Interagency Ecological Program 2023 Annual Workshop

POSTER ABSTRACTS

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COOPERATIVE ECOLOGICAL INVESTIGATIONS SINCE 1970

Abstracts are listed alphabetically by poster topic category and then by the last name of the presenting author. There are seven poster categories:

- Delta Smelt & Longfin Smelt
- Invasive Species
- Lower Food Webs
- Potpourri
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The presenting author and those that are eligible for the early career scientist award are identified with the following symbols:

* Denotes presenting author.
+ Denotes eligibility for early career scientist award.

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Delta Smelt & Longfin Smelt

Understanding larval smelt presence in the south Delta and future implications for estimating entrainment (V. Afentoulis)

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Since their respective listings under the Federal and State Endangered Species Acts, native Delta Smelt, *Hypomesus transpacificus*, and Longfin Smelt, *Spirinchus thaleichthys*, in the Sacramento-San Joaquin Delta (Delta) have continued to decline. Migration and rearing increase the exposure of smelt to the influence of large water export facilities in the south Delta. In addition to direct entrainment, smelt experience greater exposure to predators, unsuitable water quality, and lack of food availability. Detection of smelt by the state and federal salvage facilities occurs sporadically for adults but quantification of larval entrainment has not been examined. The Larval Entrainment Pilot Study (LEPS) was initiated in 2022 consistent with the requirements of the 2020 Incidental Take Permit and we report on the results of the first pilot year (2022). Sampling occurred January-April adjacent to Clifton Court Forebay and followed CDFW Smelt Larval Survey (SLS) and 20mm survey protocols with increased effort in the form more tows, on as many working days as feasible during the study period. The study detected Longfin Smelt larvae from January through March, but only with the SLS gear. In addition, larval presence adjacent to the CCF was followed across finer temporal scales during 3, 24-hour periods (light in contrast to dark sampling). Results from LEPS pilot years will aid in the estimation of larval smelt entrainment and inform efforts to understand the magnitude of entrainment as a source of mortality. In the future, LEPS will explore additional influences on larval smelt detection and vulnerability to entrainment.

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Are established morphometrics appropriate for identifying hatchery supplemental Delta Smelt? (A. Arrambide)

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The Delta Smelt *Hypomesus transpacificus* (DSM), a native fish species to the San Francisco Estuary, is a federally (threatened) and state listed (endangered) species. Proper identification of DSM at all life stages is important to estimate the abundance and distribution of DSM, primary goals of the U.S. Fish and Wildlife Service's Enhanced Delta Smelt Monitoring Program. DSM are identified primarily by morphometric characteristics, as identification via genetic assay is still developing and lacks certainty. Starting in 2022, experimental releases of cultured DSM occurred and morphological differences between hatchery and wild DSM have been observed in adult specimens. Differences among larval wild DSM morphometrics also have been observed. Staff are now faced with the identification of larval fish with differing morphometrics due to wild and cultured fish parentage. To address this new challenge, we are exploring the suite of morphometrics needed to identify larval DSM. We conducted a discriminant analysis for morphometrics of larval DSM captured in 20-mm surveys to determine if hatchery larval DSM have the same morphometrics as wild DSM. Our preliminary results will improve species identification of larval DSM.

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Phylogenetic relationships and introduction history inferred from complete mitochondrial genomes of four smelts (Osmeridae) of the modern San Francisco Estuary (M. Asadi Aghbolaghi)

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Smelts (Osmeridae) include 12 species of small fishes that inhabit inshore marine, estuarine, and lacustrine habitats within cooler northern waters in the Northern Hemisphere. Evolutionary relationships among these species are complex, and osmerid taxonomy remains poorly resolved. Collectively, smelts have a Holarctic distribution, and some taxa have been introduced outside their native range, primarily to support local fisheries. Four of these species inhabit the contemporary San Francisco Estuary (SFE): the imperiled endemic delta smelt (*Hypomesus transpacificus*) and native longfin smelt (*Spirinchus thaleichthys*); the non-native wakasagi (*H. nipponensis*); and the marine but estuary dispersant eastern surf smelt (*H. pretiosus*). For investigation of the phylogenetic relationships and introduction history of smelts in SFE, we collected specimens (n = 6) and present novel complete mitogenomes for the imperiled *H. transpacificus* (n = 1) and *S. thaleichthys* (n = 2) and provide additional representation of complete mitogenomes for *H. pretiosus* (n = 1) and *H. nipponensis* (n = 2). Phylogenetic analyses of complete mitogenome coding sequences and derivative cytochrome *b* (cyt*b*) sequences were conducted using maximum likelihood analyses and included representative species and genera from the family as well as outgroup taxa. The first analysis, based on complete mitogenome coding sequences, distinguished *H. transpacificus*+*H. pretiosus* [SFE] as separate from but sister to *H. pretiosus* [Oregon]. The second analysis, based on cyt*b* sequences, revealed that SFE *H. nipponensis* clustered with Lake Suwa [Japan] variants derived from hatchery stock introduced to Lake Shinji, Japan. The sister relationship between SFE *H. pretiosus* and *H. transpacificus* is consistent with recent origin of delta smelt from local eastern surf smelt, whereas relationships among *H. nipponensis* support inferred entry of wakasagi into the SFE after introduction of Lake Suwa stock to local reservoirs in 1959.

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Developing alternative rearing strategies for Delta smelt: Experimental assessment of larval enclosures (A. Boyd)

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Delta Smelt *Hypomesus transpacificus* abundance has been rapidly declining for decades and the species is critically endangered. In 2021-2022, UC Davis partnered with federal and state agencies to successfully conduct an experimental release of captive-reared adults to avoid near-term extinction in the Delta. However, releasing an earlier life stage could relieve the heavy labor and space burden of rearing fish to adulthood, reduce domestication selection, and complement adult releases. Our goal was to identify the optimal materials and design features to construct field-deployable enclosures for rearing larval and juvenile Delta Smelt within the Delta. Because of the size and sensitivity of larval Delta Smelt we made a layered design; a removable "larval" cage with finer material inside a "juvenile" cage with larger mesh. This design accommodates multiple life stages while minimizing handling stress and reducing flow rates. A velocimeter was used to test mesh materials with different hole diameters and openness. Velocity was affected by openness, but hole size had little effect. We used a regression model to predict which openness would ensure that velocities remain low to avoid impingement or exhaustive swimming, enough water exchange to prevent hypoxia and allow food particles to enter, and to prevent fish escapement. Results showed that inner enclosures should be 50-60% open with ~300 micron diameter holes and outer enclosure material should be ~23% open with hole diameters of ~600 microns. These cage specifications are currently being tested on larval and juvenile Delta Smelt. Future work will likely include testing these cages in the wild.

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Can Sacramento-San Joaquin Delta Island ponds be used as a tool to support delta smelt supplementation? (J. Buxton)

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The population of endemic delta smelt (*Hypomesus transpacificus*) in the Sacramento-San Joaquin Delta began declining in the 1980s and has shown no signs of recovery. Therefore, plans to supplement the wild population with hatchery raised fish are being explored and implemented. One possible tool to aid supplementation is the use of semi-natural ponds on islands in the Delta owned by the Metropolitan Water District. The goal of this study is to examine how environmental conditions vary seasonally among ten ponds located on Bacon Island, Bouldin Island, Holland Tract, and Webb Tract. From November 2021 through November 2022, we measured water quality parameters (temperature, dissolved oxygen, turbidity, specific conductance, salinity, chlorophyll, and pH) bimonthly, collected zooplankton monthly, and sampled fish once at each pond. Water quality parameters were measured at the surface and bottom of each pond and mid-depth in ponds that were less than 1.5m in depth. Zooplankton were collected at 1m depth using a Schindler-Patalas 12L plankton trap. Fish were sampled opportunistically by beach seine, gill net, and electrofishing. Quantitative analyses are on-going but preliminary results indicate that environmental and biological conditions of ponds varied within and among islands. Several ponds have been deemed suitable to support delta smelt and have already supported successful experiments with hatchery raised delta smelt.

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Hydrological influence on the distribution, salinity habitat and relative abundance of native and introduced fishes (G. Castillo)

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How hydrological conditions influence the distribution and abundance of fish in estuaries are central research and management questions, particularly in complex evolving systems such as the upper San Francisco Estuary (USFE). We used 20-mm Survey data to evaluate the hydrological responses of larval-juvenile fishes in four native (Delta Smelt, Longfin Smelt, Northern Anchovy, Pacific Herring) and four introduced species (American Shad, Mississippi Silverside, Striped Bass, Threadfin Shad) during winter-spring 1995-2017 in the USFE. We used the position of the 2 isohaline (X2) as an index of hydrological forcing on the: 1) upstream distribution, 2) catch-weighted salinity per survey (salinity habitat), and 3) catch per unit volume (CPUV) of fishes. Although the mean distribution for all eight species across surveys shifted upstream with increasing X2 (range: 45-85 km), mean salinity habitat was a function of X2 only for native species. The ratio of the mean salinity habitat to mean salinity per survey (field salinity) (log-transformed) decreased towards higher X2 positions in all species, with the mean salinity habitat being generally lower than the mean field salinity for Delta Smelt and all introduced fishes, while the opposite occurred for the other native fishes. Over the observed range of X2, mean field salinity only overlapped mean predicted salinity habitat of Delta Smelt, American Shad and Striped Bass. Mean annual log10 CPUV+1 was associated with X2 in five species, increasing with X2 for Northern Anchovy and decreasing with X2 for American Shad, while Delta Smelt, Longfin Smelt and Striped Bass reached highest CPUV at intermediate X2 values (65-75 km). The position of X2 at maximum CPUV for these five species was associated with the corresponding position of X2 when the mean salinity habitat was closest to mean field salinity, further supporting the value of X2 and salinity habitat to interpret changes in fish populations.

