as the wet conditions resulted in dilution decreasing all parameters to low values such that any upgrade response was almost negligible. The decrease in nutrients, chlorophyll and ammonium uptake post upgrade were muted in the wet transects. Secchi depths and water clarity were decreased post-upgrade in 2016 (wet year), whereas they were increased post-upgrade in 2014 (dry). Any future data synthesis or studies comparing pre- and post-upgrade or other water quality management actions should include the influence of variable flow and ensure that wet and dry years, and spring vs fall sampling should be included.

Posters

There are nine categories of poster presentations:

1. Contaminants & Water Quality (9 posters)
2. Effects of Flow (3 posters)
3. Habitat (2 posters)
4. Management & Monitoring (5 posters)
5. Methodology Assessment & Improvement (10 posters)
6. Other Fish (5 posters)
7. Phytoplankton & Zooplankton (10 posters)
8. Salmonids (3 posters)
9. Smelt (6 posters)

Contaminants & Water Quality

Highlights from the Long-term USGS San Francisco Bay Water Quality Measurement Program

- Erica Nejad*[1], U.S. Geological Survey, enejad@usgs.gov
- Heidi Bockisch[1], Tara Schraga[1], Tamara Kraus[1], Brian Bergamaschi[1], Joel Fritsch[1], Ariella Chelsky[2], David B. Senn[2]

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The USGS has collected measurements in the San Francisco Bay and Delta of the Sacramento and San Joaquin Rivers since 1969, with the goal of capturing the seasonal and spatial variability of water quality parameters, and their changes in response to hydro-climatic variability and human activities. This 55-year dataset is one of the longest continuous records in North America, complementing that of the Interagency Ecological Program, and is publicly available through our website. Present-day water quality cruises collect monthly measurements of salinity, temperature, chlorophyll-a, dissolved oxygen, suspended particulate matter, dissolved inorganic nutrients, total nutrients, and phytoplankton taxonomy from flow-through and profiling aquatic sensors, and discrete water samples. The dataset documents a remarkable range of conditions across the estuary over time. In this presentation we highlight some of the San Francisco Bay-Delta (SFBD) events and trends that were detected using this dataset, and how they have informed managers and policymakers, and shaped our understanding of this system. Some of these highlights include: dissolved oxygen data used to demonstrate the success of the Clean Water Act and profound impact wastewater treatment upgrades have on water quality in the SFBD (Cloern and Jassby, 2012), three decades of chlorophyll-a data revealing changes inside the SFBD caused by an atmospheric shift in the North Pacific Ocean, discovering a previously unrecognized mechanism of ocean-estuary connectivity (Cloern et al. 2007, Raimonet and Cloern, 2016), record high water temperatures in the SFBD illustrating how estuaries respond to global- and regional-scale weather anomalies (Cloern et al., 2017), and a comprehensive review of the nutrient dataset to provide policymakers the information needed to determine appropriate protections for the SFBD (Cloern et al., 2020).

Landscape-Scale Wildfires in Northern California Lead to Dramatic Increases in Timberland Herbicide Use

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**Presenting author*

Twelve of the top 20 largest wildfires in California history have occurred since 2018, burning more than 5.2 million acres mostly in northern California. This recent surge in catastrophic wildfires has increased forest regeneration efforts as well, and the use of herbicides to ensure seedling survival has increased at a similar scale. Data from the California Department of Pesticide Regulation shows that several herbicides are applied in commercial timberland operations and the most heavily used are glyphosate, hexazinone, imazapyr, oxyfluorfen, and triclopyr. Application of these herbicides increases substantially in the post-fire environment. For example, pesticide use after the North Complex fire, which burned significant portions of the Feather River watershed in 2020, increased more than 30-fold by 2022. An increase of similar magnitude occurred after the Carr fire, which burned more than 230,000 acres in the Sacramento River watershed in 2018. Water samples collected as far downstream as the Sacramento-San Joaquin Delta have shown increased frequency of detection and concentrations of post-fire herbicides in the years following major wildfires.

The effects of herbicides used in post-fire environments are not well understood or well regulated. Some streams located in watersheds affected by wildfire and subsequent forest-regeneration efforts are home to sensitive species, including federally listed endangered or threatened salmonids. Beginning in 2025, the USGS, in cooperation with the Central Valley Regional Water Quality Control Board and the University of California Davis, will begin a research study focused on understanding the occurrence of post-fire herbicides in mountain streams downstream from recently burned commercial timberland.

Dense and diverse: An overview of abundant USGS water quality data in the San Francisco Bay and Delta

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Long-term, reliable, and intercomparable datasets of environmental observations are valuable tools for informing management decisions and keeping the public informed about ecosystem health. Multiple stakeholders have an interest in the management of the California San Francisco Bay and Sacramento-San Joaquin Delta (Bay-Delta) to achieve objectives related to water quality, water supply, recreation, and ecosystem status. The U.S. Geological Survey (USGS) Biogeochemistry group, in cooperation with the Bureau of Reclamation, Sacramento Area Sewer District, San Francisco Estuary Institute, and others, has established a network of about 20 water quality monitoring stations throughout the Bay-Delta. These stations collect data at 15-minute intervals, providing real-time high-frequency measurements of water quality parameters, including temperature, specific conductivity, turbidity, dissolved oxygen, pH, dissolved organic matter (DOM) fluorescence, chlorophyll fluorescence, and nitrate concentrations. At each monitoring station, supplementary discrete water quality samples are collected approximately monthly and analyzed for nutrient and cyanotoxin concentrations, as well as identification and enumeration of phytoplankton. USGS data have been used to identify trends, understand environmental drivers, compute fluxes, and validate coupled hydrodynamic-biogeochemical models. USGS water quality monitoring stations have long periods of record with high temporal resolution, and we hope to increase awareness of the data and its potential uses in service of improving Bay-Delta science and management.

Long-Term Continuous Flow Monitoring in the Sacramento-San Joaquin Delta

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The U.S. Geological Survey has been collecting continuous data in the Sacramento-San Joaquin Delta (Delta) for decades. The network has expanded from several experimental stations in the 1970s and 1980s to a robust and integrated monitoring network. Today more than 40 stations are collecting a range of water-level, discharge, and water-quality data that support critical real-time water management decisions as well as in-depth analyses. Our group collaborates with stakeholders to increase the power of the data being collected across the monitoring network. The data are transformed into information in a variety of ways, including constituent mapping, salmon out-migration survival studies, interdisciplinary tidal-marsh function studies, and hydrodynamic model calibration and validation.

Long-term datasets in conjunction with modelling efforts and process-based studies provide insight into the impacts that various habitat restoration and water management actions have had on circulation and mixing in the Delta. More changes are proposed for the future that will directly impact the basic hydrodynamic processes at work in the Delta. These long-term monitoring data provide a framework for assessing the impacts of proposed actions. Moreover, as they are integrated with additional data streams, such as biological monitoring, scientists can gain insight into the impacts that physical and chemical processes have on the distribution of native and non-native species in the Delta.

Long-Term Suspended-Sediment Monitoring in the Sacramento-San Joaquin Delta and San Francisco Bay

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The U.S. Geological Survey has been collecting suspended-sediment data in the Sacramento-San Joaquin Delta (Delta) and San Francisco Bay for decades. The network has expanded from several experimental stations in the 1990s to a robust and integrated monitoring network. Today, more than 25 stations are reporting suspended-sediment data based on turbidity surrogate models. Our group collaborates with stakeholders to increase the power of the data being collected across the monitoring network. The data are transformed into information in a variety of ways, including constituent mapping, interdisciplinary tidal-marsh function studies, and model calibration and validation.

Long-term datasets in conjunction with modelling efforts and process-based studies provide insight into the impacts that various habitat restoration and water management actions have had on circulation and mixing in the Delta. More changes are proposed for the future that will directly impact the basic hydrodynamic processes at work in the Delta. These long-term monitoring data provide a framework for assessing the impacts of proposed actions. Moreover, as they are integrated with additional data streams, such as biological monitoring, scientists can gain insight into the impacts that physical and chemical processes have on the distribution of native and non-native species in the Delta.

Water We Measuring? A Dive into Suisun Marsh Water Quality

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The Department of Water Resources (DWR) conducts continuous (15-minute interval) water quality monitoring in Suisun Marsh and Grizzly Bay, critical habitats for the endangered Delta Smelt, other native fish species, migratory waterfowl along the Pacific Flyway, and various endangered plants and animals. As part of the 2020 Incidental Take Permit (ITP) for the State Water Project (SWP), enhanced monitoring in Grizzly Bay was required to "improve measurement of temperature, salinity, turbidity, and other relevant abiotic factors." This led to the addition of three new water quality stations near the existing Grizzly Bay station, originally mandated by Water Rights Decision 1641. Two of these stations were installed as temporary buoy stations to inform management decisions regarding the Suisun Marsh Salinity Control Gate (SMSCG) Action Plan and ensure sufficient spatial coverage to detect SMSCG effects. This study evaluates the effectiveness and potential redundancy of two of these newly added stations.

We assessed whether high-frequency monitoring at these stations enhances the detection of spatial variability in water quality, or alternatively, if stations are statistically indistinguishable from their nearest counterparts. Our analysis compares data from paired regional sites before, during, and after SMSCG operations to assess redundancies in station locations and identify trends in water quality from 2018 to 2024. The four monitored stations—Montezuma Slough at Hunter Cut, Montezuma Slough Mouth at Grizzly Bay, Grizzly Bay West, and Grizzly Bay East—are managed by the Continuous Environmental Monitoring Program and the Water Quality Assessment Unit.

