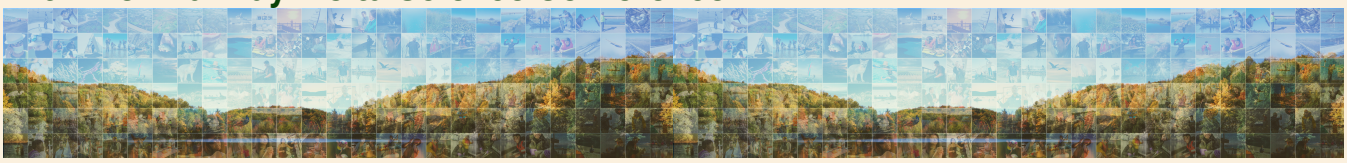
11th Biennial Bay-Delta Science Conference



BUILDING RESILIENCE THROUGH DIVERSITY IN SCIENCE

April 6–9, 2021 ■ Virtual ■ #BDSC2021

POSTER ABSTRACTS

2021 Bay-Delta Science Conference: Poster Abstracts

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Navigating this booklet

Posters are sorted by theme, then by first author. The number-letter key (e.g., 001-CC) should help you navigate to the correct poster on the conference website.

Climate Change (CC)

001-CC: Projected Air Temperatures and Water Temperatures for Selected Regions of the Upper San Francisco Estuary under 20 Scenarios of Climate Change

Larry Brown[1], Brock Huntsman[1], Marissa Wulff[1]

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Understanding the effects of climate change is a substantial challenge in estuarine systems because the mixing of freshwater and ocean water adds complexity to climate change projections. Such climate change projections have been conducted in the San Francisco Estuary as part of the U.S. Geological Survey's CASCADE Project. In this project, we assessed downscaled air temperature data from 10 Global Climate Change models under two Representative Concentration Pathway (RCP) trajectories for greenhouse gas concentrations for three regions of the upper San Francisco Estuary: Suisun and Grizzly Bays, Suisun Marsh, and the legally defined Delta. We also utilized previously derived regression models to estimate future water temperatures at 16 locations within the upper estuary based on the projected air temperature data. The data suggested no major differences in the trajectory of air temperatures for the three regions. Annual mean daily air temperatures (mean of daily maximum and minimum) were projected to increase approximately 2.7°C and 5.3°C by the end of the century for the low and high RCP scenarios, respectively. The number and duration of heatwaves is projected to increase under both RCPs. Annual mean daily water temperatures were also projected to increase, but the rate of change depends on location and RCP. The highest projected annual mean water temperatures at the end of the century are in the northern and southern Delta (20.8°C and 20.9°C, respectively). The station at Martinez at the western end of Suisun Bay remains relatively cool (18.6°C). These values represent projected increases of about 3°C over the century. Although the changes in water temperatures seem modest, they can potentially have large effects on habitat quality for a wide array of native and invasive species. These data are currently being incorporated into several analyses of potential ecosystem effects of climate change.

002-CC: Effects of Projected Climate Change on Flooding and Water Temperatures of Yolo Bypass: Implications for Fishes and Ecosystem Function

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Yolo Bypass is an important ecological feature of the Bay-Delta ecosystem, providing floodplain habitat for spawning and rearing of native fishes. Inundation of Yolo Bypass is particularly important for spawning and rearing of Sacramento Splittail (*Pogonichthys macrolepidotus*) and rearing of juvenile Chinook Salmon (*Oncorhynchus tshawytscha*). We used outputs from 10 climate change models for two Representative Concentration Pathways (RCPs) for greenhouse gas concentrations to assess the effects of climate change on the frequency, duration, and timing of flood flows in Yolo Bypass We also assessed water temperatures during flood flows. Response was measured as the mean of the projections for each combination of climate change model and RCP annually from 2010 to 2099. We also assessed a planned modification to the primary weir that controls inflow that will cause Yolo Bypass to be inundated at lower river flows. As intended, the notched configuration provided more frequent flooding of longer duration compared to the existing no-notch configuration. These differences were maintained through the end of the century under both RCPs. There were few strong trends in projected flood metrics through the end of the century. Projected winter water temperatures during flooding generally increased through the century for both RCPs (~2°C). Projected spring water temperature exhibited little change for the lower RCP and increased slightly for the higher RCP. Similar to winter, the projected change over the century is relatively small (<2°C). Our climate change projections suggest that the notch will increase the ecological value of Yolo Bypass to the fishes that use it for spawning and rearing and that these benefits will be maintained through the current century. These assessments should be updated as climate change projections continue to improve.

003-CC: Riparian Vegetation Productivity Trends Across the San Francisco Bay Delta Watershed

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Drought and intensive land use can interact as stressors on groundwater-dependent riparian vegetation and aquatic ecosystems that make up the major tributaries of the San Francisco Delta. Knowledge of past riparian response to drought and land use change can provide land managers with a better understanding of changes induced by upstream management actions, climate change and chronic stressors. To investigate the response of riparian vegetation productivity to drought and land use, we developed an 18-year time series (2000-2018) of growing season vegetation dynamics using the Landsat near-infrared reflectance of vegetation (NIRv), as a proxy for primary productivity for riparian vegetation communities across 30 HUC 8 watersheds that drain into the San Francisco Bay Delta. Cloud computing technology allowed us to process and analyze large spatial datasets including climate, land use, topography and stream data, and model their effects on riparian vegetation productivity dynamics.

We observed an overall increase in riparian vegetation productivity across the study period on a broad scale, however, temporary declines in vegetation productivity occurred during/as a result of drought conditions. At a local level, vegetation communities' response to drought and post-drought productivity dynamics were highly variable across biophysical settings and land use gradients. Disentangling the different environmental conditions that drive vegetation productivity response can assist land managers in implementing appropriate mitigation strategies – as these ecosystems serve essential functions for maintaining biodiversity and carbon storage. Our methods are scalable and can be used for continuous, rapid monitoring of riparian vegetation, fostering actionable intelligence in land management decision making.

004-CC: Evaluation of Hydrogeologic Processes Affecting Levee Stability in the Sacramento San Joaquin Delta; an Integrated Approach for Sea-Level Rise and Land Use Scenarios.

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Underseepage through the 1,100 miles of Delta levees Delta cause hydraulic exit gradients at levee toe-drains which can be amplified by land subsidence and sea level rise. Large underseepage hydraulic exit gradients can erode levee foundations and increase levee failure risk. In this context, a predictive tool which integrates multiple interacting long-term hydraulic and geophysical stressors from an interdisciplinary perspective, can effectively help decision makers allocate resources. As part of the Next Generation Multi-Hazard Levee Assessment project, we created such a tool. A steady state groundwater flow model was developed for Bacon Island using MODFLOW-2000 and calibrated using historic water-level data. In parallel, the land subsidence model SUBCALC was calibrated and validated using LiDAR, extensometer, and carbon flux data. Also, the previously validated SEDCALC model was used to simulate accretion in impounded marshes. The SUBCALC and SEDCALC models were used to generate subsidence and land accretion scenarios corresponding to the implementation of mitigation measures such as non-tidal wetlands restoration. Mean tidal datum values were used to simulate different sea-level rise scenarios. We simulated scenarios of varying tidal datums and land subsidence/accretion combinations representative of possible climate change and land use scenarios. Results show that high exit hydraulic gradients currently exist on Bacon Island and will likely be aggravated in the future under sea-level rise and land subsidence. These high hydraulic gradients represent a threat to levee integrity. Land uses which stop subsidence (e.g. rice agriculture) and promote soil accretion (e.g. wetland restoration) can provide climate change infrastructure resilience and hazard mitigation by keeping hydraulic exit gradients within safe levels.