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Liver glycogen as a sensitive indicator of food limitation in Delta Smelt (T. Dhayalan)

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Assessing habitat quality is a major goal of conservationists and restoration practitioners, but to associate habitat quality with biomarkers of vagile animals the biomarkers must respond rapidly. Here we identified a biomarker capable of rapidly detecting food limitation in the imperiled Delta Smelt (*Hypomesus transpacificus*), a pelagic fish endemic to the San Francisco Estuary (SFE). We conducted an experiment with fed and unfed treatments of cultured, sub-adult Delta Smelt that were sampled at 12 time points: 0, 1, 2, 3, 4, 5, 6, 7, 9, 11, 14, and 21 days. We then compared four biomarkers on Day 21 fish: RNA/DNA in liver, triglycerides in liver, glycogen in liver, and glycogen in muscle. Of the three liver endpoints, liver glycogen had the largest, most significant difference between treatments at Day 21, so we compared it to muscle glycogen across all time points. Liver glycogen declined after just one day of fasting, and remained depressed in the fasting treatment across all subsequent time points. Muscle glycogen also responded rapidly, taking only two days to decline in the fasting treatment, but the difference was small and inconsistent across subsequent time points. When applied to hatchery-released Delta Smelt collected from the SFE, we found that the liver glycogen concentrations were less than half that of the fed hatchery fish and were indistinguishable from the unfed hatchery fish, consistent with the hypothesis of food limitation in the wild. This study highlights the utility of biochemically determining liver glycogen concentrations of wild-caught Delta Smelt to provide insight into local habitat quality.

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Progress update on the Longfin Smelt Science Program (M. Eakin)

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Since its listing as threatened under the California Endangered Species Act in 2009, Longfin Smelt (Spirinchus thaleicthys) have been a focal species for managers in large scale water project permitting efforts across the state of California. In March of 2020, the California Department of Fish and Wildlife issued the California Department of Water Resources an Incidental Take Permit (ITP) for the long-term operation of the State Water Project, providing incidental take for four of California's imperiled species, one of which is Longfin Smelt. However, due to a combination of data gaps and uncertainty, Longfin Smelt science was lacking or absent in key topics, and managers believed that such science could be developed over the 10-year lifespan of the permit. Because of this, the Longfin Smelt Science Program was established as a condition of the ITP and was intended to provide the forum for addressing Longfin Smelt science priorities through 2030. Here, we provide a progress update on the scientific efforts currently underway as part of the Longfin Smelt Science Program. Some key updates include: 1) success in our partnership with UC Davis in reaching new milestones in Longfin Smelt aquaculture, increasing the likeliness of closing the life cycle in captivity. 2) Expansion of existing monitoring programs, with 15 new survey stations added to the Smelt Larva and 20 mm surveys within San Pablo Bay for 2023. And 3) Initiation of a multi-agency effort to develop a comprehensive life cycle model for Longfin Smelt. Lastly, we want to invite you to please join us for the July Estuarine Ecology Team meeting where we plan to have a series of discussions on Longfin Smelt Science Program updates and we are interested in hearing from you.

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Exploring the reproductive biology of Longfin Smelt in the San Francisco Estuary (N. Floros)

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The genetically distinct population of Longfin Smelt (Spirinchus thaleichthys) in the San Francisco Estuary (SFE) faces increasing risk of extinction. Although many studies have aimed to inform conservation and management for this species, little remains known regarding maturation and variation in its reproductive biology. Here, we assessed the ontogenetic, temporal, and spatial variation in wild Longfin Smelt using fish collected throughout the SFE between 2011–2022. Results indicate that Longfin Smelt begin to mature at ~70 mm standard length and that maturing Longfin Smelt migrate from high-salinity habitats into low salinity wetland habitats such as Alviso Marsh during the rainy spawning season (November–March). Furthermore, results indicate that female Longfin Smelt may contain 2,000–10,000 eggs and that ovaries may contain eggs at multiple developmental stages, indicative of multiple clutches and repeated spawning. Ultimately, results of maturation and fecundity analyses will be combined with otolith aging and environmental data to develop an improved understanding of the reproductive biology and population dynamics of this imperiled anadromous forage fish.

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Examining the effects of managed flow actions on habitat quality for osmerids in the North Delta (P. Higginson)

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Delta Smelt (*Hypomesus transpacificus*) are listed as endangered and one of the primary factors cited for the species' decline is a decrease in the availability of planktonic food resources. In 2022 the U.S. Fish and Wildlife Services (USFWS) 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. The amplified flows are hypothesized to enhance downstream transport of lower trophic-level resources that are important for Delta Smelt growth and survival. As part of this study, water samples were collected at sites around Cache Slough and Rio Vista and analyzed to quantify the levels of chlorophyll α, an indicator of phytoplankton biomass. Other nutrients included were nitrate + nitrite (NO3 + NO2), ammonium (NH4), ortho-phosphate (PO_4^{3-}), silica ($Si(OH)_2$), and dissolved organic carbon (DOC). High concentrations of nutrients like ammonium and nitrogen could limit phytoplankton production, thus impacting Delta Smelt food abundance. Here we examine levels of chlorophyll α and other nutrients in the North Delta before and after managed pulse flows and compare to catch distributions of the osmeridae delta smelt, longfin smelt (*Spirinchus thaleichthys*), and wakasagi (*Hypomesus nipponensis*) in monitoring surveys to look for correlations between changes in habitat quality and fish presence. This comparison can assist with determining what nutrient levels are influencing the osmerids of the Delta.

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Potential biomarkers to assess wild-caught Delta Smelt larvae and the influence of salinity on survival and growth of Delta Smelt larvae (K. Huynh)

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Annual recruitment of adult Delta Smelt relies on the survival of larvae. However, the health of Delta Smelt larvae in the wild is poorly understood, and little is known regarding how environmental factors such as salinity influence Delta Smelt in the early stage of development. In this study, we determined the effect of salinity on Delta Smelt larvae by exposing hatchlings to a range of salinities (0.125-16 ppt) for 45 days and comparing their survival and growth among salinities. We found that larval survival was optimized at 4 ppt, while growth was optimized at 8 ppt. We also compared the sensitivities to fasting of several biomarkers for potential application to wild larvae. We stopped feeding Delta Smelt larvae at 45 days post hatch in fasting group while continue to feed the control group. We collected larvae at seven time points (0h, 12h, 1d, 2d, 3d, 4d, and 5d) and quantified condition factor, whole-body RNA/DNA, and whole-body glycogen. Whole-body RNA/DNA was highly sensitive to fasting and condition factor was moderately sensitive, responding to fasting at 3d and 4d, respectively. Whole-body glycogen was sensitive but inconsistent across time-points. Our results show that Delta Smelt larvae survive and grew better at moderate salinity, and indicate that RNA/DNA and condition factor are suitable to assess the nutritional condition of Delta Smelt larvae.

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The larval Smelt preservation method evaluation study: Morphology results (J. Jimenez)

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A new study will quantify the entrainment of larval Delta Smelt and Longfin Smelt in Clifton Court Forebay. This increase in sampling warrants a new protocol to prioritize samples that may contain these species. The Interagency Ecological Program was tasked with developing protocols that combine environmental DNA (eDNA) with traditional larval fish microscopy. In this context, eDNA refers to the DNA within the liquid preservative within the sample vials. Samples are currently preserved in 10% buffered formalin, a preservative that inhibits genetic analysis. This larval smelt preservation evaluation study sought to find an alternative preservative that can facilitate an eDNA-based screening tool to prioritize samples containing larval Delta Smelt and Longfin Smelt for early analysis, while also preserving morphological characteristics for identification. This poster only shows the morphological results in this two-part study. We evaluated seven preservatives' ability to maintain larval Delta Smelt morphology over time and results were compared between sizes classes (5-15 mm and 15.1-25 mm). The preservatives selected were 10% Hydantoin, 70% DESS, 70% ExCell Plus™, DNA Shield™, 50% ethanol, 70% ethanol, and 10% formalin. Fish were measured to total length and a visual rank was given to each fish based on the condition of various identification characteristics at different time points: day 1, 3, 7, 28, and 168. DNA Shield™ was discontinued after day 1. After 168 days, 10% formalin, 70% ethanol, and 50% ethanol caused the least degradation, while 10% Hydantoin, 70% DESS, and 70% ExCell Plus™ caused tissue flaking and fin disintegration over time. In addition to providing a prioritization tool for sample processing, there is also a need for an alternative preservative to allow researchers to genetically determine the parentage of larval Delta Smelt collected in monitoring.

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Contaminated or conserved: Experimentally assessing the effects of different chemical fixatives on otolith appearance, otolith microchemistry, body morphometrics, and tissue histology of Delta Smelt (A. Lama)

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When preserving specimens of endangered species, it is vital to have reliable methods that can satisfy multiple research needs from a limited supply of wild individuals. Key considerations include the effects of preservation methods on body size, otolith structure, and otolith chemistry. Here, we experimentally tested how preservation in four different fixatives (95% ethanol, 100% ExCell Plus, 10% buffered formalin, and liquid nitrogen) affected the weight, length, otolith structure, and otolith chemistry of endangered Delta Smelt (*Hypomesus transpacificus)* across four time increments (1 week, 1 month, 6 months, and 1 year). Our results demonstrate that preservation in ethanol led to significant declines in body weight, minimal reduction of body length, and effective preservation of otoliths. Formalin gradually increased body weight, slightly reduced body length, and degraded otoliths. Excell Plus reduced body weight, slightly reduced body length, and severely eroded the otoliths. Finally, liquid nitrogen exhibited little effect on body weight, slightly reduced body length, and preserved the structure of the otoliths similarly to those fixed in ethanol. The chemistry of otoliths preserved in liquid nitrogen and ethanol were most similar to controls, whereas those preserved in ExCell Plus exhibited significant degradation and abnormal chemistry within 1 month of fixation. Our results highlight key tradeoffs between fixative choice, with important and conflicting tradeoffs between those that better preserve calcified versus soft tissues.