We compared specific conductance at these paired stations, beginning each year one month prior to gate operations and ending one month after gate operations concluded using a comparison of percent difference as a function of salinity, and a linear mixed model. We found that while the absolute percent difference between the stations can be high at lower salinities, there were no statistically significant differences between stations when looking across the entire dataset.

Observed implications of anti-fouling paint on water quality data retention and reliability

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The San Francisco Bay is a complex estuarine system that has been continuously monitored for water quality and suspended sediment transport since 1989. The USGS has monitored parameters such as temperature, specific conductance, turbidity, dissolved oxygen, chlorophyll, and suspended sediment concentration throughout the bay to reach a better understanding of ecological concerns and water management. Because this is such a complex tidally influenced system that has qualities of freshwater and saltwater, managing data quality can be quite a challenge. One of the biggest challenges of measuring water quality in the bay is the extreme amount of biological fouling. This fouling can include barnacles, hydroids, isopods, bryozoans, and much more. Biological fouling can grow on water quality equipment that can severely affect the accuracy and quality of the data that the USGS collects. To combat this issue, solutions like copper tape, anti-fouling paint, copper sonde guards, and frequent field visits are used. For this poster, extreme fouling and the use of anti-fouling paint are discussed to promote a better understanding of how hydrologic technicians can help increase water quality data retention and reduce biological fouling in the field.

DeltaSMASH: Hyperspectral Remote Sensing of Harmful Algal Blooms in the San Francisco Bay and Delta

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The San Francisco Bay and Sacramento-San Joaquin Delta have experienced major phytoplankton- and cyanobacteria-driven harmful algal blooms (HABs and CHABs) in multiple areas in both the bay and the Delta. Satellite-based multi-spectral remote sensing imagery has been used to identify phytoplankton and cyanobacteria blooms based on chlorophyll levels in water bodies for well over a decade. This approach is highly useful for routine monitoring and to focus field sampling efforts. Recent deployments of hyperspectral airborne sensors provide the spectral resolution to support algorithms that differentiate algae and cyanobacteria by using the spectral properties of pigment reflectance. One such approach is the Spectral Mixture Analysis for Surveillance of Harmful Algal Blooms (SMASH) software package, which uses an end member mixture analysis model to identify fractional abundance of phytoplankton and cyanobacteria taxa in a waterbody. Initial results from the application of this software package to hyperspectral imagery acquired by the Airborne Visible/Infrared Imaging Spectrometer (AVIRIS3) in September 2023 of Little Franks Tract in the Sacramento-San Joaquin Delta, and the use of a library of cyanobacterial reflectance spectra are presented here. These results confirm the potential of hyperspectral imagery to provide additional information on HAB & CHAB community composition.

Lethal and Sublethal Effects of Fire Retardants on Salmonid Early Life Stages: Establishing Toxicity Thresholds for Aquatic Health

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Increased wildfire activity across the western United States has driven extensive use of fire retardants, which often contaminate nearby waterways through runoff and spray drift, impacting aquatic ecosystems. However, data are sparse, particularly for the effects of fire retardants on early life stages of Chinook salmon (*Oncorhynchus tshawytscha*) and Rainbow trout (*Oncorhynchus mykiss*). Chinook are particularly vulnerable during out-migration; and trout are a useful surrogate species that is available year-round for testing. Building on previous research on rainbow and brown trout, we are investigating both lethal and sublethal impacts of weathered and non-weathered formulations of the commonly used Phos-Chek retardant and a more environmentally-friendly formulation, Pyrocool, on two early life stages of both salmonids. Embryos and alevins were exposed to a range of concentrations over 96 hours simulating first-flush events following retardant applications. Preliminary data in Rainbow trout suggests that LC50s are in line with those previously published, and that older alevin may be more sensitive than those still retaining their yolk sacs. UV-weathered retardants were also included to represent realistic environmental conditions. Measured outcomes included mortality (LC50), hatching success, and morphological and behavioral changes. We hypothesize that the LC50 of Chinook salmon embryos and alevins will be similar to that observed in trout. We expect to observe reduced hatching success and altered behavior in individuals exposed to sublethal levels of fire retardants compared to control fish, with weathered formulations exhibiting greater toxicity than non-weathered counterparts due to increased potency following UV exposure. Overall, the goal of this study is to underscore the compounded risks posed by fire retardants in salmon habitats already stressed by climate change and pesticide residues. Results will provide critical thresholds for fire retardant concentrations in sensitive habitats, underscoring the need for fire management practices that minimize runoff into salmon-bearing waterways.

Effects of Flow

Comparing zooplankton density and fish catch 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. We will use zooplankton data collected from 2019-2023 NDFS studies which encapsulates high and low water years, and controlled flow. This will be compared to catch data from the Enhanced Delta Smelt Monitoring (EDSM) program taken from areas between Lisbon Weir and Rio Vista in an effort to compare food availability and fish abundance or biomass. Zooplankton data was measured as density (individuals/m3) and fish will be assessed as total number of individuals caught or as biomass. This comparison can give insight to how various flow actions can affect food levels and fish populations in the delta.

Summer Townet Survey: Trends in Fish and Zooplankton Catch during Summer-Fall Habitat Actions

- Margaret Johnson*†, California Department of Fish and Wildlife, margaret.johnson@wildlife.ca.gov
- Spencer Breining-Aday, California Department of Fish and Wildlife

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The San Francisco Estuary (SFE) is a highly dynamic environment that is subject to changes both man-made and natural. Long-term monitoring is crucial to better understand the community dynamics and recruitment of fishes that use the upper estuary as a nursery. The Summer Townet Survey is one of the longest running pelagic fish sampling surveys in the state, beginning in 1959. The survey targets juvenile fish (12-55 mm FL) in the SFE to better understand fish recruitment patterns, abundance, and distribution relative to freshwater Delta outflow. More recently, this study has helped to inform actions taken to improve habitat conditions for native fish species such as Delta Smelt during the summer and fall. Summer Townet Survey provides fish, zooplankton and environmental data for the Summer-Fall Habitat Action (SFHA) and modified operation of the Suisun Marsh Salinity Control Gates (SMSCG) which are implemented under the State Water Project's Incidental Take Permit. In this study, we investigated trends in fish and zooplankton abundance and diversity during the years in which SFHA and SMSCG were implemented, and how these relate to outflow. Clarifying these patterns will provide valuable insight to assist with future management decisions.

Fall Midwater Trawl fish and zooplankton CPUE and diversity trends in the San Francisco Estuary during Summer-Fall Habitat Actions

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The California Department of Fish and Wildlife (CDFW) has conducted long term monitoring of fish and plankton assemblages in the San Francisco Estuary (SFE) for decades. The Fall Midwater Trawl (FMWT) has sampled 100+ stations throughout the estuary September-December since 1967. The main goal of the survey is to monitor pelagic fish abundance, distribution, and recruitment patterns throughout the SFE. More recently, this study has helped to inform actions taken to improve habitat conditions for native fish species such as Delta Smelt during the summer and fall. The FMWT has conducted concurrent fish and zooplankton tows at select stations throughout the estuary since 2011. FMWT provides fish, zooplankton and environmental data for the Summer-Fall Habitat Action (SFHA) and modified operation of the Suisun Marsh Salinity Control Gates (SMSCG) which are implemented under the State Water Project's Incidental Take Permit. Long term monitoring programs like FMWT have allowed for a greater scope and comparison of food web and environmental trends in the estuary over time. This study aims to compare regional fish and zooplankton catch per unit effort (CPUE) during the years in which SFHA and SMSCG were implemented, and how these relate to outflow. Clarifying these patterns will provide valuable insight to assist with future management decisions.

Habitat

Creating and reconnecting floodplain habitat in the Yolo Bypass: an overview of DWR restoration projects

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The Yolo Bypass is critical to protecting the metropolitan and agricultural areas surrounding Sacramento, California from inundation during flood conditions. Moreover, the Yolo Bypass is the largest contiguous floodplain remaining in California's Central Valley and constitutes critical habitat for diverse taxa of fishes including Winter- and Spring-Run Chinook Salmon and Steelhead Trout. Ecosystem-wide changes in habitat quality and connectivity have reduced instream habitat conditions and eliminated corridors for migratory fishes. Furthermore, non-native species have altered trophic interactions and habitat suitability, further complicating efforts to support native fishes in the Yolo Bypass. In effort to improve habitat conditions and increase connectivity for native fishes within the floodplain, California Department of Water Resources (DWR) is implementing a suite of landscape-scale restoration projects to promote natural floodplain processes. In collaboration with federal, state, tribal, and private entities DWR has implemented a multitude of creative projects supported by holistic monitoring and adaptive management. DWR scientists have developed and implemented several long-term projects designed to monitor fish community composition, trophic interactions, and water quality. The purpose of this presentation is to highlight multiple process-based restoration projects occurring in the Yolo Bypass floodplain, including the creation of floodplain habitat to provide enhanced food availability for juvenile salmonids and improved migratory corridors between the Yolo Bypass, Sacramento River, and northern Sacramento - San Joaquin River Delta. Projects discussed will include Yolo Bypass Salmonid Habitat Restoration and Fish Passage, Wallace Weir Fish Rescue Facility, Lower Elkhorn Basin Levee Setback, Little Egbert Slough, Lookout Slough, Prospect Island, and more.