005-CC: Trophic Transfer, Bioaccumulation and Transcriptomic Effects of Permethrin in Inland Silversides, Menidia Beryllina, under Future Climate Scenarios

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Global climate change (GCC) significantly affects aquatic ecosystems. In the Sacramento-San Joaquin Delta, maximum water temperatures are anticipated to increase by up to 5 °C by 2099. Concurrent with climate change, continual use of insecticides, such as pyrethroids, represents a further threat to aquatic ecosystems. However, the effects of GCC and pyrethroid exposure on Bay-Delta fishes remain poorly understood. Consequently, the present study aimed to determine the impacts of temperature and salinity changes on the trophic transfer, bioaccumulation and genomic responses to permethrin, a commonly detected contaminant in the Delta, in the Inland silverside (*Menidia beryllina)*. *M. beryllina* were fed ^{14}C-permethrin dosed pyrethroid-resistant *Hyalella azteca* for 14 days at 18 and 23°C and 6, 13 and 20 practical salinity units (PSU). *H. azteca* are a common dietary item for Bay-Delta fishes, with pyrethroid resistance of aquatic invertebrates an emerging issue in California and elsewhere. Fish were analyzed for total body residues and percent metabolites as a measure of biotransformation, as well as expression of genes relating to contaminant detoxification, metabolism and stress response in brain and liver. *M. beryllina* bioaccumulated significant amounts of permethrin across all treatments, ranging from 39 to 557 ng g^{-1} lipid. Salinity had a significant effect on total bioaccumulation, owing to greater bioaccumulation at 6 PSU compared to 13 and 20 PSU, which may be due to alterations to xenobiotic elimination at different salinities. Permethrin bioaccumulation led to upregulation of genes involved in xenobiotic elimination, directly impacted by both temperature and salinity, which also elicited changes in genes relating to growth, development, and immune response. This is one of the first studies confirming dietary bioaccumulation and consequences to Delta fishes. This research was funded by a Prop 1 grant, aimed at evaluating the transfer and effect of contaminants in the Bay-Delta.

006-CC: Combining Soil Chamber and Eddy Covariance Measurements to Better Constrain CO2 and CH4 Fluxes in a Restored Tidal Wetland

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Interpretation of net ecosystem exchange measurements of CO_2 and CH_4 in tidal wetland ecosystems is challenging due to effects from tidal activity and heterogeneous landscapes. In this study we are using eddy covariance and soil chamber measurements in a restored tidal wetland consisting of three land cover types (*Spartina foliosa*, *Salicornia pacifica*, and bare mudflats) to better understand sources and sinks of CO_2 and CH_4 and improve partitioning algorithms. Two years of eddy covariance data have demonstrated the tidal marsh to be a strong sink for CO_2 and small source of CH_4. Annual cumulative exchange of CO_2 is -436.6 g C-CO_2 m^{-2} yr^{-1} (sd=26.4 g C-CO_2 m^{-2} yr^{-1}) and of CH_4 is 0.51 g C- CH_4 m^{-2} yr^{-1} (sd=0.362 g C-CH_4 m^{-2} yr^{-1}). As the marsh is often flooded at night, nighttime ecosystem respiration is negligible, making partitioning of net ecosystem exchange of CO_2 difficult. On average, daytime soil fluxes from all landcover types are sources of CO_2 and CH_4. Soils in vegetated areas consisting of *S. foliosa* are the greatest source of CH_4, while bare mudflats are the greatest source of CO_2. Soil chamber measurements show that average soil surface CO_2 flux from mudflats is 49.5 mg C-CO_2 m^{-2} hr^{-1}. Average soil surface CH_4 flux from *S. foliosa* is 0.164 mg C-CH_4 m^{-2} hr^{-1}. We plan to use footprint analyses paired with satellite imagery to upscale the chamber data and inform estimates of soil respiration, which will be used to improve partitioning algorithms. Better constraint on ecosystem respiration, as well as the functional relationships between land cover type and fluxes, will allow for improved understanding of the exchange of greenhouse gases in tidal wetlands. These data will be used to parameterize a process-based model and predict regional greenhouse gas budgets from restored wetlands in the California Bay-Delta region.

Diversity, Equity, and Inclusion (DEI)

007-DEI: (*IEP) We Dig Data: The IEP's Data Utilization Work Group and Our Efforts to Pursue the Open Science Ideal

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The Interagency Ecological Program's Data Utilization Work Group (DUWG) has been working to increase Open Science practices within its nine member agencies who collect ecological data on the San Francisco Estuary. Over the past four years, the DUWG has developed recommendations for how scientists can participate in the open science movement, through developing data management plans, developing quality

assurance and quality control procedures, writing metadata, and publishing their data in open-access data repositories. Through this work, the DUWG has identified some of the key obstacles for agency scientists in making data available, including lack of time/resources, lack of knowledge, and fear of misuse. To help overcome these obstacles, the DUWG has hosted several training workshops, has developed templates for data management plans, metadata, and SOPs, and has become a cheerleader for the open science movement. The goal of the DUWG is to increase access to science for all.

Fish Biology, Ecology, and Protection (FBEP)

008-FBEP: (*IEP) Effect of Temperature and Flavobacterium Columnare on Juvenile Chinook Salmon (Oncorhynchus Tshawytscha) Exploratory and Locomotor Behavior

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Associated with climate change-driven rising water temperatures, diseases are among the most pressing risk factors that contribute to the imperiled status of salmonids in the Pacific northwest. *Flavobacterium columnare* is a significant bacterial pathogen and the etiological agent of columnaris disease. Columnaris is regarded as a re-emerging disease in the PNW particularly during the summer and early fall months. This study aimed to determine how *F. columnare* infection affects Chinook salmon exploratory and locomotor behavior at 18^{o}C. To evaluate this, we determined pathogen abundance in gill tissue of juvenile salmon, their exploratory and locomotor behavior, as well as measuring expression of behavior-related genes in brain, which have been shown to be impacted by columnaris disease.

Fish were assigned to one of two treatments, designed as *F. columnare*: challenged or non-challenged, maintained at 18^{o}C. To evaluate the infection progression in term of *F. columnare* abundance, and differential gene expression of behavior related genes, 12 fish per treatment were sampled at 0, 1, and 6 days post infection. To evaluate the swimming behavior, fish was observed in a standardized behavioral assay designed to measure risk taking response.

Qunatitative PCR-based determination of *F. columnare* abundance showed that bacterial infections in challenged fish were significantly elevated, reaching the peak after 24h infection, accompanied with an increase in expression of the gene associated with brain injury, brain-derived neurotrophic factor, BDNF. Swimming behavior data is being analyzed.