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Powers and pitfalls in the use of otolith geochemistry to reconstruct salinity, temperature, and natal origins in estuarine fishes (L. Lewis)

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Otolith geochemistry is a powerful tool for reconstructing the life history of teleost fishes in order to inform and improve management and conservation efforts. However, each analytical approach, and the associated ecological applications, has important limitations that can act as pitfalls if they are not acknowledged and addressed during analysis and interpretation. This is particularly true in complex and highly dynamic environments like those of the San Francisco Estuary. Here we reflect on the results of several recent studies that can be used to address key assumptions in the application of (1) Sr isotopes to reconstruct salinity histories, (2) oxygen isotopes to reconstruct salinity histories, (3) oxygen isotopes to reconstruct temperature histories, and (4) elemental concentrations (e.g., Sr:Ca, Ba:Ca, Li:Ca) or 'fingerprints' to infer natal origins. By highlighting the limitations and pitfalls of each approach, we simultaneously can highlight their respective strengths, thus further Improving the value and application of otolith geochemistry to address key fisheries management and conservation needs.

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Exposure to fluctuating temperatures during ontogeny increases Delta Smelt's upper thermal tolerance (F. Mauduit)

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Starting in 2022, Delta smelt (*Hypomesus transpacificus*) spawned and reared at the UC Davis Fish Conservation and Culture Laboratory (FCCL) have been released into the San Francisco Bay Delta as a last resort to prevent the extinction of the wild population. One major concern is that refuge populations adapt to captivity and may not be fit for the challenges posed by a wild environment. For instance, the current FCCL husbandry conditions include a stable temperature of 16°C throughout the life of the organisms, which may result in fish with reduced temperature tolerance. In that context, we assessed the possibility of increasing Delta Smelt upper thermal tolerance by exposing embryos from fertilization to hatch to three temperature regimes: controlled-stable 16°C, controlled-fluctuating 16-20°C, and uncontrolled environmental conditions using cages in a pond. At hatch, we measured the upper thermal tolerance of larvae from the three treatments using a cardiac assay. Three indexes of thermal tolerance were determined: 1) the Arrhenius breakpoint temperature (T_{AB}) as a proxy for thermal optimum, 2) the maximum heart rate (f_{Hmax}), and 3) its corresponding temperature (T_{peak}). T_{AB} was found to be a degree higher in fish exposed to fluctuating or pond conditions compared to those raised at a stable 16°C (16°C: 26.34°C, Fluctuating: 27.33°C, Pond: 27.51°C). Individuals exposed to fluctuating temperatures were also able to increase their heart rate higher than the two other treatments (f_{Hmax}; 16°C: 191 +/- 4 bpm, Fluctuating: 222 +/- 4 bpm, Pond: 195 +/- 4 bpm). T_{peak} was at 27°C in the 16°C and fluctuating temperature treatments and 28°C in the pond group. Altogether, this suggests that temperature fluctuation in the laboratory or the pond increased upper thermal tolerance without any observed detrimental tradeoff. This study could inform future husbandry practices and improve the supplementation program's chance of success.

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Pesticide concentrations in Delta island ponds assessed for delta smelt supplementation habitat (J. Orlando)

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Delta smelt (*Hypomesus transpacificus*) are endemic to the Sacramento-San Joaquin Delta ("Delta") and are listed as endangered by Federal and State agencies. As a result, resource managers are pursuing supplementation of the wild population with fish from a refugial conservation population. Identifying suitable natural habitats for delta smelt is a considerable challenge for conducting research on delta smelt supplementation. We addressed this challenge by measuring the presence of over 170 current-use pesticides in water and sediments in the ponds and pond water sources of natural pond habitats on four Delta islands (Bacon Island, Bouldin Island, Webb Tract, and Holland Tract) in the Winter and Summer of 2022.

Twenty-nine pesticides were detected in water samples, and all water samples contained multiple pesticides. The most frequently detected dissolved pesticides were the insecticide methoxyfenozide and the herbicides glyphosate, bentazon, and hexazinone. Dissolved pesticide concentrations were generally less than 100 nanograms per liter (ng/L) except for the herbicide glyphosate, which had observed concentrations of up to 6,820 ng/L. All bed sediment samples also contained multiple pesticides, and a total of 23 pesticides were detected. The most frequently detected pesticides in bed sediments were p,p'-DDE, bifenthrin, and pendimethalin.

Of the four islands in this study, the sites on Holland Tract contained the least amounts of pesticides, while ponds and pond inlets on Bouldin Island generally had higher concentrations. The Bouldin Island East Pond and its inlet site were the only sites where pesticide concentrations exceeded EPA aquatic life benchmarks. At many sites, pond inlets contained higher total pesticide concentrations than their corresponding pond. Resource managers can use the results from this study to help evaluate the suitability of these pond habitats for delta smelt supplementation and to adaptively manage pond water inputs to mitigate the potential effects of pesticides on smelt in the ponds.

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What habitat metric most influences delta smelt population growth rates and what will it take to reverse declines? Life cycle modeling says summer outflow and a lot of it! (L. Polansky)

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Many features of the Delta hydrology and aquatic habitat can and do influence delta smelt recruitment and survival. What is less understood is which ones are most important for regulating the delta smelt population growth rate, and what conditions will lead to positive growth. We developed a life cycle model that linked habitat metrics to the population growth rate from 1991-2016 in order to rank these in order of importance, and to identify conditions which would lead to positive growth. The model describes four seasonally resolved vital rates: recruitment in the spring followed by summer, fall, and winter survival. During this time period, factors consistently emerging as most important were spring food for adult spawners and water temperature, summer Delta outflow, fall X2 location, and winter Old and Middle river flows interacting with south Delta turbidity. A comparison of vital rates between cohorts with negative and positive growth rates showed that recruitment and summer survival were distinctly higher for cohorts with positive growth rates, whereas fall and winter survival rates were not clearly differentiated. Sensitivity analyses showed that summer outflow is the factor most frequently having the greatest potential to change the population growth rate. We quantitatively describe the population growth rate distribution across the six covariates, and boundaries within the covariate space that delineated negative from positive growth were identified. These boundaries are nonlinear and complex, but show that with summer outflow typified by dry years no subsequent conditions will result in positive population growth. This suggests a multi-annual perspective will be needed for conservation and recovery actions. From a Pareto optimization perspective these boundaries also delineate combinations of recovery strategies that could lead to positive growth with a non-zero probability while maximizing anthropogenic use of the natural resources contained within the Delta.

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Effects of salinity on fertilization, hatching, and larval performance of longfin smelt *Spirinchus thaleichthys* (M. Rahman)

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Understanding the spawning and rearing habitats of fishes is critical to effective fisheries management and conservation. Longfin smelt, *Spirinchus thaleichthys*, is an imperiled migratory fish that is believed to spawn and rear in habitats of varying salinities; however, optimal conditions for each stage remain unknown. Here, we examined the effects of variation in salinity on egg fertilization, hatch success, and larval growth and survival. Eggs that were fertilized in freshwater (0.4 ppt) exhibited a significantly higher fertilization rate (81%) than those fertilized in brackish water (62% at 5.0 ppt), with no detectible effects of fish origin or female size. In contrast to fertilization rates, hatching rates of embryos were not affected by fertilization salinity, incubation salinity, nor their interaction; however, hatching success (77% to 96%) and larval survival (25% to 98%) both increased with increasing maternal body mass. Larval growth rate appeared independent of salinity and maternal size. Taken together, the results indicate that fertilization is optimal at lower salinities; however, embryos and larvae can perform well across a range of salinities. Furthermore, results indicated that larger mothers produced higher-quality offspring, a finding that supports the 'bigger is better' paradigm in fisheries science and management. These results likely explain, in part, the spawning and rearing behaviors of wild longfin smelt and suggest that the conservation culture program would likely be optimized by utilizing freshwater fertilization and the largest females as broodstock.

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Understanding complexity in juvenile Longfin Smelt life history using otolith Sr isotope geochemistry (A. Scott)

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There is a strong correlation between freshwater outflow through the San Francisco Estuary and recruitment of the California Threatened Longfin Smelt. However, the mechanisms that drive this relationship are not well understood. To better understand the relationships between outflow and life history, Strontium stable isotope ratio (87Sr/86Sr) was analyzed along the growth trajectory of the otoliths from age-0 Longfin Smelt caught over two decades. Chemistry profiles were paired with otolith-based age estimates to characterize the movements of individuals across salinities over time. Results revealed at least four broad clusters in the early migratory life history of Longfin Smelt. Longfin smelt appeared to hatch or rear in a variety of different salinities (0 to >6 ppt), and migrated downstream to higher salinity habitats at various times, including some that exhibited prolonged residency in freshwater. Saltwater migrants typically began migration between 50-100 days-post-hatch, and had completed the migration to saltier water by 150 days-post-hatch. During periods of drought, a higher proportion of age-0 individuals hatched and remained in freshwater, whereas in wet years, a higher proportion of fish hatched and remained at higher salinities. These results highlight the diversity of life histories expressed by this imperiled species, and suggest that freshwater outflow is important for downstream dispersal of recruits to higher-salinity rearing habitats, possibly affecting growth, survival, and recruitment success.

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Environmentally-relevant concentrations of neurotoxic compounds significantly impact larval Delta Smelt behavior (A. Segarra)

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Insecticides are commonly used globally in agricultural, industrial, and household settings and have been detected in surface waters worldwide. In the San Francisco Bay Delta (SFBD), the population decline of the endangered Delta Smelt (*Hypomesus transpacificus*) has been significantly associated with multiple stressors, including insecticide use. This endemic species is prone to exposure to a multitude of toxic contaminants throughout its life cycle. Early life stages, such as yolk-sac larval stages, are the most sensitive to contaminants, and exposures to environmentally relevant concentrations of insecticides have the potential to alter neurodevelopment and behavior. Our study addresses behavioral toxicity of six pyrethroids to yolk-sac larval Delta Smelt, as well as behavioral effects following exposure to ambient water samples collected at 4 sited in the SFBD. Larvae were exposed for 96 h after which they were subjected to a dark and light cycle stimulus assay, under which we determined behavioral toxicity. Assessment of locomotion, photomotor response, and arena exploration were used to evaluate potential neurological alterations. Our data indicate that exposure to all six pyrethroids and ambient water samples significantly affected larval behavior. Depending on pyrethroid concentration and site location, larvae became either hypo- or hyperactive, non-responsive to light stimuli, and more prone to take risks; likely to translate into increased risk of predation. In conclusion, our study suggests that environmentally relevant concentrations of contaminants can significantly alter larval Delta Smelt behavior, and confirms that behavior is a highly sensitive and ecologically relevant endpoint. This approach can be used to monitor toxicity across known nursery sites for this species of conservation concern, particularly in association with planned supplementation.