Lighting Up the Delta: Using LIDAR and Electrofishing to Assess Fish Distribution within SAV, FAV, and Emergent Marsh

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The U.S. Fish and Wildlife Service (USFWS) conducts standardized electrofishing surveys throughout the Sacramento-San Joaquin Delta (Delta) to supplement Delta Juvenile Fish Monitoring Program (DJFMP) beach seine data, providing a more robust sampling of nearshore fishes. This method allows crews to sample areas that are incompatible with beach seining, particularly heavily vegetated habitats. Non-native submerged aquatic vegetation (SAV) and floating aquatic vegetation (FAV) have become more abundant in the Delta over the last two decades, leading to lower dissolved oxygen, turbidity decline, and higher water temperatures, impacting fish assemblages. Due to the rise in non-native aquatic vegetation, the California Department of Fish and Wildlife (CDFW) has funded and maintained datasets of airborne hyperspectral imagery since 2004 to map submerged and floating vegetation. Our goal is to examine the relationship between SAV, FAV, emergent marsh habitats, and fish diversity throughout the Delta for 2021 and 2022. By combining pre-existing DJFMP electrofishing data and CDFW vegetation data, we performed a multivariable analysis evaluating the impacts of different aquatic vegetation types and environmental factors on fish diversity. Increased knowledge of these relationships can help agencies make informed decisions on management of SAV and FAV throughout the Delta.

Management & Monitoring

An Overview of BayInsight, an Integrated Science & Monitoring Program to Guide Management for the San Francisco Estuary

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**Presenting authors*

The San Francisco Estuary is a dynamic system with multiple programs studying, monitoring, and striving to understand the complexities of this large system, but there are limited opportunities for coordination and integration across these programs. BayInsights is a project supported by the EPA at the San Francisco Estuary Institute (SFEI) which endeavors to work with other programs and agencies around the San Francisco Bay to maximize sampling and monitoring efforts. The project aims to build collaboration among monitoring entities to integrate and optimize monitoring efforts, fill high-priority data gaps, and help inform management decisions or characterize ecosystem responses to specific management actions. By leveraging sampling and data across agencies, the BayInsights project is an opportunity to learn more from the data collected providing insights into nutrient trends and water quality. We will introduce the BayInsights program, outline the goals of the program, and share preliminary data from our early analyses.

A Comparison of Fixed vs. Random Sampling Designs for the Fall Midwater Trawl

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- Aroon Melwani, Applied Marine Sciences, Inc.

**Presenting author*

The California Fish and Wildlife's Fall Midwater Trawl spans several decades and has provided valuable information about pelagic fish population responses to environmental and anthropogenic changes. To facilitate future monitoring design improvements, a two-year special study was conducted in the fall of 2021 and 2022 to address inherent bias or uncertainty due to sampling of geographically fixed sites. Our objectives were to address two key questions: 1) what differences exist in catches between fixed site designs and stratified-random site designs?; and 2) what bias may have been introduced in understanding fish community composition, size distributions of species, and indices of relative abundance, based on catches from fixed sites only? To answer these two questions, we compared monthly samples from fixed and random sites to examine fish community composition, species diversity, regional abundance estimates with confidence intervals, and size distributions of species of concern to understand the effects of survey design on these metrics. Preliminary results suggest that fish catch and community composition was not significantly different between fixed and random stations, however variation among stations was high. This would direct attention to another focus of the survey redesign team, spatial balance inconsistencies among regions in the San Francisco Bay Delta.

Advancing Scientific Understanding and Management of the Delta Through a Food Web Perspective

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**Presenting author*

The Delta is a complex ecosystem characterized by multiple food webs dynamics. The ability to predict the impact of habitat restoration, fishery management actions, changes in environmental drivers on ecological carrying capacity and productivity, as well as the bioaccumulation of contaminants on species and the ecosystem, requires an understanding of food web processes. The Delta Independent Science Board, which is legislatively mandated to provide scientific oversight of adaptive management, has finished conducting a review of the current and emerging science related to food webs, with emphasis on upper trophic food webs. This poster will provide an overview of findings and recommendations from the review. The goal of the review is to provide relevant information to help organizations, including State and federal agencies, assess how to better incorporate and advance food web knowledge in managing the Delta's ecosystems and to identify what tools are available or should be developed. This review is based on an analysis of published literature, public comments, community engagement through a series of conference calls, and a focused two-day workshop. A key finding is that an improved mechanistic understanding of food webs is essential to predict the impacts of biophysical drivers and management actions on individual fish species and ecosystem-level processes. Collaboration among agencies, academia, Indigenous Tribes, and the public, along with adaptive management, will be needed to make implementation of the recommendations efficient and effective. The benefits will be improved capacity to forecast effects on fish and other aquatic organisms due to management actions and their interactions with an ever-changing climate and ecosystem.

The History of the Salvage Database

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The Central Valley Project's (CVP) Tracy Fish Collection Facility (TFCF; starting in 1957) and the California's State Water Project (SWP) Skinner Delta Fish Protective Facility (SDFPF; starting in 1968) are fish protective facilities, which reduce fish losses associated with water exports. Fish (>20mm) are directed away from and removed from exported water (Byron, CA), and released back to the Sacramento-San Joaquin Delta, a process called salvage. The California Department of Water Resources and the United States Bureau of Reclamation are required to provide salvage information for stake holders such as the Smelt Monitoring Team and the Salmon Monitoring Team for near real time management of listed species according to their respective Biological Opinions.

The salvage database is one of the oldest databases in the state dating back to 1957 when the TFCF became operational. Initially data was stored in datasheets and in Excel files but quickly outgrew these programs. The Access salvage database became operational in 1998 and has data from 1993 to current. It currently contains more than 25 million records and is updated on a daily basis to meet real-time management needs of State and Federal Agencies. It includes the count, length and expansion metrics for calculating salvage and loss. For Salmonids, the salvage database contains tag and genetic identifications as well as associated run assignments. This poster will list data, reports, and timelines of creation in the database:

- Database structure and size
- The salvage interactive web page and FTP site for daily postings of data
- Salmon and steelhead reports for stakeholders
- Smelt reports for stakeholders
- DNA race data for salmon
- CWT tag race data for salmon
- Server location of database

A Standardized Sample Frame for Evaluating Fish Species Abundance and Distribution in the San Francisco Estuary

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**Presenting author*

In 2021, the California Department of Fish and Wildlife (CDFW), U.S. Bureau of Reclamation, Department of Water Resources, U.S. Fish and Wildlife Service (USFWS), National Marine Fisheries Service, and State Water Resources Control Board began a detailed technical evaluation of five long-term monitoring surveys of pelagic fishes in the San Francisco Estuary (Estuary) conducted by CDFW. The surveys reviewed were the Smelt Larval Survey, 20-mm Survey, Summer Townet Survey, and Fall Midwater Trawl. A Steering Committee was formed to provide high-level guidance on survey redesign considerations provided by a technical “Design Team” comprised of agency representatives with support by Aroon Melwani (Applied Marine Sciences, Inc) and Michael Tillotson (ICF International). The Design Team is evaluating opportunities to improve the design of existing monitoring surveys in the Estuary by exploring a standardized sample frame with various scales of volume (regions, strata, and subregions), to consistently evaluate spatial monitoring effort across surveys. Effort has included adapting and expanding upon spatial scales used by the USFWS Enhanced Delta Smelt Monitoring Study. A standardized set of CDFW spatial areas for evaluating fish species abundance and distribution has been developed throughout the Estuary. The San Francisco Bay Study (Bay Study) was recently incorporated to expand upon evaluations of spatial balance in CDFW monitoring designs to 1) assess littoral habitat relative to deeper habitat, 2) improve abundance estimates, and 3) improve spatial balance among studies. This poster will provide an update on methods and status of the CDFW sample frame refinement with inclusion of the Bay Study.

Methodology Assessment & Improvement

Comparing methods to upsample unevenly-spaced time series to capture fine-scale ecological trends

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Biomonitoring programs often target taxa that differ in generation times. However, sampling frequencies that may be adequate for longer-lived organisms may be too coarse to detect fine-scale dynamics in fast-fluctuating taxa. Different statistical techniques are available to interpolate abundances between sampling periods, and thus ‘upsample’ coarse biomonitoring data to facilitate comparison between populations. However, limited research has examined the precision and ability of these techniques to capture populations’ peaks and troughs. Here, we sought to assess the efficacy of two interpolation methods (LOESS smoothing and cubic splines) on data from the monthly IEP Zooplankton Monitoring Program. Using data spanning 1972-2021 from sampling station NZ064 in the Delta, we upsampled biomonitoring data collected at monthly time-steps into a consistent daily frequency. We focused on the abundance of *Bosmina spp.*, a cladoceran common throughout the San Francisco Bay Estuary. While both methods produced daily time series, LOESS generally had higher mean square error (MSE 1.93) than cubic splines (MSE 0.884), indicating that LOESS predictions generally diverged more from observed data relative to cubic splines. In addition, tests evaluating distributions of predicted vs. observed data revealed that some facets of these divergences may not necessarily be captured by MSE alone, and thus may be worth exploring in detail. We also explored how recent advances in complex network structures (e.g., Recurrent Neural Networks) can improve efforts by integrating environmental covariates and multiple streams of data (e.g., across nearby stations), effectively transferring statistical power from data-rich to data-poor moments and places. We show that advances in time-series methods can enable a wide range of ecological applications that require evenly-spaced, high-frequency data. However, these exercises should be carefully validated via specific tests designed to challenge whether upsampled data aligns with expected ecological dynamics.