Our results, from this, and prior studies, suggest that at elevated water temperatures (18°C), juvenile Chinook salmon may become more susceptible to *F. columnare* infection, with potential behavioral consequences, which may impact foraging ability as well as make them more susceptible to predation. Data from this study could aid in the evaluation of infectious disease development and subsequent vulnerability of exposed Chinook salmon populations.

009-FBEP: Assessing Fluorescent Dye Methods for Osmerid Mark-Recapture Experiments

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We are developing a fluorescent marking method for juvenile Longfin Smelt *Spirinchus thaleichthys* to conduct mark-recapture experiments at the John E. Skinner Delta Fish Protective Facility (SDFPF) of the State Water Project (SWP). These dyes can stain live organisms and are invisible until excited by specific light wavelengths. Previous work used SE-Mark^{tm} (a calcein solution) to mark osmerids, but high mortality in marked Longfin Smelt highlighted the need for alternatives. Most Longfin Smelt salvaged at SDFPF are too small for commercially available visible and electronic tags.

For our experiments we marked Delta Smelt *Hypomesus transpacificus* as a proxy for Longfin Smelt, which were unavailable in the target size range. We assessed 5 fluorophores: 4-Di-1-ASP, BODIPY FL C12, BODIPY 505/515, Nile red, and SE-Mark. We assessed survival and fluorescence during three marking experiments, while revising handling methods between treatments to maximize survival.

SE-Mark was the most effective dye and had high Delta Smelt survival. Nile Red had good survival and moderate fluorescence, while 4-Di-1 ASP had moderate fluorescence and poor survival, and BODIPY 505/515 had poor fluorescence and survival. BODIPY FL C12 had an extra component in the dye mixture, which led to high mortality, and will need to be addressed in future experiments.

Future dye tests will be necessary before Longfin Smelt can be used in mark-recapture studies, but multiple dyes showed promise for further assessment. If we develop a marking method for Longfin Smelt, researchers can begin evaluating the movement of these small osmerids throughout the Delta. Having a reliable way to mark large numbers of juvenile osmerids will provide researchers a tool to identify recaptures of these small fish that are listed for protection under the state and/or federal Endangered Species Acts.

010-FBEP: Effects of Thiamine Deficiency on Physiology and Survival of Early Life-Stage Winter-Run Chinook Salmon

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In 2019, multiple fall-run Chinook salmon (Oncorhynchus tshawytscha) hatcheries in the Central Valley of California reported high levels of fry mortalities and abnormal swimming. It was discovered that immersing the fry in a thiamine (vitamin B1) bath rescued the fish, correcting their lethargic swimming and decreased mortality rates. A depletion of thiamine, an essential nutrient for metabolic processes, can lead to thiamine deficiency complex (TDC). TDC in fishes is most commonly associated with high early life-stage mortality as observed previously in Atlantic salmon and recently at Central Valley hatcheries. The goal of this study was to determine the status of thiamine deficiency in winter-run Chinook salmon, a critically endangered run, and observe the effects thiamine deficiency may have on survival and whole organism physiology. Female winter-run Chinook salmon adults were collected at the fish collection trap at Keswick Dam and transported to Livingston Stone National Fish Hatchery. At the hatchery, 33 adult females received intraperitoneal injections of thiamine (treated) and 28 females received a sham injection (untreated). Females were spawned at the hatchery and a subset of eggs from each family were frozen for thiamine analysis. Once embryos reached the eyed stage, embryos from each of the 61 families were transported to UC Davis. Upon arrival, embryos from each family were transferred to individual tanks. Hatching success, survival, and symptoms of TDC were monitored daily. In addition, we examined physiological and behavioral performance to assess potential sublethal effects of thiamine deficiency. Here we present the larval survival and upper thermal tolerance of individual fish, measured as critical thermal maxima (CTM), from each family of both treatment groups. Using the data collected, we were able to estimate the mean egg thiamine concentration (nmol/g) necessary for 50% survival of a family. Upper thermal tolerance was not affected by egg thiamine level.

011-FBEP: Vulnerability of Longfin Smelt to Changes in Turbidity and Warming: a Physiological Perspective

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The Longfin Smelt (*Spirinchus thaleichthys*) is a threatened fish species found along the Pacific coast of North America, including the San Francisco Bay-Delta (SFBD). Threats to this species include but are not limited to, changes in food webs, toxic substances, disease, competition, introduced species, predation, loss of genetic integrity, and increased temperatures due to climate change. In the SFBD, fishes must deal with fluctuating turbidity levels that at times reach up to 220 NTU depending on natural and anthropogenic factors. Turbidity has been shown to have direct effects on Delta Smelt (*Hypomesus transpacificus*), such as feeding ability and swimming activity in larvae, as well as indirect effects through changes in food availability and light intensity. Currently, there is lacking data on the impacts of turbidity on the physiology of Longfin Smelt. We examined the combined effects of temperature (11°C and 14°C) and turbidity (1, 4 and 11 NTU) on the stress response and tolerance of juvenile Longfin Smelt (164-235 dph) following two and four weeks of acclimation. Preliminary data suggests that survival was higher in low turbidity treatments. Acclimation temperature increased upper thermal tolerance, as measured by CTMax, while no interactive effects were seen with turbidity. The CTMax from all 14°C treatments combined was 26.32 ± 0.08°C (avg ± SEM) while the CTMax from the 11°C treatments combined was 24.59 ± 0.18°C. Additional molecular and biochemical analyses (gene expression, cortisol, lactate, and glucose) are underway as means to further evaluate feeding and stress status under tested conditions. Understanding the biological consequences of climate change in combination with changes in turbidity in estuarine systems may provide insight into the recent decline of Longfin Smelt and will offer fundamental information to improve management of this species of conservation concern.

012-FBEP: (*IEP) Community Patterns for the Early Life Stages of Fishes in the Upper San Francisco Estuary

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Remarkable ecological changes have been revealed by long-term surveys in the upper San Francisco estuary (USFE) since the mid-20th century. Yet, little is known about environmental forcing on the community patterns for the early life stages of fishes across the USFE. We analyzed the 20-mm Survey data conducted at 41 stations in the USFE by the CDFW (1995 and 2017 from mid-spring to early-summer). Our objectives were to evaluate: 1) general patterns for environmental conditions and habitat components for early life stages of fishes, 2) patterns in distribution, relative abundance, diversity and habitat usage by native and introduced pelagic and demersal fish groups, and 3) fish community variation across environmental, spatial and temporal gradients.

Based on the average water temperature in which each fish species was caught, native and introduced species predominated respectively in the lower and upper temperature ranges. Fish relative abundance declined significantly for native and introduced pelagic groups over the study period but not for both demersal groups. Based on non-parametric multiplicative regression models, the most influential habitat components for relative abundance and diversity of fish groups were in decreasing order: water temperature, salinity, Secchi depth, bottom depth and zooplankton biomass. Habitat models also showed general segregation of early life stages by fish origin, with warmest and lowest-salinity waters more associated to introduced fishes, and cooler-saltier waters more associated to native fishes. Results showed the salinity field peak increasing towards upstream areas over the study period. In contrast to earlier cool and warm years (2010-11 and 1995-97, respectively), peak salinities in years 2014-15 coincided with peak water temperatures. This study demonstrates the remarkable influence of the 2012-16 drought on fish habitat and lends support to the hypothesis that droughts intensified by climate-change can greatly exacerbate human-induced synergistic interactions implicated in the long-term declines of native pelagic fishes.