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Season-scale risk of post-larval longfin smelt entrainment is predicted by hydrologic conditions and adult abundance (M. Tillotson)

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Longfin smelt (LFS) are at risk of entrainment into the South Delta and pumping facilities at multiple life stages. While adults are sporadically observed in the fish salvage facilities, post-larval LFS are more commonly counted in salvage in some years, and qualitative larval monitoring suggests that the smallest life-stages are also at risk. Most salvage of post-larvae occurs in the late winter and spring, and during this period efforts to minimize entrainment are undertaken by the Smelt Monitoring Team (SMT). These efforts include managing combined Old and Middle River (OMR) flows based on a combination of fixed triggers (e.g. survey catches of LFS at multiple South Delta stations) and a more holistic risk assessment that combines multiple data sources with expert opinion to assign low, medium or high risk of LFS entrainment. While this real-time assessment of risk is an important tool for minimizing entrainment of threatened species, the historical patterns of LFS salvage suggest that entrainment is influenced not only by geographically and temporally proximate conditions, but also by life-history dynamics that operate on seasonal timescales. Based on a working theoretical model, we hypothesized that the interaction of adult LFS abundance and migratory phenology with hydrologic conditions during the late fall and winter could be used to predict season-scale risk of post-larval LFS entrainment during the following spring; providing early warning to resource managers and potentially allowing for early management interventions. To test this hypothesis, we developed a series of relatively simple classification tree models using predictor variables that would be available during the late fall and winter. We found that hydrology was by far the strongest predictor of entrainment risk while adult abundance played a secondary, but significant role. These results could be used to complement the current management process by adding context to real-time data used in risk assessments.

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Invasive Species

Spread of Invasive Bluefin Killifish (*Lucania goodei*) in Sacramento/San Joaquin River Delta (G. Smith)

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Bluefin Killifish (*Lucania goodei*) are a topminnow species that are native to the states of Florida, Alabama, and Georgia in the southeastern United States (Page & Burr, 1991). This species was first detected in the Sacramento/San Joaquin Delta in 2017 by the US Fish and Wildlife Service Delta Juvenile Fish Monitoring Program (DJFMP) (Mahardja et al. 2020) and have since spread throughout the delta. This poster illustrates the spread of Bluefin Killifish over the last 5 years in the Sacramento/San Joaquin delta system. The Bluefin Killifish was first detected in the Delta Cross Channel near Walnut Grove, CA. The species remained local to the region around the Cross Channel for the first two years after their detection. In 2019 sampling programs detected a rapid spread of *Lucania goodei* throughout the delta. By 2022 they were found as far north as Knights landing on the Sacramento River and as far south as Mossdale Landing on the San Joaquin River. The documentation of the Bluefin Killifish from discovery to the present provides a unique look into the spread of a non-native species in the Sacramento-San Joaquin River Delta.

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A look at species identification using morphologic characteristics and genetic analysis procedures for the nonnative Wakasagi (*Hypomesus nipponensis*) (J. Stagg)

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Accurate species identification is critical to the operation of any fish monitoring program. In the San Francisco Estuary, efforts to monitor the imperiled Delta Smelt (Hypomesus transpacificus) using morphologic characteristics can be challenging due to the presence of the similar looking nonnative Wakasagi (Hypomesus nipponensis). Since 2017, the U.S. Fish and Wildlife Service has implemented a two-stage verification process to distinguish between the two species to help prevent misidentification that can affect evaluation of the relative population size and distribution of Delta Smelt. Under this process, Wakasagi are initially identified in the field then independently identified a second time by an experienced staff member in the laboratory and stored on-site where they can be made available for future studies. Recently a subset of Wakasagi collected during routine sampling between 2017 and 2021 were sent to the UC Davis Genomic Variation Lab for independent genetic verification using the newly developed Specific High-sensitivity Enzymatic Reporter un-LOCKing (SHERLOCK) assay for Wakasagi. This genetic verification validated our Wakasagi identification protocols and serves as an effective quality control measure. Here we present the morphologic criteria use by the USFWS to distinguish between the two species and explain how recent developments in genetic tools like SHERLOCK can offer an effective and efficient hybrid approach for ensuring accurate species identification in the future.

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Non-native Wakasagi males and endemic Delta Smelt females spawn together successfully under laboratory conditions (Y. Tsai)

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In the San Francisco Estuary, hybridization is known to occur between non-native Wakasagi (*Hypomesus nipponensis*) and endemic Delta Smelt (*H. transpacificus*), which could be a threat to the genetic integrity of Delta Smelt. Thus far, all field-caught hybrids have had a Wakasagi maternal parent, suggesting that hybridization in the wild between these two species is asymmetrical. We explored whether this asymmetry can be explained by pre-zygotic barriers. Five mature, wild Wakasagi males and five ripe, cultured Delta Smelt females were introduced into spawning tanks and video recorded for four days. Videos were analyzed for spawning behavior, and resulting eggs were incubated, counted, and categorized as being fertilized or dead. We found that Wakasagi males and Delta Smelt females willingly and successfully spawned together. Specifically, they engaged in a mean ± SE of 34.6 ± 11.7 spawns and 66.8 ± 21.4 attempts per 24 hr (N = 7 trials). This was a similar rate of spawns, but a much higher rate of attempts, than that of trials between cultured Delta Smelt males and cultured Delta Smelt females (37.1 ± 8.4 spawns and 25.5 ± 6.7 attempts per 24 hr; N = 17 trials; Tsai *et al.* 2021). We also found that eggs were successfully fertilized in all trials (52.5 ± 8.5% fertilization success). Thus, spawning behavior, physical capability, and zygotic compatibility between Wakasagi males and Delta Smelt females are not barriers to hybridization. Instead, post-zygotic mechanisms or sex- and species-specific differences in spawning location or timing may better explain the observed asymmetry.

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Lower Food Webs

Monitoring, modeling, prediction (MMP) project: looking for patterns in nutrients, and water quality leading to phytoplankton blooms (R. Dugdale)

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MMP, a project supported by CDFW (Prop 1) endeavors to enhance food production for Delta Smelt by improving the existing ability to predict phytoplankton blooms. It combines multidimensional modeling, high-resolution observations and shipboard transects to test whether blooms occur 1) when ambient ammonium concentrations decline and nitrate uptake by phytoplankton is initiated, and/or 2) at specific locations due to tidal forcing of chlorophyll from upstream. A relationship between low ammonium and high chlorophyll due to the repression of nitrate uptake has been described. We have also found an association between a salinity minimum and both a chlorophyll maximum and an ammonium minimum. Typically, a reduction in salinity is observed in the seaward direction accompanied by reduced ammonium concentration and increased chlorophyll.

The potential role of salinity and circulation in genesis of an observed phytoplankton bloom (>25 µg/L chlorophyll on 16 April 2021) was studied. Vertical profiles showed this chlorophyll extended to depth, with a subsurface maximum at US649, 85km from the Golden Gate. Salinity contours revealed a salinity front at ~81km from GG, near to the sub-surface chlorophyll region. This suggests a two-compartment system separated by a density front, one in saltier water (seaward), the other fresher (landward) where a bloom may incubate as a blob that is pushed up and downstream by tidal saltwater. This is supported by fixed station fluorometer data from Decker Island that showed elevated chlorophyll (> 10 µg/L) on 1 April, 16 days before the 16 April bloom observed at US649, which also showed up at the Decker site. Both nutrient regimes and tidal forcing are associated with bloom development. The coupled SCHISM-CoSiNE biogeochemical model reproduces the pattern of salinity and fluorescence observed in the April 2021 bloom at Decker Island and predicts the bloom observed at USGS649.

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Using Image Analysis of Zooplankton to Fill Gaps in Food Webs of Fishes (T. Ignoffo)

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Monitoring of zooplankton by IEP has resulted in one of the longest-running and quantitatively dense records anywhere and forms the basis for assessing food availability for fishes of concern such as delta and longfin smelt. To assess the quantity of food available, we need estimates of biomass. The goal of our project is to develop a method for estimating zooplankton biomass using an image analysis technique calibrated to carbon biomass. Image analysis has advantages over carbon analysis in that it can be done easily and accurately with less expensive equipment. In this project we sampled zooplankton at multiple salinities and seasons to capture as many zooplankton taxa as possible and assess the effects of five preservation methods on their volume and carbon content. The samples were sorted by taxon, measured, imaged, and analyzed on an elemental analyzer for carbon content. The images of the same specimens were analyzed to estimate their volumes. Volume-to-carbon conversions are being developed. Once individual species and stages have been analyzed, we will determine if processing bulk samples is feasible as a quick analysis of the carbon content of multiple species simultaneously. To date, volume estimates have been completed for the copepods *Eurytemora carolleeae* and *Acartiella sinensis*, the mysid *Hyperancanthomysis longirostris*, the cladoceran *Daphnia magna*, and the amphipod *Gammaras daiberi*. Carbon and volume measurements for *E. carolleeae* have been analyzed across all preservation methods, with 2% glutaraldehyde producing the best fit between volume and carbon content. These data and a tested protocol for collecting them will fill gaps in knowledge of the prey of listed smelt species, providing the scientific community with a tool that can be used to assess the food biomass available to the smelt and other pelagic fishes and to assess trophic transfer in the Delta and Suisun and San Pablo Bays.