Implementing and Optimizing Machine Learning Models to Automate a Video Review Workflow

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Automating video review processes offers several key benefits, including significant cost and time savings, as well as reduced bias and human error. However, implementing an automated computer vision pipeline requires extensive research, iterative testing, and investment in both hardware and software. FishViz, developed by Cramer Fish Science, is a computer vision project designed to automate the analysis of video data collected by the Sampling Platform. The Sampling Platform highlights how integrating rapidly advancing technologies into its scientific approach ensures innovation, accuracy, and integrity in its Bay-Delta assessments. This poster outlines the development of FishViz through three key phases:

1) Problem Identification, Research and Planning—The first step involves identifying the largest challenges of the system, including environmental factors, species-specific behaviors, and the variability of the data. Extensive research is conducted to understand these factors and select appropriate open-source object detection models. Establishing clear goals, formulating targets, and defining a timeline are critical to planning the project.

2) Model Training and Iterative Testing—Once a training dataset is built, multiple models are trained on the data. The models are then tested on videos not seen during training to identify areas of underperformance. The iterative process involves retraining and refining the models to improve accuracy and precision, until a goal is met. This can often include revisiting the research step.

3) Production, Upgrades and Optimization—As the quality of input data directly affects the model's performance, we upgraded hardware to ensure higher image quality, which in turn enhances the algorithms' effectiveness. These improvements are an ongoing process as the field of computer vision rapidly evolves. FishViz stays on the cutting edge of both hardware and software development, as it's continuously improved to deliver accurate, scalable, and robust results.

Comparison of Fish Species Catch between Beach Seine and Boat Electrofishing Methods of Near Shore Sites

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The Lodi Fish and Wildlife Office (Lodi FWO) performs fisheries monitoring sampling of the Sacramento-San Joaquin River Delta (Delta) using a standardized beach seine method to determine juvenile fish species abundance in the Delta. In recent years, boat electrofishing has been added to Lodi FWO sampling methods to supplement the data collected by beach seines and gain a better understanding of all life stages of species assemblages within the Delta, particularly in areas where beach seining is difficult. We used catch data that overlapped spatially and temporally (samples from the two surveys are within 500 m and within the same sampling week) to compare fish assemblages from 2018–2023 and identify potential limitations in each sampling method. Accordingly, we analyze differences in catches between the two methods by year, season, habitat characteristics, and environmental conditions to explain differences in catch rates between the two sampling methods. This poster represents the first step in an efficiency study that will be conducted by the Lodi FWO between beach seine and boat electrofishing sampling methods.

Old Clips, New Tricks: Dry Fin-Clip Preservation for High-Throughput Genetic Processing

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Due to the steep declines of spring-run Chinook Salmon (*Oncorhynchus tshawytscha*) populations in the Sacramento River Basin, the Spring Run Juvenile Production Estimate (SR-JPE) program was developed to monitor the annual number of outmigrating spring-run Chinook juveniles. To achieve accurate counts, the Genetic Monitoring (GeM) Lab at the California Department of Water Resources utilizes genotyping workflows (GT-seq and CRISPR-based SHERLOCK) to distinguish spring-run from the other Central Valley Chinook Salmon runs (fall, late fall, and winter). Based on the need for rapid and precise identification of the roughly 2,000+ samples collected each year for the SR-JPE, optimizing the sample collection and processing workflows for field and lab crews is critical. The current method for tissue collection includes the direct insertion of fin clips into tubes containing a custom rapid DNA extraction buffer (2% Proteinase K, 98% Low TE). While this collection method was relatively successful for the 2024 JPE, effective preservation of the DNA relies on maintaining the temperature of the buffer pre- and post-collection at 4°C and -20°C, respectively. This introduces the potential for complications during transport and storage of the sample tubes and tissues before they are returned to the lab. For this project, we aim to explore an alternative method of fin clip preservation where a sample is placed onto Whatman paper and allowed to dry inside a collection tube (rather than in coin envelopes, which are typically used to hold dry fin clip specimens). This dry preservation technique reduces processing time by facilitating the direct addition of DNA extraction buffer in the lab and streamlines field collections by eliminating the need for buffer temperature control.

Evaluating Image-Based Deep Learning Methods for Zooplankton Sample Processing

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Zooplankton are a crucial part of food web dynamics that support Bay-Delta fish, including threatened or endangered species. Zooplankton monitoring collections are carried out by five CDFW surveys using three different gear types for IEP, in which 1,500 total samples are collected annually. Processing these samples is time-consuming and requires expertise. This project evaluates the use of image-based classification (“Deep Learning”) modeling to identify and count the zooplankton species in IEP survey samples. These auto-detection methods have the potential to reduce processing and reporting time, and to improve data quality.

The application of image-based deep learning is optimized with large reference image libraries (a high number of images per class). We used culturing methods to propagate zooplankton species that were collected with pump sampling (micro-zooplankton) by the Environmental Monitoring Program survey (Department of Water Resources). We imaged the zooplankton cultures using a FlowCam 8001 (Yokogawa Inc).

We used the web-based deep learning model, Ecotaxa, to test the strength of our reference library. We pre-processed images using the Zooprocess software package to segment objects from raw FlowCam images, standardize backgrounds, and generate image filter data. We uploaded images and associated data to Ecotaxa and validated species identification to establish a primary “project” (a collection of images that have been sorted against validated images by the deep learning tool) having three taxa classifications.

For testing, we exported the primary project library and set a randomized subsample to the ‘unknown’ status. These, together with the remainder as the test library, were uploaded to a test project in Ecotaxa. The resulting Ecotaxa class predictions for the unknowns were 99.3% accurate.

With this early deep-learning classification success, image library development and testing efforts will be continued in order to support accurate identification of all 23 micro-zooplankton classes documented in IEP surveys.

Utilizing ArcGIS Field Maps Mobile Phone Apps for Field Operations

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Presenting author

Released by Esri in 2020, the United States Geological Survey (USGS) California Water Science Center Estuarine Hydrodynamics and Sediment Transport Group (EHST) has been utilizing the ArcGIS Field Map (AGFM) mobile app since 2022. AGFM allows field staff to access important geographic data sources from a mobile phone. Staff using AGFM can: find a station in relation to their current location; measure distances; locate established site information such as standard cross sections; access GIS layers within the app for additional information about a station; locate marinas and boat launches; identify river names and much more. The mobile phone app can be easily used by anyone who has no background in GIS and the EHST uses AGFM as a learning tool for new staff. In addition, the robust offline capabilities of AGFM ensure continued functionality in the field even where Wi-Fi-internet coverage may be scarce. By incorporating ArcGIS Field Map into standard field workflows, Estuarine Hydrodynamics and Sediment Transport Group staff have increased efficiency in field operations through quick access to critical station and safety information.

Integration of Machine Learning in a Passive Video System

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The Aquatic Species and Habitat Sampling Platform (Sampling Platform) is a novel sampling system that assesses fish communities across various habitat types using low impact sampling. We have successfully deployed the Sampling Platform in the Bay-Delta, where the presence of sensitive or protected species requires a less invasive sampling approach. The Sampling Platform passively samples fish using a pass-through video camera system to elucidate habitat associations while minimizing stress and mortality compared to traditional sampling methods. The videos captured by the Sampling platform have primarily been reviewed by humans, which can be time consuming and costly. Machine learning and computer vision offer an opportunity to reduce processing time and expenses. We aim to optimize the video review process by integrating a machine learning model known as FishViz, which can automatically detect and enumerate fish. We identified videos containing few fish as an early point of integration, as this would reduce time spent manually reviewing footage of an empty live box, while minimizing the risk of greatly undercounting fish. We performed analyses comparing FishViz to human reviewers, focusing on the frequency and magnitude of over and undercounting fish. These analyses showed that the current FishViz model could be reliably integrated into the review process for videos in which it detected 10 fish or fewer. For such videos, human reviewers can verify observations produced by FishViz, thus eliminating the need to watch the entire video. This combination of manual and automated review has improved the overall video review process. It can be further improved and expanded as better FishViz models are developed, and more sophisticated recording equipment is employed on the Sampling Platform. Such advances will allow for increased volume and reduced processing time for high-quality fish community data in the Bay-Delta.

Expecting the Unexpected: Expanding SHERLOCK Genotyping Analysis to a qPCR Platform

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There are four seasonal runs of Chinook Salmon that migrate through the Delta and Central Valley. Over the years, there has been a trend of declining populations of winter and spring-run salmon, which has led to their respective listings as endangered and threatened, while fall and late fall-runs remain unlisted. Accurate Chinook Salmon run identification is critical to inform water management decisions but is challenging due to temporal and spatial overlap of runs and an inability to distinguish them visually. In the Genetic Monitoring (GeM) lab at the Department of Water Resources, we utilize cutting-edge genetic monitoring methods like the CRISPR-Cas13a SHERLOCK (Specific High Sensitivity Enzymatic Reporter UnLOCKing) assay, to obtain accurate run assignments for individual Chinook Salmon. Rapid and accurate genetic run identification is essential for mandated work such as Spring-run JPE (Juvenile Production Estimate) and Salvage operations. Our laboratory currently uses an Agilent Biotek Synergy H1 fluorescence reader for all SHERLOCK reactions. However, to build capacity and redundancy, we have optimized a protocol to use another machine (QuantStudio qPCR system) to support SHERLOCK-based assays. Adding redundancy in our laboratory gives us the ability to continue processing samples while either machine is down for maintenance (or use on other projects, etc.) Here, we will present the steps we took to ensure that this sensitive procedure can be performed using multiple platforms.

Velocity and Bubble-Field Mapping Around the Georgiana Slough Salmonid Migratory Barrier with ADCP and sUAS-Based Image-Velocimetry, 2023–2025

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The Georgiana Slough Salmonid Migratory Barrier (GSSMB) is designed to be a "non-physical" barrier to reduce the entrainment rate of out-migrating juvenile salmonids into Georgiana Slough where their survival rate is much lower. The barrier consists of subsurface frames with sound projectors, flashing lights, and orifice lines that create a bubble curtain. This combination of deterrents is intended to discourage salmonids from traveling into Georgiana Slough.