013-FBEP: How Varying Levels of Captive Ancestry Effect Cultured Delta Smelt

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Delta Smelt (*Hypomesus transpacificus*) is an endangered fish endemic to the California San Francisco Bay-Delta. As a safeguard against the extinction of the wild population, a genetically managed captive refuge population has been cultured and maintained by the UC Davis Fish Conservation and Culture Lab (FCCL) since 2008. A key component of genetic management is the annual incorporation of wild individuals into broodstock. The extreme decline of the wild population of Delta Smelt has led to the consideration of supplementation (release) of cultured fish into the Delta to avert extinction of the wild population. However, evidence of unintentional domestication selection at the FCCL has raised concerns about the ability of captive-bred fish to survive and reproduce in the wild. We conducted a study over two consecutive years to investigate the effects of captive ancestry on growth and survival of cultured Delta Smelt from two different Domestication Indices (DI), a high DI group and a low DI group. Domestication Indices are a rough measurement based on the number of generations a genome has spent in captivity (e.g. removed from the wild). DI's averaged 10.13 and 5.72 in 2019 and 9.67 and 3.00 in 2020, respectively. High and low DI groups were spawned in 2019 and 2020, then the mean length, weight, and survival were monitored from larval to adult life stages. We found that in both years the high DI group had higher growth and survival in their adult life stage compared to the low DI group. These findings indicate that faster growth and increases in survival are biased toward captive-bred individuals (high DI)

and against wild-like individuals (low DI) which is consistent with domestication selection. Such deviation from wild-like Delta Smelt could pose risks to genetic management of the refuge population and to efficacy of supplementation.

014-FBEP: Modelling Green Sturgeon (Acipenser Medirostris) Spawning via Environmental Conditions

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Green Sturgeon (*Acipenser medirostris*) are an ancient long-lived fish distributed along the North American West Coast. Of the two populations of Green Sturgeon, the southern population is listed as threatened under the Endangered Species Act and spawns only within the Sacramento River and Feather River of California. Effective management requires that surveys of sturgeon populations produce accurate estimates of population abundance and habitat use. To date, efforts to sample Green Sturgeon within the spawning reach have used acoustic telemetry data to determine what fraction of the population is sampled at any given time. Acoustic telemetry is a valuable tool, but reliance on this method entirely makes monitoring programs vulnerable to changes in funding and tagging effort. To address this vulnerability, we are developing a model that uses environmental conditions to predict the fraction of the spawning population present in the spawning reach throughout the spawning season. We paired 10 years (2007-2016) of telemetry observations from 123 fish with flow and temperature data from the NOAA/SWFSC Fisheries Ecology Division's RAFT Hindcast model. We identified the start of spawning season procedurally, then developed a model to predict the conditions under which spawning season starts. We found that movements towards the spawning grounds have a specific signature of >= 15 km per day. The start of spawning season varies between years and appears to be related to flow conditions. The proportion of spawners present in the spawning reach throughout the spawning season is relatively stable (25%-35%), increasing as the season continues. Our modeling demonstrates that spawning sturgeon interact with river conditions in a predictable way as they traverse to and from the spawning reach. Preliminary results indicate the surveys of Green Sturgeon in the spawning grounds sample 25-35% of the breeding population on any given day.

015-FBEP: (*IEP) Leveraging Molecular Methods to Investigate Predation by Invasive Piscivores on Juvenile Chinook in the Sacramento – San Joaquin Delta

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Juvenile Chinook Salmon (*Onchorhynchus tshawytscha*) migrating through the Sacramento – San Joaquin Delta have higher mortality rates than salmonids migrating through other west coast estuaries. Some hypotheses for this high mortality rate include entrainment into water export facilities, physical alterations of the river system, and predation. Large populations of piscivorous, invasive fish have been assumed to create high mortality rates for juvenile salmonids, however sufficient data for this hypothesis is scarce. In this study, I show the potential to use a novel molecular approach to quantify the abundance of Chinook salmon in the stomachs of invasive predators in the Sacramento – San Joaquin Delta. The presence of a fish species and enumeration of individuals is possible within a DNA mixture, such as stomach content, with established assays and genetic markers. Before molecular analysis can occur, it is important to conduct laboratory trials to determine the interval DNA is detectable within predatory stomachs. Factors affecting DNA detectability within a predator's digestive system may include predatory species, temperature, and feed ratio. My experiment was conducted to determine half-life detectability of Chinook DNA within the digestive tract of *Micropterus salmoides* at different temperatures and feed ratios. Preliminary results indicate that digestion rates are longer with higher feed rations. Results from these experiments will be used to develop bioenergetic models, and results from those models an inform agencies and managers on how the prey population is affected. Understanding the amount of predation occurring is a critical initial step in the conservation and recovery of Chinook Salmon in the Bay-Delta region.

016-FBEP: (*IEP) Underwater Videographic Observations of Domesticated Delta Smelt in Field Enclosures

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The Delta Smelt (*Hypomesus transpacificus*, hereafter "smelt") is a euryhaline fish species endemic to the San Francisco Estuary and currently protected under Federal and California Endangered Species Acts. Recent population declines may make smelt vulnerable to extinction. The U.S. Geological Survey, in cooperation with the California Department of Water Resources, used underwater cameras inside circular enclosures to observe behavior and responses to stimuli of domesticated smelt. Behaviors were broadly divided into "normal" and "alarm" categories. Normal behavior was calm, non-polarized swimming. Alarm behaviors included sudden, rapid darting and polarized, frantic swimming. Methods for documenting responses to disturbances were developed in an agriculture pond at the University of California, Davis. Smelt behavior changed from normal to alarm at the onset of disturbances and from alarm to normal within about two minutes after disturbances ended. Next, enclosures were placed in the Sacramento River near Rio Vista, California. We recorded the frequency and duration of alarm

behaviors exhibited by smelt in response to three types of disturbances: (1) noise generated from passing boats, (2) noise generated from the enclosure moving in response to wave energy, and (3) vertical movements of the enclosure generated from wave energy. Alarm behaviors averaged about two minutes in duration and occurred most frequently during the evening compared to midday or morning. Substantial variability in the frequency, duration, and intensity of disturbance variables was observed. Alarm behaviors appeared to be most associated with high intensity enclosure noises and vertical movements. However, limitations of the pilot study prohibited completion of a statistical analysis. Behaviors did not appear to cause injury or mortality of individual smelt. However, smelt were not evaluated for indirect or sublethal effects. Our results contribute to the growing body of knowledge needed to determine the viability of using domesticated fish to supplement the wild smelt population.