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Characterizing the diversity of microorganisms in the wetlands of the San Francisco Estuary, using molecular techniques (E. Ortiz)

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Microorganisms such as bacteria and phytoplankton serve as the foundation of food webs in aquatic ecosystems. Slight alteration to the microorganism assemblage radiates up the food chain affecting all animals, including humans. In the San Francisco Estuary (SFE), the study of microorganism communities is often neglected because they are small and diverse, and sampling them is difficult, which hinder efforts to define ecological patterns difficult in dynamic estuarine environments. In order to fill gaps in our knowledge of microorganism communities at different wetland restoration sites in the SFE, I will use high-throughput DNA sequencing (HTS) to identify differences among wetlands in the distribution and diversity of bacteria, archaea, and other plankton (pico to meso-sized). Once we have characterized the assemblages present in the study wetlands, we will determine which species are considered indicator species. Indicator species, also referred to as bioindicators, are living (often animal or plant) groups whose populations can reflect the conditions present in an ecosystem. I will identify the bacteria, archaea and phytoplankton using 16s rRNA HTS, and the zooplankton via 18s rRNA HTS to characterize which organisms are present and their relative abundance. We expect to find that the microorganism composition will differ substantially between early-stage wetlands and mature wetlands in presence or absence and relative abundance. This is primarily because of fundamental differences in the bathymetry, hydrology, history, and therefore biogeochemistry, between recently breached sites and mature tidal wetlands. With a better understanding of the microorganism diversity and patterns of distribution in recently restored wetlands, and by connecting this to other measurements such as the species of fish using the wetland, we can provide advice to restoration managers to prioritize restoration efforts in restoration projects that are more likely to provide usable habitat for fish and other species of interest.

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Impacts of Storm-Driven Contaminants on Adaptive Capacity of Prey Species in the San Francisco Bay Delta (I. Polunina-Proulx)

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Prey species found within the San Francisco Bay Delta face significant stressors, particularly from storm-driven contaminants such as insecticides. These stressors have significant impact on the food web through shifts in prey items and invertebrate community structures. For example, there have been recorded instances of prey communities evolving resistance to insecticides, which suggests ecological impairment and contributes to trophic transfer of high insecticides concentrations to fish. However the extent of adaptive resistance across invertebrate communities is not known. To better understand the extent of adaptive resistance in the San Francisco Bay Delta, common invertebrates were collected for evaluation of resistance in two genes: resistance to dieldrin (RDL) and voltage-gated sodium channel (VGSC). These genes are common targets of insecticides and mutations in these genes can confer resistance to the insecticide. The common prey items were divided by their orders, including Trichoptera, Plecoptera, Diptera, Amphipoda, Cladocera, Copepoda, Ephemeroptera, and Odonata. For each order and gene, degenerate primers were made and tested for their validity on a small number of samples from each order. Most of the degenerate primers were able to produce the expected product size for their appropriate gene and order. Degenerate primers for RDL successfully amplified gene products for Trichoptera, Plecoptera, Diptera, Cladocera, Ephemeroptera and Odonata and were identified correctly via sequencing. Degenerate primers for VGSC successfully amplified gene products for Trichoptera, Diptera, Ephemeroptera and Odonata and were identified correctly via sequencing. To date, none of the correctly identified gene sequences contained amino acid changes that would confer resistance; however the number of individuals tested per order ranged from 4-12 individuals during the project. This project has opened the door to further optimizing an assay to evaluate insecticide resistance across the key prey species of the Delta.

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How do food supplements affect the growth and reproductive rates of calanoid copepods in the upper estuary during seasonal transitions? (A. Slaughter)

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Long-term declines in delta and longfin smelt may be, in part, due to lack of food resources during critical life stages. Two important prey species, the calanoid copepods *Pseudodiaptomus forbesi* and *Eurytemora carolleeae*, change in abundance seasonally. We are investigating the mechanisms behind these seasonal patterns during key transition periods – spring (*E. carolleeae* declines), spring-summer (*P. forbesi* levels off), and autumn (*P. forbesi* declines).

Here we present results only for *P. forbesi*, but similar collections and experiments were conducted for *E. carolleeae*. When both species were present, we conducted paired-species experiments to test for possible evidence of feeding competition. We collected copepods from the field to estimate abundance, egg production, and growth rates using an incubation method. For growth rate experiments, copepods were incubated for 0 to 2 (in one case 5) days in ambient (site) or supplemented (site + added phytoplankton) water. *P. forbesi* growth rates in ambient water generally declined from spring-summer to autumn (~0.5 to 0.2 d^{-1}, respectively), while other metrics for *P. forbesi* (e.g., abundance, egg production rate) also declined. During autumn, copepod growth rates modestly increased when copepods were provided food supplements (e.g., 0.29 versus 0.39 d^{-1} in ambient vs supplemented water, respectively). Our results so far support the theory that, in our study sites, *Pseudodiaptomus forbesi* growth and reproductive rates during the autumn seem to be limited by food resources, which likely contributes to the declining population during the autumn transition. We will compare these results with data on *Eurytemora carolleeae* during the spring transition.

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Potpourri

Revealing Delta Mysteries with Underwater Mapping (S. Mayr)

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The impacts of climate change are reshaping our estuary in numerous ways. With increasing periods of extreme drought and flood, the seafloor of the Sacramento—San Joaquin Delta is constantly shifting and likely altering the habitats of its native species. Advanced sonar technologies allow us to create high resolution bathymetry maps that quantify channel topography, sediment deposition, scouring, and bed composition. The Department of Water Resources, North Central Region Office has been mapping the bathymetry of the Delta for over 30 years. Through long term monitoring and mapping of these regions, we are gaining valuable insight about the San Francisco Estuary and its diverse habitats.

* *Presenting author*

Long-term Dataset Reveals Black-crowned Night-Heron (Nycticorax nycticorax) Nest Survival is Primarily Associated with Bottom-up Processes on Alcatraz Island, San Francisco, California (D. Munoz)

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Alcatraz Island is a popular tourist attraction in San Francisco, California primarily known for its former years as a Federal Penitentiary. The island also provides important nesting habitat for multiple avian species within the San Francisco Bay Estuary. The U.S. Geological Survey has monitored black-crowned night-heron (*Nycticorax nycticorax*) nests on the island annually since 1990, culminating in one of the longest running nest monitoring programs within the estuary. Night-herons within the San Francisco Bay Area are non-migratory and can act as resident indicators of estuarine health at higher trophic levels. Given that small, short-term datasets often limit the number of hypotheses that can be investigated, our dataset provided a valuable opportunity to estimate the influence of environmental factors on night-heron nest survival. Additionally, data from other long-term monitoring projects in the estuary (e.g., CDFW Bay Study, NPGO) enabled us to formulate more comprehensive hypotheses regarding night-heron reproductive ecology than our lone dataset would have accommodated. We used Bayesian logistic exposure models to evaluate multiple *a priori* hypotheses and estimate nest survival in response to multiple abiotic and biotic variables (i.e., nest placement, nest timing, food abundance, regional productivity, and climate). We found that nest survival is positively associated with greater numbers of conspecific nests and earlier initiation dates. Nest survival was also influenced by the interplay between regional productivity, precipitation, and anchovy abundance. These elements likely mitigate the cost of reproduction for incubating adult birds. Periods with larger populations of anchovy were especially associated with increased cumulative nest survival, even when precipitation and regional productivity were low. Favorable conditions for forage fishes are beneficial to the piscivores that hunt them. Our findings addressing demographic trends in an estuarine predator can guide decisions that support sustainable nesting colonies within multiple-use urban settings. Findings are preliminary and provided for timely best science.

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Resident Fishes

Where's the hitch? The distribution of hitch (*Lavinia exilicauda*) in the Sacramento San Joaquin Delta (C. Macfarlane)

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In the highly altered Sacramento-San Joaquin Delta, flow modification, destruction of wetland habitat, and the establishment of invasive species have impacted the abundance of native fishes. The Sacramento Hitch (*Lavinia exilicauda exilicauda*) is an understudied native cyprinid fish that occupies only a fraction of its historic range in the Delta. Juvenile Hitch rear in vegetated nearshore areas before transitioning to a benthic environment as adults; however, the locations of crucial habitats within the Delta are not well defined. Identifying regions that support nursery and rearing functions is critical in understanding a species' risk of extirpation. Multiple ongoing monitoring programs provide data showing the spatial distribution of Sacramento Hitch in near-shore areas. Using fork length as a proxy for maturity, catch data from 2018-2021 Delta Juvenile Monitoring Program's littoral nearshore surveys, the Beach Seine Survey, and Boat Electrofishing Survey are analyzed to determine the distinct regions Hitch inhabit at different life stages. Hitch fork length distribution increased from suspected nursery areas in the upper Cache Slough Complex to the more tidally influenced Central and Western Delta, indicating a semi-migratory pattern like that found in their relative the Clear Lake Hitch (*Lavinia exilicauda chi*). Fork length distributions in Cache Slough were skewed towards juveniles (<100 mm) while the Central Delta maintained clusters of fork lengths both >150 mm and >350 mm. The Cache Slough region provides shallow-water sloughs, side channels, and complex cover for juvenile Hitch to mature before moving to larger water in the Central Delta, migrating between the two. To target conservation efforts that best support Hitch survival in the Delta, environmental characteristics underpinning their choice in spawning and rearing grounds and cues leading to migration must be further explored.

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Environmental factors influencing Hardhead *Mylopharodon conocephalus* CPUE on the lower Sacramento River (A. Merrens)

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The Hardhead minnow (*Mylopharodon conocephalus*) is a species of cyprinid that is endemic to California. Historically, hardhead have been detected by the US Fish & Wildlife Service's long-term Delta Juvenile Fish Monitoring Program (DJFMP) in the lower Sacramento and San Joaquin Rivers. Hardheads prefer primarily tepid clear swift flowing streams with rocky substrates in mid to low-elevations. These habitat conditions are not common in the delta, and it has been hypothesized that detection is only due to consistent flows meant for urban and agricultural use which increase water quality just enough for survivorship. Hardheads are sensitive to reduced oxygen levels in warmer water; it is likely that bottom-water reservoir releases in the Lower Sacramento River during summer provide habitat conditions that allow the species to maintain stable populations in this river.

We review catch of Hardhead by DJFMP surveys and investigate trends in catch rates as they relate to environmental factors: water velocity, temperature, and turbidity. We also examine detection frequency over time, and whether catch has increased or decreased in conjunction with changes in river flow using catch per unit effort (CPUE). Utilizing CPUE, we determine if long-term and cyclical changes in water quality are impacting Hardhead populations in the lower Sacramento. CPUE indicates elevated catch in Lower Sacramento and North Delta seine sites that experience flow increases in early summer. In contrast, CPUE is reduced along the San Joaquin where environmental conditions are influenced by reduced flows. Long term biological and environmental monitoring is crucial in population assessments, especially for native species, like hardheads, that serve as indicators of watershed health.