Traditional boat-mounted Acoustic Doppler Current Profiler (ADCP) mapping was performed across a range of flow conditions, but spatial resolution is limited to single transect locations. In addition, air (produced by the GSSMB) severely hinders the efficacy of acoustic-based equipment to measure velocity. To better understand velocity patterns and the influence of the bubble curtain on the flow field, we employed a small Uncrewed Aircraft System (sUAS) outfitted with the River Observing System (RiOS) payload developed in collaboration with the National Aeronautics and Space Administration (NASA).

The combination of boat-based and aerial mapping provides distinct, yet complementary measurements of velocity and bubble fields near the GSSMB. Observations were made over a range of varying flow conditions and GSSMB configurations (bubbles on and off) and these data will yield novel insight into both the near-barrier and reach-scale velocity fields.

(Results will be provided by way of maps and figures of the region).

How We Learned to Stop Worrying and Develop an Interactive Fish ID Training

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In October 2024, the California Department of Fish and Wildlife's Office of Training and Development published a new interactive training program, "Identification of Common and Protected Fish Species at the Skinner Delta Fish Protective Facility," that generated immediate interest from other fish identification trainers. Interactive presentations are an attractive alternative to in-person training because they are repeatable as needed, easy to schedule around other duties, and allow for interactive features that can deepen learning, but the perception that they can be time consuming and complex to develop may put off trainers contemplating one. The CDFW Fish Facilities and Larval Entrainment Unit delivers fish identification training to staff at the Skinner Delta Fish Protective Facility, covering dozens of species from diverse fish families, including protected species. To realize the benefits of interactive trainings described above, staff from the Fish Facilities and Larval Entrainment Unit collaborated with staff from the Office of Training and Development to create an interactive fish identification training. Using the existing fish identification presentation as a template, we generated a script for a training development software. Further, our efforts led to organized visits, in coordination with staff from CDFW's Office of Communications, Education and Outreach and the Federal Bureau of Reclamation, to obtain high quality images of fish specimens. The final product provides voice overs to the slides and interactive quizzes to verify learning. An open flow of communication and regular meetings allowed the subject matter experts to fine-tune biological details and test the pacing of the material, while the training and development specialist contributed options for attractive formatting and effective message delivery. This collaborative format allowed each of the participants to contribute their strongest skills to the polished final project. Interested trainers can use this poster as guide to "stop worrying" and develop their own projects.

Other Fish

Impacts of the 2022 Harmful Algal Bloom on Green and White Sturgeon in the San Francisco Estuary

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Green and White Sturgeon are two closely related anadromous fish species that migrate throughout the San Francisco Estuary (SFE), including the Delta, and surrounding Napa, Sacramento and San Joaquin River watersheds. Sturgeon are a long-lived, late-spawning species with highly variable life histories across individuals, adapted to the variable environmental conditions in California's Central Valley and the Pacific Ocean. Both species are impacted by water diversions, habitat modifications, over-fishing, and water contaminants from agricultural, mining and industrial activities. During the summer of 2022, an unprecedented harmful algal bloom (HAB) caused widespread toxins in the SFE, leading to extensive fish mortality, including sturgeon.

This study utilizes geochemical analysis of pectoral fin rays to reconstruct the age and migratory histories of sturgeon collected during and outside of the HAB event. By comparing age structures and migratory patterns, we aim to identify specific migratory phenotypes which may have been disproportionately affected by the HAB. Preliminary findings suggest a potential for habitat-specific vulnerabilities tied to migratory behavior. This research provides critical insights into how environmental stressors impact sturgeon populations, informing adaptive management strategies for these threatened and economically significant species.

Variation in Seasonal Biomass in the Sacramento-San Joaquin Delta

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The monitoring network in the San Francisco Bay-Delta consists of a variety of sampling methods. As a result, it can be challenging to compare fish community results across sampling gears and study designs. The U.S. Fish and Wildlife Service's (USFWS) Lodi office, conducts electrofishing as part of the Delta Juvenile Monitoring Program (DJFMP) to measure the biodiversity of nearshore habitat for fishes of the Sacramento – San Joaquin Delta. In response to managers' requests to better understand fish assemblage trends in the San Francisco Bay-Delta, we will summarize fish count and biomass data across Delta regions and seasons. Our goal is to present preliminary community visualization tools and metrics that can also be used to explain trends using data from other gears like beach seines and trawls.

We will use DJFMP electrofishing data collected from 2021-2023 which encompasses six major regions that span latitudinally from the Sacramento River's connection with Steamboat Slough down to Mossdale Crossing Regional Park on the San Joaquin River and longitudinally from the Mokelumne River across to the confluence near Sherman Island. Fish catch will be assessed as biomass per second shocked compared to individuals caught per second shocked. Biomass was calculated based on length weight relationships using average condition factors. We used biomass as an estimate to assess community makeup to account for different body shapes and growth rates. Using this data we hope to address, seasonal migration of fishes and assess regional productivity through these six major regions across flood and drought years.

Sacramento Pikeminnow Catch Numbers and Seasonal Water Temperature within 1976-2023

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**Presenting authors*

Sacramento pikeminnow (*Ptychocheilus grandis/SAPM*) are a temperature resilient native fish that reside in the Sacramento-San Joaquin River Delta (Delta). The Delta experiences large variability in its water temperature. Within 100 years, it is predicted that the Delta will have an overall increase in water temperature. SAPM migrate up North of the Delta in order to reach spawning grounds. This movement up North can be triggered earlier by warmer water temperatures, possibly creating a shift in seasonal numbers. As climate change predictions show an increase in water temperature, we could see a shift in SAPM catch numbers throughout different regions of the Delta. Currently, there is no recent analysis on the effects of water temperature on the population density of SAPM. This study aims to determine if there is a correlation between water temperature and catch number of SAPM within the Delta. Lodi Fish and Wildlife's Delta Juvenile Monitoring Program's Seine data gathered from 1976-2023 contains water temperature and SAPM catch numbers. The data will be analyzed through R and fit to a linear regression model depicting the number of catches of SAPM versus seasonal water temperature throughout the years. A map of the Delta will also be created to display the water temperature and catch number of SAPM in different regions for 1976 vs 2023. Based on the results of this model we can predict if there will be a change in SAPM catch numbers with increasing temperatures. This will provide needed information that may have an impact on their future conservation.

Long-term Patterns in Splittail Abundance: Is a Trend Hidden in Their Inherent Recruitment Variability?

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Splittail (*Pogonichthys macrolepidotus*) are endemic cyprinids of the San Francisco Estuary that depend on flooded seasonal wetlands for successful spawning. Splittail populations are equipped to survive drought years because individuals are long-lived with high fecundity that allow populations to rebound. However, habitat loss, contaminants, and extended drought periods still threaten Splittail survival. Splittail were listed as a threatened species by the United States Fish and Wildlife Service (USFWS) between 1999-2003 and remain a Species of Special Concern in California. Understanding the long-term abundance and recruitment of these native fish is challenging because of their inherent recruitment variability tied to the increasingly variable Mediterranean climate and floodplain inundation in California's Central Valley. We analyzed 25 years (1999-2023) of beach seine data collected by the USFWS Delta Juvenile Fish Monitoring Program to examine trends in age-0 Splittail catch. We hypothesized that catch per unit effort (CPUE) of age-0 Splittail would be significantly higher in wet years than dry years, but that overall CPUE has declined since 1999. After comparing a set of candidate models and accounting for variability in annual Delta discharge, Splittail abundance appeared to have increased. Our results also supported previous work demonstrating that Splittail abundance and recruitment was higher in wet years than dry years. Next, we analyzed Splittail catch, over the same time period, from the Yolo Bypass Fish Monitoring Program and salvage data from the Tracy Fish Collection Facility and the Skinner Delta Fish Protective Facility. The pattern of higher age-0 abundance in wet years was seen across all datasets, but patterns after correcting for Delta discharge were variable. Our results convey a variable Splittail population over 25 years, but also possibly increasing Splittail spawning or recruitment success in wet years, suggesting that current conservation and restoration efforts may have a positive effect on this species.

Loach and Key: Unlocking Population Structure and Diversity with Genetics

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In a rapidly changing environment, innovative tools like population genomics can provide valuable knowledge for more informed decision making in invasive species management. Three species of true loaches (Cobitidae) have been identified in California's Central Valley; Large-Scale Loach *Paramisgurnus dabryanus*, Fine-Scale Loach *Misgurnus mizolepis* and Pond Loach *Misgurnus anguillicaudatus*. Our study consisted of three phases. In phase one, we developed a qPCR assay to detect the eDNA from loaches then deployed a paired sampling design to compare detections of eDNA and minnow traps in canals and ponds at the San Luis National Wildlife Refuge (SLNWR). In spring 2023, we conducted phase two where we trapped and removed hundreds of invasive Cobitids from the SLNWR guided by eDNA detections. The main goal of phase three was to utilize genomic population analyses to provide regional Aquatic Invasive Species (AIS) managers knowledge of the loach population size and genetic resiliency. Tissue samples (fin clips) from 656 loaches captured in phase two were genotyped using the microsatellite loci to create multi-locus genotypes for each tissue analyzed. Various scenarios were possible: (1) Low diversity- if the population was started by a few individuals, the population may have decreased environmental and reproductive fitness. This scenario would lead to a bottleneck for the population which could be strengthened through continued removal efforts. (2) Intermediate diversity- the effective population size could be determined as well as the impact of the removal effort on the population size. This could inform future management decisions and allocation of resources. (3) High diversity- the source of invasion could be identified, informing prevention efforts to lower risks of any further introduction or additions to the population. Together, the three phased study aims to create a new framework for developing actionable information about newly discovered invasive species.