017-FBEP: Brood Year 2019 Winter-Run Chinook Salmon Operations and Monitoring Assessment

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Anchor QEA evaluated the relative success of the 2019 brood year (BY 2019) winter-run Chinook salmon (WRCS) to inform how water management strategies supported WRCS productivity. Analyses used available environmental, habitat, and biological data and a lifestage-specific hypotheses framework to assess success. Observed spawners totaled 7,852 fish (10-year average is 2,909). Flow levels were optimal for maximizing spawning habitat and temperature criteria at two monitoring sites where criteria were met 98% or more of the time. Biological responses were positive: 26.5 million eggs were produced (10-year average is 8.4 million), the number of fry and fry-equivalents was higher at Red Bluff Diversion Dam than any year since 2009, and the number of natural-origin juveniles entering the Delta was the highest since BY 2013. Fry-to-smolt survival and natural-origin smolt survival were lower due to a change in methods. Overall, BY 2019 fish experienced habitat and environmental conditions downstream to Sherwood Harbor that were similar to or better than the 10-year average or that were expected to benefit BY 2019 fish. Exceptions to these patterns included higher air temperature during egg incubation and fry emergence, floodplain access was limited, and flows were lower than normal during the second half of the out-migration due to a below normal water year. Juveniles migrated 5 to 10 days earlier through the upper reach and 57 days earlier than normal to Delta entry at Sherwood Harbor. The results represent the start of a time series that can be used to assess WRCS population status, responses to operations and hatchery influence, and document progress toward population viability objectives each year.

018-FBEP: Effects of Submerged Aquatic Vegetation on Juvenile Salmon Predation: A Project Proposal

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Predation of juvenile salmon in the Sacramento-San Joaquin Delta has been shown to contribute to salmonoids' high mortality during outmigration. Furthermore, invasive species of submerged aquatic vegetation (SAV), predominately Brazilian Waterweed *Egeria densa,* are found extensively in the Sacramento-San Joaquin Delta substantially altering the ecosystem and habitat complexity for these out-migrating salmon. Preliminary work has found that relative predation risk decreased by 11.3% and 9.2% for each meter increase in distance from SAV. These results indicate that the presence of SAV increases the relative predation risk of salmonid smolts. This study aims to determine the impact of submerged aquatic vegetation on juvenile salmon, specifically piscivorous fish density and relative predation risk of juvenile salmonids. To test these impacts of SAV a Before-After-Control-Impact (BACI) study design will be employed. A BACI study design allows us to examine predator densities and predation rates before and after SAV removal. Therefore, we will deploy predation event recorders (PERs) as easily repeatable standardized monitoring units along coastal SAV to determine predation time and location. Furthermore, in order to determine the fish community in our study site, we will deploy Adaptive Resolution Imaging Sonar (ARIS) which will allow us to qualify the relative density of large fish throughout the area. These surveys will be conducted before and after SAV removal. Submerged aquatic vegetation is notoriously difficult to remove, therefore we will remove SAV using hand tools and SCUBA divers minimize the impact on the nearby habitat. This project aims to understand how SAV removal may impact out-migrating salmon and preliminarily estimate the potential benefits of system-wide SAV removal.

019-FBEP: Quantifying Developmental Abnormalities in Otoliths of Cultured vs Wild Delta Smelt

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The Delta Smelt (Hypomesus transpacificus) is an endangered fish species endemic to the San Francisco Estuary (SFE). Delta Smelt have declined precipitously, making them a key player in California's water politics due to their impact on water export operations and sensitivity to decreased delta outflow and direct entrainment into water export pumps. Due to their conservation status, plans to release cultured Delta Smelt into the wild are forthcoming in hopes of restoring wild populations. However, little is known about the development of cultured fish in contrast to wild fish. Otoliths (fish earstones) are located in the inner ear of fish and are important for hearing, balance, and linear acceleration. Abnormalities in the development of otoliths could potentially affect prey capture, navigation, and predator evasion. Consequently, understanding differences in otolith development could help inform if cultured fish are likely to perform similarly to wild fish when released. Here, we contrasted developmental abnormalities between wild and cultured Delta Smelt by examining the crystalline structure of the CaCO3 in otoliths and asymmetry in otolith size. The prevalence of crystalline anomaly was examined using image analysis and validated using Raman spectroscopy and X-ray diffraction. Our results confirmed the visually-assessed crystalline anomaly as CaCO3 polymorph vaterite while accurately estimating vaterite prevalence above 10%. Once validated we used our visual analyses and found that in 2019, cultured Delta Smelt otoliths showed higher prevalence of vaterite but no difference in otolith size asymmetry compared to wild-caught fish, suggesting a divergence of otolith development in cultured fish that has potential health condition implications. Further studies around cultured Delta Smelt development should be explored to better inform hatchery release conservation efforts of potential differences between captive-reared and wild Delta Smelt populations.

020-FBEP: (*IEP) Development of Culture Systems for Rearing Single-Family Delta Smelt Larvae

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The current Delta Smelt (*Hypomesus transpacificus*) culture system at the Fish Conservation and Culture Laboratory (FCCL, University of California, Davis) was designed to efficiently maintain the refuge population of Delta Smelt. In this system, each fish-rearing tank houses eight equally represented multi-family groups. However, a previous study showed that this method is inadequate for maintaining high survival of larvae derived from wild parents, possibly because high domestication index (DI, an indexed level of hatchery ancestry) fish survive better than low DI ones in mixed-DI, multi-family groups. Thus, larvae may require rearing in single-family groups to improve survival. We developed a new larvae culture system to house individual Delta Smelt families. In the first design, twelve 19-L black polycarbonate tanks were installed in two stacked rows with six tanks each and plumbed into a recirculating aquaculture system.

Each tank housed 1000 larvae from 0-40 dph. Rearing trials indicated that larval growth and survival in this new system was comparable to fish reared in the current culture system. However, larvae reared in top-layer tanks were significantly larger and had significantly higher survival rates than those reared in the bottom layer. We hypothesized that these differences were due to differential light intensities between the top and bottom layers, and modified the system such that consistent lighting was provided to each tank. The new system will be tested in the coming spawning season.

021-FBEP: *Poster withdrawn*

022-FBEP: (*IEP) Testing of Wakasagi Egg Frame Box on the Hatching of Delta Smelt Eggs

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Delta Smelt (*Hypomesus transpacificus*) is an endangered fish endemic to the Sacramento-San Joaquin Delta. The Fish Conservation and Culture Laboratory in Byron, CA, is working on several projects regarding the potential reintroduction of the fish. One way to limit time spent in the hatchery and thus domestication in cultured Delta Smelt would be to release fish at the embryo stage using Wakasagi (*Hypomesus nipponensis*) hatching frames (obtained from Lake Suwa Fishing Collective). However, the feasibility of Wakasagi hatching frames for Delta Smelt culture has not been studied. Here we tested the Delta Smelt egg incubation and hatching using the hatching frame in a 1300L rectangular tank with flowing water. We also simulated the water flow interaction with the frame using computational fluid dynamics. COMSOL Multiphysics software (version 5.6) was used to create a life-sized 3D model representing the application along a hypothetical bank as implemented into the mouths of rivers in Hokkaido, Japan for recreational fishing to simulate the flow speed and patterns inside the hatching fames to better understand the flow that the eggs would be exposed to and make recommendations for future field applications. The effects of temperature on the egg hatching have also been tested in a controlled laboratory setting.