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Multi-survey assessment of White Catfish (*Ameiurus catus*) and Channel Catfish (*Ictalurus punctatus*) status and trends in the Sacramento-San Joaquin Delta (A. Nanninga)

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North American freshwater catfishes (family Ictaluridae) support popular recreational fisheries throughout their native and introduced ranges, including California's Sacramento-San Joaquin Delta (hereafter 'Delta') where multiple catfish species were introduced in the 19th century. Limited status and trend information currently exist for the two most abundant ictalurids in the Delta: White Catfish (*Ameiurus catus*) and Channel Catfish (*Ictalurus punctatus*). In this poster, we evaluated and compared standardized catch rate temporal trends for both species from four long-term monitoring programs: the US Fish and Wildlife Service's (USFWS) Delta Juvenile Fish Monitoring Program, the California Department of Water Resources (CDWR) Yolo Bypass Fish Monitoring Program, the California Department of Fish and Wildlife's (CDFW) 20 mm Survey, and the US Bureau of Reclamation's (USBR) and CDWR's Fish Salvage Monitoring Program. We observed declines in catch over time for both species across all surveys with steep declines associated with severe drought periods. The information presented can inform management of these valued naturalized species and help reconcile the need to maintain biodiversity in a human-dominated ecosystem.

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Dead Zone: Investigating the Consequences of a Hypoxia Event in Fall of 2021 (L. Olson)

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An ecologically damaging phenomenon that appears to be increasing in frequency in estuarine ecosystems since the mid-1900s is low dissolved oxygen (DO) resulting in hypoxia. We studied a small channel within the Yolo Bypass, known as the Toe Drain, that was hit by a long period of hypoxia following an atmospheric river event in late October 2021. Utilizing fish data from the Yolo Bypass Fish Monitoring Program (YBFMP) and continuous water quality data provided by the California Data Exchange Center (CDEC), we investigated the following question: What were the water quality and fish community responses in the Toe Drain following the atmospheric river? By comparing water quality and fish data in water year 2022 to historical data from water years 2014-2021, our results show that: (1) DO concentrations at Lisbon Weir in the Toe Drain averaged 2.06 mg/L during November 2021, dropping to a low of 0.71 mg/L on 11/19/2021, 2) there was a significant change in composition in catch noticeably in Black Crappie (*Pomoxis nigromaculatus*) going from a mean CPUE of 1.74 to 3.76 and White Catfish (*Ictalurus catus*) going from a mean CPUE of 22.31 to 0.29 shifting the dominance of catch to Black Crappie after the 2021 event. While further research is needed to identify the mechanisms responsible for the low oxygen conditions observed in the fall of 2021, long term monitoring efforts allows managers to better understand ecological responses to unprecedented events likely to become more common in the face of California’s changing climate.

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A preliminary look at fine-scale drivers of pelagic fish distribution in Suisun Bay, California (D. Palm)

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Physical factors such as tide, turbidity, and salinity can influence the spatiotemporal distribution of estuarine fish species at broad (estuary-wide) and finer (habitat-specific) scales. Management efforts in the upper San Francisco Estuary are often guided by long-term monitoring programs that prioritize assessment of long-term trends over fine-scale habitat relationships. Additional sampling is needed to further contextualize these fine-scale fish-habitat relationships to guide more targeted management efforts. We initiated a multi-year high-resolution sampling effort across varying environmental conditions in Suisun Bay to address fish-habitat relationships on tidal time scales. Synchronized deployments of midwater trawls and otter trawls were used to assess vertical distributions of fish throughout a range of habitat gradients. We also collected concurrent water quality and velocity measurements at variable depths to document the range of environmental conditions during trawls. This poster presents preliminary results from the first year of this study that can be used to inform continued high-frequency sampling and data collection in Suisun Bay.

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Salmon & Sturgeon

Estimating DJFMP Seine Capture Efficiency in the Sacramento - San Joaquin Estuary (M. Arndt)

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The Lodi Fish and Wildlife Delta Juvenile Fish Monitoring Program (DJFMP) is a long-term fish monitoring program that uses a variety of gear types to capture fish species across different habitats. Since 1976, DJFMP has conducted year-round beach seine monitoring to evaluate the impacts of water conveyance on the survival of salmonids in the Sacramento – San Joaquin Delta. An IEP Science Advisory Group report, completed in 2013, determined that the spatial and temporal variability of seine efficiency among sites and regions is unknown. Consequently, the ability of the DJFMP to document the true occupancy of fishes may be limited. The Beach Seine efficiency study has been estimating the species – and size – specific capture efficiency of DJFMP beach seines for fishes occurring in near shore habitats within the Sacramento – San Joaquin Delta using multiple pass depletion methods. Variability of abundance estimates is a function of how well and consistently fish numbers are approximated and can be estimated using depletion methods (Peterson et. al. 2004, Rosenberger and Dunham 2005). Depletion methods are more effective than mark-recapture methods for migrating species, such as salmonids, due to a short sampling time period and can be executed with a two pass or multi-pass sample to provide population estimates (Lockwood and Schneider 2000). DJFMP is assessing variation in abundance estimates, or 'gear efficiency', using multiple pass depletion methods. We assessed capture efficiency across multiple species, including Chinook salmon, a species of interest. Our analysis determined that DJFMP seines have variable capture efficiency across species with capture efficiencies that can range from 35 percent (Shimofuri Goby) to 67 percent (Mississippi Silverside).

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Impacts of water temperature on adult Chinook salmon energy use during migration, holding, and spawning (B. Atencio)

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As the combination of climate change and other human activities continues to affect stream conditions in California's Central Valley (CCV), especially water temperatures, it is vital to understand how and where environmental constraints may play a role in the spawning migrations of CCV Chinook salmon. Here, we aimed to quantify how the environment impacts energy use and survival of CCV Chinook salmon during their upriver migration, holding, and spawning stages. In 2021 and 2022, thousands of CCV Chinook were measured for lipid density at various stages of their migration, from ocean habitat to riparian spawning grounds. And in 2022, over 100 adult Chinook salmon were implanted with acoustic telemetry tags in the ocean and tracked with an extensive receiver network stretching from the ocean fishing grounds to the upper reaches of CCV rivers. These data will enable us to characterize individual migrations and thermal exposure using acoustic tag detections, estimate energy use empirically and with bioenergetics modeling, and explore possible environmental constraints to migration and survival. Ultimately, the results from this study will help to develop thermal thresholds specific to CCV salmonids and give us a better understanding of how climate change and water management alternatives may impact salmonids. Preliminary results suggest that CCV Chinook salmon energy densities vary inter annually and with run type. Results also indicate that fall-run Chinook salmon use a large portion of their fat reserves in the migratory and final development stages between the ocean and lower river reaches, while spring-run Chinook salmon may use the largest portion of their fat reserves during their in-river holding and development period over summer. This poster will present an overview of the project and preliminary results from the two seasons of energy density measurements.

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Relative predation risk of fish in a restored tidal wetland (D. Ayers)

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Scientists must understand if restored tidal wetlands provide essential habitat for juvenile fishes, including, for food and rearing purposes, and as predation refugia. Indeed, the prospect of increased refugia from predation underlies motivation to remediate estuarine habitats globally; yet this putative benefit is almost never quantified. We evaluated relative predation risk for juvenile Chinook salmon (*Oncorhynchus tshawytscha*) using chronographic tethers – devices that record the exact time when prey fish are retrieved by a predator. Timing of predation events, along with corresponding measurements of the environmental setting, provide novel insight into how abiotic factors shape predation risk overall. In 2022, we conducted a series of tethering trials at Tule Red, one of many tidal wetland restoration projects in the San Francisco Bay-Delta. Preliminary results demonstrate that relative predation risk is non-random and driven by tidal phase, water depth, and wetland location. These insights, particularly the relationship between water depth and predation risk, may help scientists better categorize, quantify, and restore tidal wetland habitats which support native and imperiled fishes.

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Confirmed Presence of Green Sturgeon (*Acipenser medirostris*) in the Stanislaus River (A. Dahl)

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White Sturgeon (*Acipenser transmontanus*) and Green Sturgeon (*Acipenser medirostris)* have been historically known to occupy the San Joaquin River (SJR) watershed. The Green Sturgeon is listed as threatened under the U.S. Endangered Species Act (ESA). Historical and current studies provide evidence that White Sturgeon are spawning in the San Joaquin River, however information regarding the presence of Green Sturgeon in SJR or its tributaries is limited. In July of 2022, a sturgeon was witnessed holding in a pool in the Stanislaus River below Knights Ferry. An ARIS sonar unit and Go Pro video camera was used to monitor presence and further investigate species identification. Images captured from Go Pro footage confirmed the species to be a Green Sturgeon in early October 2022. On 3 November 2022, California Department of Fish and Wildlife (CDFW) successfully captured, tagged, and safely returned the Green Sturgeon back to the river. A VEMCO V16 acoustic tag was surgically implanted along with a PIT tag, allowing the fish to be detected by VR2W acoustic receivers located at several different locations within the SJR watershed. Data recorded by these receivers allowed us to confirm the presence of the fish holding in the same pool until late December immediately following a period of high flows reaching 5,000 cfs when it was no longer detected at this location. We then downloaded receivers at upstream and downstream sites to determine the direction of its movement. The data collected revealed that the sturgeon was detected by a receiver located downstream in the Stanislaus River on 1 January 2023 and continued migrating toward the bay where it was detected at the Antioch Bridge just seven days later. Confirming the presence of an adult Green Sturgeon in the Stanislaus River emphasizes how crucial it is to better understand the ecological importance of the SJR and its tributaries.