Phytoplankton and Zooplankton

Finding the Light: Using Light Attenuation Data to Calculate the Depth of the Photic Zone in the Yolo Bypass and Sacramento River

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The Yolo Bypass is the largest floodplain in the Sacramento River- San Joaquin Delta and provides critical habitat for native fishes. As a component of the Yolo Bypass Fish Monitoring Program (YBFMP), secchi depth measurements (m) , turbidity (FNU), chlorophyll (ug/L), and light attenuation (μmol s– 1m– 2) data are collected from one station in the Yolo Bypass (Screw Trap at Toe Drain, STTD) and one station in the Sacramento River (Sherwood Harbor, SHR) every two weeks throughout the year. As a part of a scientific review conducted by YBFMP, we explored the methods, use and efficacy of the light attenuation data. Using this data, we calculated KdPAR which is the diffuse attenuation coefficient of photosynthetically active radiation and is commonly used to predict light attenuation in aquatic productivity models. We expect to find higher kdPAR values in the Sacramento River when compared to the Yolo Bypass which will result in a larger photic zone and higher primary productivity. To evaluate the data collected by YBFMP and test our hypothesis, we used kdPAR to predict the depth of the photic zone used chlorophyll as a proxy for phytoplankton abundance. Analyzing multiple years allowed us to compare seasonal change and differences in the depth of photic zone between water year types. Predicting the depth of the photic zone can be great representation of the productivity of the Yolo Bypass and Sacramento River and provide important insight into the ecological health of these systems.

Temporal patterns of the harmful algal bloom toxins microcystin and domoic acid in the San Francisco Estuary mesohaline

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As part of a multi-investigator study of harmful algal blooms (HABs) along the San Francisco Estuary salinity gradient, we conducted sampling at four shore stations in Suisun Bay and Carquinez Strait for microcystin and domoic acid (DA) algal toxins. Several approaches were employed including discrete water sampling, Solid Phase Adsorption Toxin Tracking (SPATT) passive samplers, and analysis of invertebrate tissues. Stations were sampled every two weeks from April to September and approximately monthly for the rest of the year. Here we report results from one station located in the estuary mesohaline region at the western end of the Carquinez Strait. Water samples were collected using a Van Dorn bottle and filtered for analysis. SPATT samplers were deployed during each sampling event for 48h and approximately one month. Baited minnow traps were deployed onto the sediment surface for 48 h and all invertebrates were identified, measured and frozen for analysis. Toxin analysis was performed by liquid chromatography - mass spectrometry. DA, associated with the marine diatom-HAB *Pseudo-nitzschia* was regularly observed in both SPATT and tissue samples, but rarely seen in grab samples. Microcystin congeners, indicative of freshwater cyanoHABs such as *Microcystis*, were less frequently observed in SPATT compared to DA, and were recorded seasonally, being present in summer and autumn but absent in winter and spring samples. Microcystin was detected in the majority of tissue samples. These results confirm that algal toxins, representative of marine and freshwater HABs, are regularly present in the mesohaline portion of the San Francisco Estuary and suggests that transport of toxins from both upstream and seaward habitats may be important in explaining their presence there. Additionally, sampling for HAB toxins only by analyzing discrete water samples may underestimate toxin presence and provide an incomplete picture of the role of HABs across the estuary.

Abundances of Macrozooplankton and Mesozooplankton in Estuarine Turbidity Maximums in Suisun Bay and the Lower Sacramento River

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**Presenting author*

Estuarine turbidity maxima (ETMs) are localized areas in estuaries that concentrate zooplankton, phytoplankton, detritus, and suspended sediment which can provide crucial habitat for native fishes such as delta smelt in the low salinity zone of the San Francisco Bay Estuary. ETMs are characterized by high suspended sediment concentrations and turbidity due to the interactions between denser, high salinity oceanic water and low salinity river flow. In the San Francisco Bay Estuary, ETMs are hypothesized to form when the 2 ppt isohaline (X2) is positioned in deep channels during periods of tidal asymmetry. In other estuaries, ETMs are some of the most productive regions due to the high concentration of lower trophic food web resources.

The Directed Outflow Project ETM Study was developed to see if food resources for planktivorous pelagic fish were concentrated in ETMs. We hypothesize that the presence of ETMs will predict higher abundances of zooplankton. Macrozooplankton and mesozooplankton tows were conducted at the surface and bottom of the water column from Suisun Bay up to the lower Sacramento River from June through November. Sites were categorized as inside the ETM or outside of the ETM based on stratification of salinity and turbidity at each site in when tidal parameters predicted development of an ETM. We plan on running generalized linear models to examine the influence of multiple variables including predicted presence of an ETM, turbidity, and salinity on zooplankton abundance.

The Role of Vertical Migration in Zooplankton Transport in the Cache Slough Complex

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This project is part of an ongoing effort to assess the transport of the copepod *Pseudodiaptomus forbesi* between the Cache Slough Complex (CSC) and surrounding habitats in the northern Delta. *Pseudodiaptomus forbesi* is an abundant introduced copepod that is an important food source for small fish. While net fluxes of zooplankton such as *P. forbesi* out of wetlands have been suggested as justification for restoration, there is little evidence that such fluxes occur. The day/night vertical migration behavior of *P. forbesi* may play a role in the net transport of this species: adult copepods are abundant in shallow water only at night and remain on the bottom during daylight. A 2018 field study in Wildlands marsh in the northern CSC found that this pattern of vertical migration interacted with a summertime asymmetry in tidal currents (stronger daytime ebbs and stronger nighttime floods) to produce a long-term net flux into the wetland. This project is an effort to determine if this pattern is consistent across the CSC. To do so, we utilized data on *P. forbesi* abundance from multiple field studies to develop an algorithm that predicts proportions of copepods in the water column based on turbidity and water depth. This algorithm will then be applied to long-term flow and turbidity data from six sites in the CSC to calculate net copepod fluxes over similar time periods to the 2018 study. These calculated fluxes will quantify the interaction between the vertical distribution of *P. forbesi* (modulated by turbidity and water depth) and tidal currents to determine if the long-term horizontal movement patterns of this copepod at locations across the CSC are consistent with the 2018 study's findings. The results of this project will provide a basis for subsequent hydrodynamic modeling to characterize these movement patterns in greater resolution throughout the CSC.

Phytoplankton Density and Dynamics Within Targeted Estimated Turbidity Maxima of the San Francisco Bay-Delta, California

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Estuarine turbidity maxima (ETM) may play a crucial role in primary and secondary productivity in the San Francisco Bay and Delta by concentrating suspended sediment, detrital matter, and organisms in brackish areas. The hydrodynamics of these zones are complex due to the horizontal salinity gradient, which creates a two-layer flow exchange (gravitational circulation) near the 2-PSU isohaline and are predicted in-part by tidal cycles. The gravitational circulation causes increased turbidity, detritus, and vertical mixing of phytoplankton taxa. Understanding the effects of this physio-chemical process on primary productivity is crucial to predicting where food resources may be accumulating.

The U.S. Bureau of Reclamation's Directed Outflow Project was established in part to identify the drivers of primary and secondary production to benefit Delta smelt. In the late spring to fall of 2024, ICF surveyed predicted ETMs and collected data on water quality parameters, zooplankton, and phytoplankton. As part of this study, we seek to clarify (1) how chlorophyll varies within the water column (i.e., comparison between surface and bottom samples) of predicted ETMs spatiotemporally and (2) how chlorophyll degradation (i.e., comparisons between chlorophyll-a to phaeophytin ratios) compares within and outside a predicted ETM. Chlorophyll-a can be used as a proxy for biomass, while phaeophytin can be used as proxy for algal health. Lower concentrations of chlorophyll-a to phaeophytin may indicate high algal stress/turnover. We anticipate higher concentrations of chlorophyll-a near the surface due to light penetration and algal photosynthetic needs. As turbidity, nutrients, and organisms are attenuated and shuffled in ETMs, we anticipate higher concentrations of chlorophyll-a and chlorophyll-a to phaeophytin ratios in ETMs compared to non-ETMs, indicating the presence of high productivity within these zones.

Did the POD start during a period of low primary productivity?

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**Presenting author*

There is no time-series of measured phytoplankton primary productivity in the San Francisco Estuary Delta (SFED) to evaluate levels during the start of the Pelagic Organism Decline (POD). Here, using statistically described relationships between nutrients and primary productivity, the EMP 43-year historical time-series of nutrients is interrogated and used to estimate primary production from 1979 to 2022.

Do the hydrodynamics of a dead-end channel give “rise” to phytoplankton blooms?