023-FBEP: Does the Presence of Largemouth Bass (*Micropterus salmoides*) Predators Influence Substrate Preference in Juvenile Green Sturgeon (*Acipenser medirostris*)?

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The southern Distinct Population Segment (sDPS) of green sturgeon (*Acipenser medirostris*) has declined precipitously due to anthropogenic changes to the Sacramento River Basin (SRB). Large impoundments such as Oroville and Shasta dam reduce the frequency of high flow events, leading to a reduction of pool depth and infilling of substrate interstices. Geomorphic change is thought to contribute to recruitment failure, but the mechanism is not known. We hypothesized that sturgeon would prefer larger substrates through ontogeny due to increased availability of interstitial spaces, and that predator presence would further skew this preference toward substrate with adequate refugia. Using a 7.3 m artificial stream at a constant velocity of 0.3 m/s, we assessed how four substrate sizes (sand, gravel, small cobble, and large cobble) were utilized by juvenile sDPS from 8 to 11 weeks post-hatch (5.0 cm to 13 cm, respectively), with and without the presence of largemouth bass (*Micropterus salmoides*) predators. While sturgeon used all substrate types, larger substrates were preferred in both open and predator trials. There were few predation events or attempts overall, but predator presence did reduce sturgeon movement between substrates. Additionally, we did not find a correlation between sturgeon size and the substrate size selected for fish in this test range. These results suggest that interstitial spaces in substrate may be important flow and predator refugia. Assessing substrate needs of sDPS sturgeon juveniles is important for understanding habitat suitability where dams, channel modification, water management practices, and non-native species have permanently altered the watershed.

024-FBEP: *Poster withdrawn*

025-FBEP: (*IEP) Transferable Approaches to Evaluate the Ecological Performance of Early Life Stages of a Threatened Anadromous Fish Species, the Longfin Smelt.

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Conservation efforts are sometimes constrained by lack of knowledge about the species' biology and the impact of environmental stressors upon them. Longfin Smelt (*Spirinchus thaleichthys*) is an anadromous fish species listed as threatened under the California Endangered Species Act found in estuaries and lakes along the northern Pacific coast of North America. To evaluate potential contributions of anthropogenic activities to their decline, we aimed to 1) transfer tools and approaches commonly used on model species and/or later life stages to assess the ecological performance of Longfin Smelt larvae and 2) apply these tools to determine effects of an exposure to a frequently detected pyrethroid insecticide; bifenthrin. For this, we tested the relevance of the light/dark stimuli induced behavior test and of the thermal susceptibility test for the Longfin Smelt larvae. Movement tracking of 1 to 4 dph larvae during alternating light-dark periods revealed a pattern of increased larvae's locomotion in the light followed by resting state in the dark, allowing the establishment of a behavioral model for this species. In addition, we tested larvae's thermal tolerance by monitoring the heart rate of anesthetized individuals submitted to a stepwise temperature increase. Exposure to environmentally-relevant concentrations of bifenthrin for 96h did not affect the locomotor behavior and cardiac physiology of the 1-4 dph Longfin Smelt larvae. We observed that larvae heart rate gradually increased with temperature until becoming arrhythmic. Combined, these two tests allow for the assessment of Longfin Smelt larvae ecological performance, and provide sensitive endpoints to evaluate the impact of environmental stressors upon this species.

026-FBEP: (*IEP) The Effect of Temperature on Trophic Interactions Between Largemouth Bass and Juvenile Chinook Salmon in the Sacramento-San Joaquin River Delta System

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In light of ongoing environmental change, understanding the complexities of stressor impacts across biological scales is a major challenge. Many studies examine the effects of a stressor (*e.g.* temperature, toxins, disease) on a given organism. However, focusing on a single species alone has limitations, as stressor effects likely change interspecific dynamics that are equally critical to species resilience. The aim of this study was to explore how one such stressor, temperature, mediates trophic interactions between juvenile Chinook salmon (*Oncorhynchus tshawytscha*) and their predators in the Sacramento-San Joaquin River Delta system. Here we present preliminary results, using largemouth bass (*Micropterus salmoides*) as the predator species. Temperature influences metabolism and correlates to the amount of energy available for fitness-relevant parameters (*i.e.* swim performance and escape response). Because

temperatures that maximize metabolism are species-specific, we hypothesized that optimal temperatures, or those conferring a thermal metabolic advantage [TMA], differ between bass and salmon and affect the outcome of predator-prey interactions. Specifically, we predicted that warm-water predators such as largemouth bass would have a higher thermal optimum than salmon, and vice versa. Bass should thus possess a TMA in warmer temperatures and salmon, in cooler waters. We first identified the intrinsic thermal physiology of both species, establishing the temperatures at which each possessed a TMA. We then assessed how TMA affected trophic interactions via predation trials, which were conducted across a range of temperatures. Our results suggest that temperature significantly affects both anaerobic and aerobic capacity of these fish and the outcome of the predation trials; more salmon were eaten at warmer temperatures, where bass possessed the TMA, than cold temperatures, where salmon were thermally advantaged. Ultimately, these findings could provide ecosystem managers with tools to predictively model, if not functionally suppress, predation upon juvenile salmon based on prevailing and future water temperatures.

027-FBEP: Using Physiological Methods to Assess High Mortality Rates of Out-Migrating Spring-Run Chinook Salmon (Oncorhynchus Tshawytscha) in the San Joaquin River, CA

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Spring-run Chinook salmon, once the most abundant salmon run in the Central Valley, have declined alarmingly over the last century. In the San Joaquin River, a science-based reintroduction effort is ongoing, but mortality rates of out-migrating juveniles remain high. The goal of this study is to evaluate physiological indicators of stress on out-migrating juveniles using experimental fish caged in several locations longitudinally during the outmigration period. Pathogen load was assessed using DNA detection of 6 common pathogens in California rivers. A wide spectrum analysis is being conducted on stress related markers related to water quality, clinical signs of immune response as well as assessing indices of smoltification (e.g. Na+-K+-ATPase activity) using qPCR assessing mRNA expression (using cDNA). Growth rates were also analyzed from fish sampled weekly over a month period. Environmental drivers of physiological responses will be correlated with CDEC station data, contemporaneous YSI data during sampling and Fast Automated Limnological Measurements (FLAMe). Our physiological data can also be viewed in combination with a concurrent telemetry study that is generating reach-specific survival data for smolts. We hypothesize that high salmon mortality is linked to environmental stressors resulting in accumulated sub-lethal stress along the San Joaquin River and estuary.