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Rescuing and Monitoring Sturgeon during drought on the Lower Tuolumne River (C. Diviney)

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The San Joaquin River (SJR) is located in the southern part of the Central Valley and has three primary tributaries, the Merced, Tuolumne, and Stanislaus River. Sturgeon spawning has been documented in the SJR historically, but its status is largely unknown in the tributaries. In April 2021, the Department received photos of multiple sturgeon holding in a pool in the lower Tuolumne River after spring pulse flow had receded. By June, as stream temperatures reached 30°C and river depth downstream of this pool made it improbable for sturgeon to migrate downstream, relocation of these fish became necessary. Three White Sturgeon were successfully captured using a trammel net, tagged with an acoustic tag and a PIT tag, and then released at Mossdale Crossing Regional Park. Further monitoring with the ARIS confirmed the presence of two more sturgeon holding in this pool until hyacinth completely covered the pool. After pulse flows increased in December 2021, the hyacinth had passed downstream, and the Department continued monitoring this pool and found no evidence sturgeon presence. Habitat assessments based on hydrologic conditions (such as streamflow and water temperature) and streambed composition suggest that the tributaries may offer a more favorable spawning and rearing habitat compared to the SJR. Small cobble found in the lower part of the tributaries is not the most optimal substrate for sturgeon spawning, but it offers a better alternative than the fine sediments and rip rap found in the SJR. Spring pulse flows can be beneficial for creating optimal water temperatures and habitat suitable for spawning and rearing, however as the rivers recede to summer base flows, adult sturgeon may become susceptible to stranding.

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Estimating Juvenile Salmonid Loss within the Delta State Water Project Water Diversion Facilities (P. Hurley)

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Mortality of fishes entrained into the State Water Project (SWP) Delta water diversion facilities, has been identified as a contributor to the decline of some populations including Chinook Salmon and steelhead. The SWP Delta water diversion facilities consist of a forebay and a fish salvage facility using louvers that collect fish from water being diverted to the pumps. Salvaged fish are then transported and released downstream, beyond the influence of SWP Delta water diversions. However, there is mortality/loss associated with the entrainment and salvage process. To comply with regulatory requirements, salmonid mortality associated with operations of the SWP is closely monitored and efforts are in effect to study and reduce mortality. A component of reducing loss requires knowledge of how juvenile salmonids survive and move through the facilities. Since 2017, an acoustic telemetry study has been conducted to estimate survival and to evaluate movement behavior of juvenile salmonids within different reaches of the SWP. Bayesian survival models are used to analyze the detection records. Results to date have revealed that survival is highly variable within and between years and across different categories of juvenile salmonids. By continuing to monitor salmonid movements and losses within the SWP facilities, targeted measures can be implemented to increase the likelihood of survival through the entrainment and salvage process.

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Acute toxicity of bifenthrin and fipronil to juvenile Chinook Salmon (*Oncorhynchus tshawytscha*) using whole body residues (K. Knaub)

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Salmonid populations in California have been in decline since the 1950s, and recent projections suggest extirpation of several salmonid species in this region within the next 50 years. Pesticide pollution has the potential to contribute to population declines and has been identified throughout the salmon rearing and migration areas of the Sacramento-San Joaquin Delta (Delta). Though many pesticide toxicity studies have used aqueous concentration as the dose metric, its use has limitations when considering confounding factors such as bioavailability and physical characteristics of the system (e.g., temperature and pH). This reduces the relevance of these studies to understanding population health in larger ecosystems. Furthermore, risk assessments that utilize field water pesticide concentrations may under predict pesticide toxicity because field water samples only represent a snap-shot of what may be available in that system at the time of collection. As an alternative, the use of internal body residues can provide a time-weighted average of what a fish is exposed to in the system. Specifically, quantifying toxic response according to body residue is a more appropriate dose metric because it better represents exposure in the fish. We seek to establish a relationship between toxic response and body residue in Chinook Salmon (*Oncorhynchus tshawytscha*) by establishing the median lethal residue (LR_{50}) for two current-use pesticides that have been previously detected in field Delta salmon, bifenthrin and fipronil. In our study, Chinook Salmon were exposed to either bifenthrin or fipronil for 96 h, subsequently euthanized, and preserved for pesticide analysis. The calculated LR_{50} for bifenthrin, parent fipronil, and the sum of fipronil and its toxic metabolites were 0.61, 7.4, and 9.0 nmol/g wet weight, respectively. Different normalization techniques using dry weights and lipid fractions will be contrasted. Inter-laboratory comparisons will be performed to assess variability across labs and Chinook Salmon populations.

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Challenges and Results of the CDFW Stanislaus River Steelhead Redd Surveys (R. Kok)

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Dedicated steelhead monitoring in the San Joaquin River and its tributaries has historically been very limited apart from the annual steelhead fishing report cards that were implemented by the California Department of Fish and Wildlife (CDFW) in 1991. To improve management decisions, additional long-term studies were needed to better understand the fishery and populations. In 2021 the CDFW began a steelhead redd survey on the Stanislaus River to evaluate the amount and distribution of steelhead spawning as one component of the steelhead life cycle monitoring program outlined in the reasonable and prudent measures of the 2019 Biological Opinion on Long Term Operation of the Central Valley Project and State Water Project. We evaluated the results of the first two years of the survey and the various challenges that were encountered. These findings will be used to determine what methods were effective and which ones could be improved for future surveys.

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The Tunnel at the End of the Light: Could reducing artificial nighttime illumination benefit native fish? (B.M. Lehman)

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The Sacramento–San Joaquin Delta has been invaded by several species of non-native predatory fish that are presumed to be impeding native fish population recovery efforts. Since eradication of predators is unlikely, there is substantial interest in removing or altering manmade features in the Delta that may exacerbate predation on native fish (contact points). Manmade features such as artificial lighting at night (ALAN) may contribute to increased levels of predation by attracting predators to prey, increasing predator reaction distance, and foraging success. Field experiments in the Delta have found ALAN to attract both large and small fish, and to increase predation rates on juvenile salmonids by non-native predators. Removing, altering, or reducing the intensity of artificial lights that illuminate waterways is a feasible and potentially beneficial restoration action to improve the fate of native fish. However, to date there has been no inventory of ALAN in the Delta and quantifying light levels that are relevant at small spatial scales is difficult with existing remote sensing data. To inform the potential of reducing ALAN to benefit salmon, we surveyed all major channels in the legal Delta and created an inventory of illumination sources that cast measurable light onto waterways. We combine this with experimentally gathered information on predation rates as a function of ALAN and other environmental covariates, as well as frequency of waterway use by salmon, to prioritize light sources that could be addressed to benefit salmon.

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Quantifying the white and green sturgeon die-off resulting from the 2022 San Francisco Bay Area harmful algal bloom (HAB) event (A. Ortega)

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Harmful algal blooms (HABs) occur when colonies of algae overpopulate. HABs can produce toxins, causing adverse effects for humans, fish, shellfish, marine mammals and birds. The decomposition of algae that follows a HAB event can also trigger a depletion of dissolved oxygen (DO) in the water. In the San Francisco Bay Area, a HAB event caused by the algae, *Heterosigma akashiwo,* lasted from early to late August of 2022 and caused a massive fish kill of an extent that has not been observed before in this system. As a result of this event, numerous white sturgeon (*Acipenser transmontanus*) and southern distinct population segment (sDPS) green sturgeon (*Acipenser medirostris)* were killed. White and green sturgeon carcass data were aggregated from citizen science sources, such as iNaturalist, the San Francisco Estuary Institute (SFEI), as well as from Cramer Fish Sciences and CDFW's open water and shoreline surveys. To control for potential misidentification and multiple reports of the same carcass, records and associated images were manually analyzed. From these data, a total of 877 sturgeon carcasses, including at least 203 white sturgeon and 21 green sturgeon, were identified. These numbers represent minimums, since sturgeon carcasses may sink before they wash up on shore, and large sections of shoreline were not surveyed. Given the potential that many more sturgeon likely died in the 2022 HAB than were recorded, this event may represent a population scale impact for both white sturgeon (a state species of special concern) and sDPS green sturgeon (ESA Threatened). These events may also increase in frequency and severity due to climate change and water management, as associated changes in water temperature and flow create conditions suitable for HABs.

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Understanding and incorporating traditional ecological knowledge into habitat restoration efforts within the San Francisco Estuary (A. Ramos Hurtado)

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For approximately 5,000 years, Indigenous communities inhabited and stewarded the land we now know as the San Francisco Estuary (SFE). Their stewardship is founded in traditional ecological knowledge, an understanding of ecosystems on a relational and spiritual level, reinforced by oral traditions. Traditional ecological knowledge is grounded on principles like reciprocity, kinship, and sustainability which foster responsible guardianship of sacred resources like Chinook salmon. Beginning in 1769, this way of life was irrevocably changed as European settlers forcibly removed over 100,000 indigenous peoples from the SFE. Now a highly populated region and a human-dominated landscape, the SFE serves as the water delivery hub for statewide agricultural and municipal needs. Land and resource use changes have contributed to the loss of approximately 95 percent of tidal wetlands and floodplains which once characterized this region. Large-scale restoration of wetland habitats is currently taking place but generally excludes traditional ecological knowledge from decision-making spaces. However, recent research has documented significant overlap between scientific, public, and Indigenous values; thus, great opportunity exists to integrate TEK into restoration efforts with public buy-in. We encourage integration of ancestral tribes into the restoration decision-making process whereby native communities can help foster better community stewardship, communicate the intrinsic value of nature, and reflect historical and cultural values of the SFE.

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Water Quality

Monitoring and Modeling Pathogen Exposure in Salmon Migrating to the Delta (M. E. Daniels)

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The survival of Chinook Salmon outmigrating to the Delta is affected by a number of factors, one likely being exposure to pathogens. How pathogens affect the probability of mortality for salmon outmigrating to the Delta, the location and timing of exposure risk, and how environmental conditions influence the susceptibility of salmon reaching a disease state are important unanswered questions. The goals of this project were to address these research needs under two overarching tasks. First, we developed a better understanding of pathogen exposure and salmon immune response in the Sacramento and Feather rivers by screening for a wide array of pathogens in environmental water samples and salmon tissues and by assessing immune response to pathogen exposure in a subset of salmon. Second, we addressed questions around disease mortality and interactions with environmental stressors (e.g. water temperature) by developing a disease transmission model (parameterized with local field data collected in task 1) for salmon outmigrating to the Delta. The model simulates the expected health outcome on salmon from being exposed to a potential pathogen of concern in the Central Valley, *Ceratonova shasta* (*C. shasta*) and one that can has been managed for in other systems. By bringing together the monitoring and modeling frameworks in this project, this research directly improves the understanding of how Chinook Salmon, pathogens, and environmental stressors (e.g. water temperature) interact. This presentation will provide an overview of the project and preliminary results.