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Dead-end channels in the Sacramento-San Joaquin Delta are known to frequently support cyanobacteria harmful algal blooms (cyanoHABs), which can exceed water quality standards. Cyanobacteria possess gas vacuoles that enable them to float to the surface, in some cases forming dense blooms and outcompeting beneficial phytoplankton species, which can sink below the photic zone without sufficient mixing energy. The low-energy dynamics of dead-end channels may promote cyanoHAB formation in certain conditions but remain understudied in the Delta. To study the hydrodynamics of dead-end channels, we conducted a field study in the Stockton waterfront during August 2024, instrumenting three sites chosen to span a variety of wind and tidal forcing as the channel shallows and curves into a dead end. We instrumented each site with a vertical array of temperature sensors and water quality sondes, and deployed anemometers and upward-facing acoustic doppler current profilers (ADCPs) at two sites to capture wind velocities and net-flow throughout the water column. We use an energy balance approach to investigate the stability of the water column and compare the sites in Stockton’s dead-end channel to hydrodynamic observations in Delta main channels. We observed frequent diurnal stratification in the top 1–2 m of the water column with mixing occurring overnight. Stratification was strongest in the channel’s dead-end where afternoon temperature differences between the surface and mixed layer reached 3–4 °C. During a strong wind event (velocities >6 m/s), stratification did not occur, and a recovery period of several days occurred before stratification resumed at its previous extent, providing insight into the effects of mixing and relative contributions of wind and tidal forcing. Ongoing analyses will characterize the vertical distribution of phytoplankton and water quality indicators to assess how hydrodynamics affect phytoplankton biomass and community composition. These findings will support the identification of hydrodynamic processes, gradients, and thresholds underpinning the formation of cyanoHABs in low-energy regions of the Delta.

Temporal and Spatial Variability of Cyanobacterial Diversity in the Sacramento-San Joaquin Delta: Environmental Drivers Across Sites and Seasons

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The Sacramento-San Joaquin Delta is experiencing a growing diversity of cyanobacterial harmful algal blooms (cyanoHABs), with significant implications for water quality, ecosystem health, and public safety. Over the course of eight months in 2023, we conducted a comprehensive study across 10 sites, combining whole-genome metagenomics, cyanotoxin profiling, and detailed water quality assessments. Sampling efforts were expanded into the north and south Delta during July and October 2023 to better capture spatial dynamics and identify the environmental drivers influencing their diversity and dominance.

In our samples, we were able to assemble more than 50 genomes from multiple cyanobacterial genera, including *Microcystis*, *Aphanizomenon*, *Dolichospermum*, *Planktothrix*, and *Cyanobium*. Our findings revealed distinct seasonal shifts in community structure, with different cyanobacterial taxa dominating in spring, summer, and fall. Key factors, including nitrogen availability and hydrological conditions, shaped the co-occurrence and spatial distribution of nitrogen-fixing and non-nitrogen-fixing cyanobacteria, as well as the dominance of specific species. Additional analyses will further characterize the environmental variables associated with different cyanobacterial species and strains in the Delta. These results emphasize the importance of spatially resolved sampling to understand the occurrence of different species and strains.

This study highlights the complexity of environmental conditions driving cyanobacterial diversity in the Delta. Understanding how cyanobacterial species will respond to changing environmental conditions in the Delta will help improve cyanoHAB predictions under future water management or hydrologic scenarios.

Active Chlorophyll Fluorescence Methods for Measuring Primary Productivity in the Sacramento-San Joaquin Delta

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Primary productivity is an important measure of how much energy is available in an ecosystem. Unfortunately, methods for quantifying primary productivity have previously been costly and time consuming, often leading to this measurement being left out of monitoring programs. However, new advancements in Active Chlorophyll Fluorescence (ACF) methods have emerged as a time and cost-effective method of quantifying phytoplankton primary productivity. Previously, ACF methods have primarily been used in the ocean, an environment with low concentrations of suspended sediment and phytoplankton. Despite more optically complex waters in estuarine environments, such as the Sacramento-San Joaquin Delta (Delta), our results show that this instrument can be applied in these settings. We were able to utilize ACF methods with a labSTAF (Single Turnover Active Fluorometry) instrument. The labSTAF allows for rapid, noninvasive measurements of primary productivity that can be correlated with other mapping data to better understand seasonal, regional, and tidal influences on phytoplankton primary productivity in the Delta. In 2024, the U.S. Geological Survey utilized the labSTAF instrument four times, twice in April and twice in October. It was run alongside discrete sampling and the Boat Based Flow Through System which can measure different water quality parameters, such as chlorophyll, dissolved oxygen, pH, and turbidity. Preliminary results show that photosynthesis is more efficient during spring. We will further investigate STAF measurements to improve monitoring efforts and understand changes in primary productivity.

Larval fish diets as indicators of food web dynamics in tidal wetland restoration

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Fish populations in the San Francisco Estuary (SFE) have been declining for decades due to multiple interacting factors, including a reduction in tidal wetlands and a decline in zooplankton abundance throughout the estuary. Tidal wetlands in the SFE are being restored to enhance fish populations by providing beneficial habitat and food web resources, such as a richer zooplankton assemblage than in open waters. Longfin smelt (LFS; *Spirinchus thaleichthys*) is a declining native fish and a threatened species. Copepod abundance in wetlands directly affects LFS populations, since larval LFS rely on copepods as their primary food source. The purpose of this in progress study is to identify food web resources in close proximity to wetland restoration sites, compare them with ecological indicators in wetlands at different stages of restoration (early, intermediate, mature), and identify zooplankton indicator species associated with beneficial habitat for LFS. High-throughput sequencing (HTS) will be utilized to identify the diversity of prey available in the water column, including calanoid and cyclopoid copepods (*Eurytemora carolleeae*, *Acanthocyclops americanus*, *Acanthocyclops robustus, Pseudodiaptomus forbesi*), and indicator species in diets of larval fishes, specifically LFS, Pacific herring (*Clupea pallasii*), and Prickly sculpin (*Cottus asper*), which use wetlands as nursery grounds during the same time of year as LFS. HTS is advantageous for DNA diet analysis as it can identify diverse zooplankton in the diets of larval fishes, including species not previously described as a food source that microscopy was not able to identify. HTS will identify the DNA of prey consumed by the larval fishes, ambient zooplankton species available to the larval fishes, and indicator species at each wetland restoration site. This study will expand upon current limited databases for copepod identification, provide information for zooplankton monitoring near wetlands, provide information for wetland restoration managers; including prey availability of 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 support zooplankton abundance and larval fish populations, which will ultimately benefit declining fish populations in the SFE.

Salmonids

Historical Knights Landing Rotary Screw Trap Efficiency of Chinook salmon in the Sacramento River

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Estimating the passage of out-migrating juvenile Chinook salmon from the Sacramento River to the Sacramento- San Joaquin Delta has played a large role with the rotary screw trapping within the Central Valley to understand the population dynamics of resident salmonids. A key factor in developing passage estimates for salmonids is understanding how efficient a project is within the aquatic system. The Knights Landing rotary screw trap project has conducted over 25 years of efficiency data for Chinook salmon to develop passage estimates. VIE (Visible Implant Elastomer) tagging and whole body dying with BBY (Bismarck Brown Y) groups of juvenile salmonids between 500-3000 were released for mark and recapture to create trap efficiency estimates. Main stem rotary screw trapping projects present many difficulties in creating relevant efficiency estimates compared to smaller tributary projects due to increased flow, consistency in sampling periods, and abundance of salmonids to sample. This presentation highlights the findings of the Knights Landing rotary screw trap efficiency estimates over the duration of the project beginning in 1995, as well as comparing similar projects efficiency data to understand the pitfalls of main stem trap efficiency trials.

Pathogen Monitoring to Support Chinook Salmon Reintroduction in the McCloud River

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Since the completion of Shasta Dam, winter-run Chinook salmon have been disconnected from their ancestral home on the McCloud River and subject to population declines which have pushed them towards extinction. To reduce this extinction risk, the Winnemem Wintu Tribe in partnership with federal and state agencies are leading an emergency action to reintroduce winter-run to their ancestral home on the McCloud River. Many factors have likely contributed to the decline of winter-run, including climate change, fragmentation of habitat, and disease. However, the extent of disease associated with pathogen exposure on winter-run is largely unknown. This study aims to advance our knowledge of pathogen exposure and disease risk during the reintroduction of winter-run into the McCloud River above Shasta Reservoir. To do so, we are employing comprehensive environmental monitoring through both water sampling and fish tissue analysis to identify links between reintroduction and pathogen dynamics. A component of this monitoring includes collecting weekly water samples that are being analyzed using molecular methods to detect and quantify a wide range of salmonid pathogens (47 pathogens, including viruses, bacteria, and parasites). This environmental surveillance provides essential data on pathogens present in the habitat and helps to estimate potential exposure levels for winter-run. Complementing this water-based environmental assessment, a winter-run field infection study was conducted, where tissues from juvenile salmon that were reared in the McCloud River were assayed to assess pathogen presence and abundance. This poster will present data on these two pieces of data, and provide a more holistic view of pathogen distribution and disease potential on the McCloud River to inform management strategies for winter-run reintroduction.

Assessing the Life History of Central Valley Steelhead Using Otoliths

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The California Central Valley Steelhead (CVS) is a distinct population of anadromous Rainbow Trout (*Oncorhynchus mykiss*) that is listed as 'threatened' under the Endangered Species Act. Critical information gaps regarding our knowledge of Steelhead demographics and life histories in the Sacramento and San Joaquin River watersheds hinder their effective management and conservation. Here we report on the preliminary results of a new collaboration between the Otolith Geochemistry & Fish Ecology Laboratory at UC Davis, the Norwegian Institute for Nature Research, the US Bureau of Reclamation, and the CA Dept. of Fish and Wildlife. In this project we are utilizing increment and geochemical analyses of archived otoliths (ear stones) from 700 CVS to reconstruct the age structure, growth, and migratory life history of Steelhead from the Upper Sacramento, Feather, American, Tuolumne, Merced, and Stanislaus Rivers. These data will allow us to explore the region-wide variation in the life history of CVS. Our initial findings highlight the value of otoliths in providing age, growth, and migratory information for CVS life history analysis. Annual age of adult CVS was reconstructed using opaque and translucent banding patterns. Daily growth rate of the juvenile part of the otolith was reconstructed from daily increment widths. Life history patterns such as natal origin, migratory phenotype, and maternal phenotype are reconstructed using Strontium isotopes (87Sr/86Sr).