028-FBEP: Impacts of Artificial Illumination on Predator Density and Salmonid Predation Risk

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Predation of juvenile salmonids within California's Sacramento – San Joaquin Delta (the Delta) and throughout the Central Valley, has been identified as a contributing factor to low survival during outmigration. Artificial lighting at night (ALAN) may contribute to increased levels of salmonid predation by attracting predators and prey, increasing predator reaction distance, and foraging success. To assess ALAN effects on predator (piscivorous fishes) density and the relative predation risk of juvenile salmonids, we preformed field based experiments with both introduced ALAN and an existing light structure. In 2019, we used ARIS (Adaptive Resolution Imaging Sonar) cameras to generate predator density estimates among experimentally manipulated light and dark treatments throughout the Delta. We simultaneously deployed predation event recorders (PERs) to estimate ALAN impacts on relative predation risk. In 2020, we assessed ALAN impacts on predator density and salmonid predation risk with similar methods at the illuminated Sundial Bridge in Redding, CA. Late at night (3-5 hours past sunset) in the Delta, ALAN presence increased predator density and the relative predation risk of juvenile salmonids, but no effects were seen early in the night (1 - 3 hours past sunset). Preliminary analysis from the Sundial Bridge indicates that bridge illumination across all treatments (25, 50, and 100% ALAN intensity) increased the density of large fishes; however, predation at this illuminated structure was non-existent. Low predation rates at this bridge were likely due to a low degree of Rainbow Trout piscivory. Our results suggest that throughout the Central Valley, ALAN attracts large bodied fishes and when these fishes are piscivores (e.g. Striped Bass and Largemouth Bass), ALAN increases juvenile salmonid predation risk, a trend that concurs with the literature. Therefore, it appears that reducing artificial illumination is a practical management strategy to reduce predation.

029-FBEP: Characterizing the Stress Response in Juvenile Delta Smelt

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The Delta Smelt (*Hypomesus transpacificus*), once among the most abundant fish to inhabit the Sacramento-San Joaquin Delta, are now endangered and threatened by extinction. Drastic declines in their population resulted in an apparent population

collapse in 2015, when the Californian Department of Fish and Wildlife (CDFW) reported their first zero abundance index for this species of fish. Declines in natural populations are likely due to a variety of interacting stressors which include, but are not limited to, reductions in freshwater outflows, introduction of invasive species, changes in the food web, increases in pesticides and contaminants, destruction of natural habitats and environmental changes associated with climate change. Investigating their stress response will help us better understand perceived benign vs. stressful conditions for Delta Smelt. This in turn can be used not only to help elucidate the conditions best suited for their successful culture, but also to more accurately characterize stressors in their natural environment. Our study characterized the stress response of juvenile Delta Smelt reared under current (17°C) and projected environmental warming (21°C), by measuring cortisol levels following both a handling stress and a predator cue. There is a paucity of data regarding the time course and magnitude of cortisol induction in Delta Smelt, partly due to the complex dynamics of this stress hormone. Therefore, our first goal was to test basal and peak cortisol levels of juvenile Delta Smelt prior to and following a netting stress, to provide a time course of cortisol induction in Delta Smelt. Following a similar time course, we examined cortisol levels in response to exposure to a predator-borne water cue. In the future, we plan to investigate how different turbidities in the absence or presence of natural predators (and/or cues) affect cortisol induction and stress-induced behaviors in juvenile Delta Smelt.

030-FBEP: Key Findings from the First Three Field Seasons of a Native and Nonnative Predator Research Program on the Stanislaus River

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Federal legislation (Water Infrastructure Improvements for the Nation [WIIN] Act; passed Dec. 16, 2016) required the Oakdale and South San Joaquin Irrigation Districts and NOAA Fisheries to jointly establish a nonnative predator research and pilot fish removal program in the Stanislaus River. Since 2017, we collaborated with NOAA Fisheries and California Department of Fish and Wildlife to develop study plans and implement a suite of predator-related studies. Here, we focus on several key findings from the first three seasons (2018, 2019, and 2020). We used boat electrofishing to sample and collect information about native and nonnative predatory fish diets across a 40-mile reach in the Stanislaus River. Sites were randomly selected (n = 39; ~10% of the reach), then repeatedly visited within and between seasons (2019 and 2020), which allowed for understanding of spatial and temporal aspects of predation on juvenile Chinook salmon. Despite very high discharge levels and cool water temperatures for most of the 2019 field season, we observed predation on juvenile Chinook salmon in every month (March – June). The frequency of occurrence of juvenile Chinook salmon in diet samples was highest for striped bass, slightly less for black bass, and negligible for Sacramento pikeminnow. No catfish, sunfish, or hardhead were observed to have

consumed salmon over the three years. At a landscape level and across each season, predation on juvenile Chinook salmon was observed in about one third of the habitat units sampled. In the Stanislaus River, predation on juvenile Chinook salmon occurs at a low, but persistent rate even in habitats devoid of anthropogenic features. These findings prompt a need to more critically examine factors associated with predation and cumulative mortality throughout the watershed rather than just at hotspots.

031-FBEP: Ecology of Piscivorous Sport Fishes in the San Joaquin River and South Delta

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Striped bass, black bass (largemouth, smallmouth, and spotted), and catfish are popular sport fishes in the San Joaquin River and South Delta, yet little information exists on their distribution and abundance both locally and regionally. Additionally, these predatory species are thought to be inhibiting recovery efforts for native fishes, although predator-prey dynamics are still poorly understood. Since 2019, we have been targeting these species using large fyke traps and boat electrofishing to better understand their local abundance, distributions, habitat associations, seasonal movements, and diets. Upon capture, individuals were implanted with a Passive Integrated Transponder (PIT) tag to provide individual level detection histories, and a subset were given external reward tags with reporting information. Mark-recapture methods were used to model population dynamics, specifically abundance through time. Between May 2019 and June 2020, the weekly abundance of striped bass ranged from almost 20,000 to just under 200 individuals. Striped bass recaptures reported by agency biologists and anglers indicated a population comprised of both resident and migratory individuals, with recaptures occurring in the ocean, the San Francisco Bay-Delta, San Joaquin River tributaries, and the Sacramento River approximately 130 km upstream of Knights Landing. Black bass species were more sedentary and were more likely to be associated with submerged aquatic vegetation than striped bass, but catfish species were rarely encountered. Using gastric lavage, gut contents were collected from 219 individuals captured in the South Delta in January and February of 2020. Diets varied by predator species, but lamprey ammocoetes and small-bodied fishes (awaiting genetic ID) were important prey items as were amphipods and crayfish. The naturalization of these species has increased the diversity of the Bay-Delta trophic structure and represent novel energetic pathways. Co-management of these and important natives (e.g., Chinook salmon) will be necessary to build resilience in the Bay-Delta ecosystem.

032-FBEP: Interannual Variation in Growth and Life History of Wild Juvenile Longfin Smelt in the San Francisco Estuary

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The Longfin Smelt (*Spirinchus thaleichthys*) is a native forage fish that was once abundant in the San Francisco Estuary, but whose population has declined dramatically in recent decades. To improve species conservation and water management, a better understanding of habitat suitability for Longfin Smelt is needed, including spatial variation in habitat use and growth. Otolith microstructural (age) and geochemical (strontium isotopes) analyses were used to assess ontogenetic and spatial variation in growth rates and habitat (salinity) use and migration of wild juvenile Longfin Smelt collected throughout the San Francisco Estuary over two decades. Growth rate increased from hatch, generally peaking between 60-90 days old, then decreased steadily through the rest of the first year, ending in annulus formation, though the timing of this is variable among individuals and years. Life history was complex; fish generally hatched in low-salinity brackish water then migrated to saltier water, but the salinity at hatch and timing of transitions were variable among fish. Furthermore, some fish remained in brackish water for the entire period before they were caught as juveniles. Results of this work complement those of recent field studies, particle tracking models, and embryological salinity tolerance experiments, all of which suggest that Longfin Smelt can utilize a variety of low-salinity estuarine habitats throughout their life-cycle.