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To tow or not to tow? Comparing sampling methods for potentially toxic cyanobacteria (T. Flynn)

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Potentially toxic (PTOX) cyanobacteria inhabit estuaries worldwide, including the Sacramento-San Joaquin River Delta, and can form dense overgrowths of toxin-producing cells known as harmful algal blooms (cyanoHABs). These occurrences pose a health risk to organisms in these environments and present a challenge to resource managers, as the mechanisms that drive cyanoHAB formation remain poorly understood. CyanoHABs also challenge environmental monitoring programs, as they can be highly localized to the water's surface and difficult to sample adequately using typical methods. Here we compare two methods for sampling PTOX cyanobacteria and other phytoplankton: one by pumping samples from 1m depth and another by towing a fine mesh (75 μm) plankton net across the water's surface to concentration colonies of PTOX cyanobacteria. Sampling was conducted in 2021 and 2022 at Franks Tract, a flooded Delta island. We observed a greater diversity of PTOX cyanobacteria earlier in the year in towed samples compared to 1m depth. For example, cells from the PTOX genus *Aphanizomenon* were detected in May in the tows but were not detected at 1m depth. From June through September, when PTOX abundance is generally greatest, PTOX taxa (*Aphanizomenon*, *Dolichospermum*, *Microcystis*, and *Oscillatoria*) comprised 91-99.7% of the surface tow community. Only in August, at the peak of the bloom, did PTOX organisms comprise most (81%) of the sample biovolume at 1m depth. These results highlight the importance of taking the growth habits of PTOX cyanobacteria into consideration when designing monitoring plans for cyanoHABs in the Delta and elsewhere.

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Identifying Microcystin Sources and Producers In San Francisco Bay (A. Jaegge)

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Microcystins have been detected in San Francisco Bay (SFB) since 2011; however, the primary source(s) and taxa responsible for production remain unknown. Cyanotoxins negatively affect human and ecosystem health, and understanding how cyanotoxins enter SFB can help managers plan mitigation efforts. Study objectives include assessing potential microcystin sources, identifying microcystin-producing taxa, and determining microcystin degradation rates and mechanisms. From analysis of monitoring data collected in SFB between 1992-2018, we identified 7 potentially toxigenic taxa (*Planktothrix* spp., *Raphidiopsis* spp., *Dolichospermum* spp., *Oscillatoria* spp., *Aphanizomenon* spp., *Microcystis* spp., and *Anabaenopsis* spp.). The most frequently detected organism was *Planktothrix* spp., a known microcystin producer, with 66 detections. Additionally, five potential sources of microcystins have been identified including the Sacramento-San Joaquin Delta ("the Delta"), freshwater creeks and streams, South Bay ponds, shoals, and picocyanobacterial communities. Using quantitative polymerase chain reaction methods (qPCR), monthly samples from the Delta and SFB have been analyzed to quantify the abundance of the *mcyE* microcystin biosynthesis gene. From June through November 2022, detectable abundances of *mcyE* ranged between 455–6,142 gene copies mL^{-1}. Highest abundances were found in the Delta near Rio Vista, California, in June and August 2022, and South Bay returned a detectable abundance in July 2022. The abundance of *mcyE* will be examined in 2023 along with toxin concentration using liquid chromatography and tandem mass spectrometry (LC-MS/MS), and taxa will be identified using next generation DNA sequencing and microscopy. A microcystin degradation experiment planned for July 2023 will be conducted with water collected from San Pablo, Central, South, and Lower South Bays to explore biodegradation, photodegradation, and adsorption as potential mechanisms driving microcystin removal. The results of this study will inform models, public health, and the research community studying the impacts of microcystin in aquatic ecosystems.

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Development of a continuous suspended sediment monitoring network in South San Francisco Bay (L. Mourier)

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Suspended sediment dynamics are relevant to a wide range of San Francisco Bay (SFB) water quality and morphological processes including marsh habitat protection and resilience, contaminant transport, sea-level-rise resilience, and biogeochemical cycling. Despite the importance of sediment dynamics to SFB, continuous suspended sediment concentration (SSC) data are currently limited to a few deep channel locations of the Bay. In January 2022, the SFB Sediment Monitoring Project (SMP) began expansion of continuous SSC monitoring to the shallow areas of South San Francisco Bay (SSFB) as a collaboration between the Nutrient Management Strategy (NMS), the Regional Monitoring Program, and the South Bay Salt Pond Restoration Project. Leveraging existing NMS long term high frequency turbidity data (EXO2 sondes) with monthly discrete SSC samples from the NMS Moored Sensor Network, we have developed a turbidity-SSC calibration for 8 stations throughout SSFB. These stations encompass a range of Bay environments (channel, shoal, slough) spanning the area from the San Mateo Bridge to Alviso Slough. Turbidity - SSC calibrations were performed using a linear mixed effect model (LME) that considers both interdependence between sites as well as site-specific characteristics. This has resulted in a high-frequency (15 min) SSC dataset spanning nearly ten years (2013-present). Initial results suggest greater SSC at slough sites compared to channel and shoal sites. At the 15-minute scale, slough sites have an interquartile range from 80 mg/L - 171 mg/L and a maximum recorded value of 2,145 mg/L, while shoal sites have an interquartile range from 17 mg/L - 38 mg/L and a maximum recorded value of 1,715 mg/L. This continuous SSC dataset will eventually be available for use by various stakeholders and local agencies for sediment transport model calibration/validation and SB sediment-related empirical studies.

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Potential Effects of *Microcystis* Abundance on Water Quality and Dissolved Nutrients in Relation to Delta Outflow (J. Taylor)

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Harmful blooms of the cyanobacteria *Microcystis* can rapidly and efficiently uptake ammonium when environmental conditions are favorable, altering water quality in the region. These blooms have increased in magnitude and duration in the Upper San Francisco Estuary (USFE) and threaten the health of the food web by creating secondary metabolites that are toxic to both zooplankton and native fish. We collected data on the surface colonies of *Microcystis*, dissolved nutrients, and several environmental variables throughout five regions in the USFE from April 2019 to November 2022. Our dataset encompasses both wet and dry years, which is an important driver for variation of *Microcystis* abundance in the USFE. During extreme dry years, decreases in outflow have been linked to higher abundance of *Microcystis* in regions around the San Joaquin River. In the lower San Joaquin River, the lowest average *Microcystis* abundance index was seen during the wet year of 2019, but this was not consistent across all regions in our survey. Our results highlight relationships between *Microcystis* presence, outflow, and several environmental parameters to examine the potential effects of *Microcystis* blooms on water quality in five regions of the USFE.

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Occurrence Of Pesticides in Island Drainage Canals in The Sacramento-San Joaquin Delta (M. Uychutin)

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Data from previous studies have shown that surface waters throughout the Sacramento-San Joaquin Delta (“Delta”) frequently contain pesticide compounds at concentrations that may be toxic to various organisms. One source of these pesticides includes Delta islands used for agriculture. Drainage canals route surplus water from these islands to pump locations that are ideal sampling locations for pesticide contaminants. We measured pesticide concentrations in surface-water samples collected from two Delta islands as part of a larger project in the same island drainage system with the overall goal of quantifying particulate and dissolved carbon, nutrients, dissolved gases, and cyanotoxins. Island locations were selected to compare pesticide detections and concentrations from an island used mostly for agriculture (‘farmed island’) to an island used partially for wetland restoration (‘managed island’). Surface-water samples were analyzed for a suite of 178 current-use pesticides and suspended-sediment samples were analyzed for 173 current-use pesticides. Eleven to 14 pesticides were detected in each individual water sample from the farmed island and all samples contained 3,4-dichloroaniline, azoxystrobin, chlorantraniliprole, clothianidin, fluridone, hexazinone, and methoxyfenozide. A total of 22 different pesticides were detected in surface-water samples collected from farmed islands. Five pesticides had detections over 100 ng/L. In contrast, only 10 different pesticides were detected in water samples from the managed islands. Overall, water samples from the farmed island exceeded U.S. Environmental Protection Agency aquatic life benchmarks for dichlorvos, clothianidin, cyhalothrin, and bifenthrin. Water samples from the managed island exceeded EPA aquatic life benchmarks for cypermethrin. These results provide insights to better understand the transport and fate of contaminants that can affect the food web in the Delta.

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How do phytoplankton and nutrients measured in spring vary in years sampled before and after a waste-water treatment upgrade? (F. Wilkerson)

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A recent comparison of data collected in fall, in years before and soon after EchoWater implementation by Regional San (Glibert et al. 2022), indicated there was improved phytoplankton growth in SF Bay Delta in 2021 following the upgrade that reduced nitrogen discharge by 75% including ammonium removal. Here, we compare nutrient and phytoplankton data collected during spring in years before (i.e., 2012, 2013, 2014, 2015, 2016) and following (2021 and 2022) EchoWater implementation. 18 stations were sampled by the same research team from above Regional San in the Sacramento River along a downstream transect through Suisun Bay. The pre-upgrade sampling, during the third week of March, occurred in a variety of "water year" conditions, from below-normal (2012, 2016), dry (2013) to drought conditions (2014, 2015). Phytoplankton blooms (20-30 µg/L), centered downstream of Rio Vista, were observed in the dry years and post upgrade, 2021 and 2022 (~16 µg/L). Conditions in the Sacramento River below the Regional San discharge also varied by year with water clarity greatest 2021 and 2022. Ammonium concentrations were highest during dry and drought years but lower in below-normal years (2012, 2016), and during post-upgrade (2021, 2022). Nitrate was highest in 2012 and 2015, and relatively low in 2013 and 2016 as well as post-upgrade (2021, 2022) due to reduced N loading from Regional San. Further analysis of historic water conditions data from pre- and post EchoWater implementation will contribute to understanding the consequences of this ecosystem-scale management action and help untangle the multiple drivers of pelagic primary production and food web processes in the upper estuary.

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