Smelt

Inside the hot box: Experimental enclosures for Delta Smelt summer-fall habitat actions

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Field enclosures have long been used to test how fish respond to habitat conditions. The Department of Water Resources (DWR) began using Delta Smelt enclosures in 2019 to test the ability of cultured smelt to survive and grow in the estuary and test key management questions. These questions include understanding the effects of season, location, hatchery ancestry, supplementation strategies, and managed habitat actions in summer-fall that affect smelt, but we have found that some of these questions can be tested more effectively than others. Here, we focus on summarizing field deployments in summer and fall periods of 2019, 2023, and 2024, designed to test the effectiveness of the Fall X2 and Suisun Marsh Salinity Control Gates managed habitat actions. We contrast fish survival and condition metrics (e.g., condition factor, hepatosomatic index (HSI), liver glycogen, and upper thermal tolerance (CTmax)), where feasible across the three deployment years. We also assess zooplankton and diets of caged fish compared to wild-caught fish during similar time period, when possible. We found >50% survival in all years of caged smelt in summer- fall, with generally higher survival in the Sacramento River at Rio Vista compared to Suisun Marsh. Other metrics such as condition factor, HSI, liver glycogen, and CTmax were influenced by year and location. Together, our findings challenge the hypotheses behind these management actions (with mixed rejection and support) and raise concerns about confounding factors limiting our ability to extend the results of the cage experiments to broader habitat conditions (e.g., biofouling, restricting foraging behavior, and food limitations). Overall, we highlight DWR's Delta Smelt enclosure program, key findings from deployments, and critical problems that may confound future summer-fall deployments.

Color vision deficiency reduces the efficacy of visible implant elastomer tag identification in Delta Smelt

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Visible implant elastomer (VIE) tagging is a commonly-used method for marking and monitoring large numbers of cultured fish released into the wild for conservation purposes, such as the supplementation of endangered Delta Smelt. This method is favored for its low-cost materials, rapid processing, and low mortality rates, as well as its high tag retention and detectability under field conditions. The variety of VIE colors available also facilitates batch marking unique groups, which can be used to evaluate the effectiveness of different release methods, locations, and times during ‘experimental releases’ for the Delta Smelt supplementation program, for example. However, the ability to distinguish between batches of released fish depends on the correct assignment of fish to their corresponding tag color (i.e., original release group). We surmised that color vision deficiency (CVD) in humans, a common condition that affects approximately 9% of males and 2% of females worldwide, could influence accuracy of these assignments. To test this, we solicited observers with and without CVD to identify the tag color (blue, green, orange, red, and yellow) of anesthetized, VIE-tagged Delta Smelt from photos and in person. Observers without CVD correctly identified VIE color in 96.8% of photographed fish and 94.8% of fish observed in person, whereas observers with CVD correctly identified VIE color in 60.0% of photographed fish and 43.9% of fish observed in person. For both in-person and photo-based identifications, observers with CVD were most proficient at identifying blue tags (99.0% correct) and least proficient at identifying green (89.9% incorrect) and yellow (88.1% incorrect) tags. We showed that, although CVD reduces the accuracy of VIE-tag-color identification in Delta Smelt, complementary use of high-quality photographs offers a robust, independent means to verify field-based identifications.

Estimating Delta Smelt size and condition with a non-contact morphometric approach

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The Delta Smelt, endemic to the San Francisco Estuary and Sacramento-San Joaquin Delta, is an endangered species on the brink of extinction. Understanding how these fish utilize habitats and respond to environmental variation is important for implementing and assessing the effectiveness of conservation efforts. Since wild Delta Smelt are rarely encountered, controlled enclosure experiments seek to assess fish response over time using hatchery raised individuals. However, one of the challenges of working with Delta Smelt is that they are sensitive to physical handling resulting in an acute stress response, often with direct or delayed mortality. This precludes multiple measurements of an individual needed for calculating growth rates and necessitates the use of apparent population growth rates which include excessive inherent variability. To avoid this undesired outcome and improve growth assessments at multiple points in a fish's life, we developed a non-contact approach to measuring Delta Smelt size and condition. The approach was adapted from a method developed by Holmes and Jeffres (2020) on juvenile Chinook Salmon. The process involves collecting oblique fish images in a narrow aquarium, manual landmark digitization, and regression of the resulting truss network measurements to estimate a fish's length, weight, and condition. The method proved to be precise with a mean absolute percent error (MAPE) of 3.37% and a mean absolute error (MAE) of 0.07g, and unbiased with distributions centered around 0. This method can be performed on an unstable platform, such as a boat, where traditional weight measurements are prohibitive. This method has the potential for inclusion in fish sampling workflows for various species where accurate size and condition information is desired and where minimal handling of sensitive and imperiled fish species is needed.

Ultrastructural Insights into Sperm Morphology of Three California Smelt Species

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This study presents the first comprehensive investigation of sperm morphology in three smelt species in California: the endangered delta smelt (*Hypomesus transpacificus*), the threatened longfin smelt (*Spirinchus thaleichthys*), and the introduced wakasagi (*H. nipponensis*). We analyzed the ultrastructure of their spermatozoa, focusing on the head length, head width, head area, midpiece length, flagellum length, and total sperm length using Scanning Electron Microscopy (SEM) and Transmission Electron Microscopy (TEM). SEM images revealed that all three species share a rounded sperm head with a short midpiece connecting to the flagellum, as in most teleosts. For delta smelt, average measurements for sperm head length, head width, head area, midpiece length, flagellum length, and total sperm length were 1.61 ± 0.16 μm, 1.03 ± 0.08 μm, 1.34 ± 0.23 μm^2, 0.75 ± 0.16 μm, 27.41 ± 3.97 μm, and 29.39 ± 4.19 μm, respectively. In longfin smelt, these measurements were 1.63 ± 0.16 μm, 1.01 ± 0.07 μm, 1.32 ± 0.15 μm^2, 0.83 ± 0.16 μm, 30.46 ± 3.93 μm, and 32.13 ± 4.38 μm. Wakasagi sperm had averages of 1.65 ± 0.10 μm, 0.98 ± 0.07 μm, 1.32 ± 0.13 μm^2, 0.82 ± 0.11 μm, 31.57 ± 4.66 μm, and 33.80 ± 4.50 μm. TEM analysis highlighted critical internal features of the midpiece, including the centrioles, nucleolus, and surrounding nuclear envelope. It also showed the presence of proximal and distal centrioles, with the flagellum connected to the distal centriole. The typical nine peripheral doublets and two central microtubules (9+2) of flagellum was also clearly visible. This pioneering study fills a significant knowledge gap by detailing the sperm morphology of these smelt species, providing a foundation for future reproductive research and potential conservation efforts.

Delta Smelt Diet and Habitat Use During Suisun Marsh Salinity Control Gate Operations of 2018-2019

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Suisun Bay and Suisun Marsh, especially Montezuma Slough, are historically important habitat for endangered Delta Smelt (*Hypomesus transpacificus*) and other fishes in the San Francisco Estuary (SFE). The Suisun Marsh Salinity Control Gates (SMSCG) in eastern Montezuma Slough are typically operated in the fall to increase low salinity habitat in Suisun Marsh to benefit waterfowl. In 2018, the gates were operated in August to potentially benefit Delta Smelt by increasing low salinity habitat during the summer, as outlined in the Delta Smelt Resiliency Strategy. The gates were opened during ebb tides and closed during flood tides to maintain fresh water in Montezuma Slough. During this time, the California Department of Fish and Wildlife (CDFW) added additional zooplankton monitoring from July to October to examine the effect of gate operations on the zooplankton community. This zooplankton data, coupled with fish collected by routine CDFW and U.S. Fish and Wildlife Service surveys, gives us the opportunity to determine the effect of augmented flow (via SMSCG operation) on fish diets and prey selectivity in the SFE. The CDFW Diet and Condition Study examined the diets of Delta Smelt and other co-occurring fish—Longfin Smelt (*Spirinchus thaleichthys*), Striped Bass (*Morone saxatilis*), American Shad (*Alosa sapidissima*), and Threadfin Shad (*Dorosoma petenense*)—found within the SMSCG footprint from Suisun Bay to the lower Sacramento River. We compared fish diets during the SMSCG action in 2018 to those in 2019, a non-action wet year. This study not only allows for comparisons of fish diets during the SMSCG management action but also adds valuable information about dietary overlap between native and invasive species, prey selectivity, as well as information on the previously unknown diets of fish species in the SFE—all of which will inform management decisions aimed at increasing beneficial habitat and prey availability for native fishes.

Assessing trends in maturation, fecundity, and age of Longfin Smelt

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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 and culture methods, which rely on accurate parameter estimates for age-at-maturity, size-at-maturity, and size-specific fecundity. Here, we summarize ontogenetic, temporal, and spatial patterns in maturation and fecundity of wild Longfin Smelt collected across the SFE over the last two decades. We also summarize size-independent age estimations, generated via otolith-based aging methods, which allow for better distinction among age-1, age-2, and age-3 fish. The gonadosomatic index (GSI) of Longfin Smelt increased sharply above 60 mm standard length (SL), and over 50% of fish over 70 mm SL were found to contain gonads with either fully mature oocytes or oocytes approaching full maturity. Clutch fecundity averaged ~5000 eggs per female, but could potentially range to >15,000. These findings are key to future conservation efforts such as UC Davis's fledgling Longfin Smelt Conservation & Culture Program.