033-FBEP: *Poster Withdrawn*

034-FBEP: (*IEP) Length-at-Date Versus Genetic Race Assignments of Juvenile Chinook Salmon Captured at Knights Landing

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Length-at-date criteria have been utilized in the field to identify four races of Central Valley juvenile Chinook salmon for over 30 years. Numerous genetic analyses have been performed to validate the accuracy of LAD assignments. However, genetic

analyses indicate two critical assumptions of the LAD approach were invalid, i.e., lengths of races do not overlap on any calendar day, and growth rates are constant among the four salmon races. Genetic results further revealed a large percentage of three salmon races, with the exception of winter-run, have been misidentified while utilizing LAD criteria. At Knights Landing (KL) on the Sacramento River, two rotary screw traps have been used to capture emigrating juvenile salmon with the intent to inform Delta water managers of the emigration timing of listed Chinook salmon into the Delta. During 2017-2019, a subset of 1600 juvenile Chinook salmon captured at KL were assigned a race based on LAD criteria, then a tissue sample was collected to verify race utilizing genetic analyses. Genetic results indicated 92 percent accuracy for winter-run LAD assignments, 88 percent accuracy for fall-run, 5 percent accuracy for spring-run, and zero percent accuracy for late fall-run. The genetic analyses of juvenile salmon captured at KL corroborate results obtained from previous genetic studies of salmon race identification. The importance of correctly identifying listed winter- and spring-run races emigrating through the Central Valley and Delta cannot be understated when species recovery, and water operations affecting supplies for people, agriculture, and industry are at stake. Genetic race identification is currently the preferred technique for accurately identifying salmon races; however, results can take days or weeks to obtain and can be cost prohibitive. Therefore, the development of a new or modified real-time technique to accurately assign race, especially for spring-run Chinook salmon, is prudent for generating juvenile production estimates.

035-FBEP: Sub-Lethal Effects of a Pyrethroid Pesticide (Bifenthrin) on Larval Sturgeon

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Aquatic contaminants are pervasive in the SFBD, and they are recognized as a potential threat to recruitment of California sturgeon. However, knowledge of the vulnerability of sturgeon to aquatic contaminants is limited. Our goal was to investigate sub-lethal effects of a pyrethroid pesticide (bifenthrin) on early life stages of sturgeon. We conducted laboratory exposures of yolk-sac larvae to multiple concentrations of bifenthrin to identify concentration-dependent impacts on growth, motor-coordination, activity levels, and thermal-tolerance. We saw greater sensitivity in White Sturgeon (*Acipenser transmontanus*) than in Green Sturgeon (*A. medirostris*), yet both displayed marked loss of motor-control and reduced activity after three days at the highest exposure concentrations. White Sturgeon have been shown to be more sensitive to many aquatic contaminants compared to other fish species commonly used in toxicity testing. Interestingly, in our study, the bifenthrin concentration at which sturgeon larvae demonstrated an observed effect was higher than concentrations at which effects were

observed in fathead minnows or rainbow trout in the literature. This may suggest that sturgeon respond to aquatic contaminants in different ways than other more derived fish species. Evaluation of thermal performance in white sturgeon after the exposure period also showed a concentration-dependent loss of thermal tolerance. However, after three weeks of recovery in clean water, fish which had been exposed to low and moderate bifenthrin concentrations (<500ng/L nominal conc.) had regained motor control and no groups showed differences in thermal tolerance. This suggests that larval sturgeon can partially recover from short-term bifenthrin exposure at environmentally relevant concentrations. However, bioaccumulation is also likely a concern and should be addressed in future work, along with the potential for synergistic effects with water temperature and contaminant mixtures. This increased knowledge about how sturgeon respond to common contaminants will allow for more targeted management of the species and their habitats.

036-FBEP: (*IEP) Circular Tow Tank Testing of General Oceanics Flowmeters

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General Oceanics 2030R flowmeters are commonly used by CDFW to measure distance and speed during aquatic ecosystem sampling. General Oceanics recommends the use of a 2030CF Spin Resistance Tester as a means to check for the proper functioning of these flowmeters, but this tester does not give any indication of the accuracy of the flowmeter at a particular tow speed. In the past, linear tow tanks and flumes have been used in an attempt to check the accuracy of these flowmeters at various tow speeds, but currently these methods are not readily accessible by CDFW. As a means to test the accuracy of the 2030R flowmeters, a Circular Tow Tank (CTT) was designed and built at the CDFW La Grange Field Office in 2020. By using the CTT, it is possible to test flowmeters at tow speeds from 0.18 m/s – 1.80 m/s over extended distances. The 2030R flowmeter CTT test results indicate that General Oceanics single stated rotor constant of 26,873 is reasonably accurate at tow speeds above 1.00 m/s. At tow speeds below 1.00 m/s, the General Oceanics 26,873 rotor constant should not be used. Instead, an interpretation of General Oceanics Velocity Curve for High Speed Rotor graph should be used at tow speeds from 0.75 m/s – 1.00 m/s. At tow speeds below 0.75 m/s, 2030R flowmeters exhibited considerable variation from unit to unit. The use of 2030R flowmeters at tow speeds from 0.25 m/s – 0.75 m/s is therefore not recommended unless they are used in conjunction with their corresponding CTT test results. At these tow speeds, CTT testing of General Oceanics flowmeters will reduce both distance and speed measurement errors from 2 - 10% during aquatic sampling, and as a result, lead to more accurate population estimates for a wide array of Bay-Delta organisms.

037-FBEP: (*IEP) Machine Learning Tools for Reducing Entrainment Risk of Endangered Salmonids at Water Export Facilities

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Incidental entrainment loss of fishes at large-scale state and federal water diversion facilities in the Sacramento-San Joaquin Delta, California, can trigger protective management actions when limits imposed by environmental regulations are exceeded. These management actions can result in substantial economic costs, and likewise, they can impact the status of species protected under state and federal statutes. Predicting the near-term risk of entraining protected species could help to reduce impacts on threatened fish populations and reduce the likelihood of triggering additional restrictions on water diversions. To this end, we developed and compared a range of machine learning models based on classification and regression trees and integrated their predictions into a web-based forecasting tool. We trained and validated the models using historical entrainment observations (water years 1999–2017) of Sacramento River winter-run Chinook salmon and Central Valley steelhead in response to a suite of environmental and water operations variables. A quantile modeling approach was used because of the importance of low-frequency, but high impact major loss events which are unlikely to be properly described by a point estimate. Predictive ability was judged relative to several precautionary quantiles (i.e. 75, 90 and 95%) with a focus on the frequency and magnitude of underprediction, and pilot testing was conducted during the 2020 water year. K-fold and leave-one-out cross validation both indicated that severe underprediction was rare (e.g. winter run loss exceeded the 75th predicted quantile by >50 fish only ~5% of the time) and that the 75th quantile may provide an appropriately precautionary prediction of risk. A beta version of a web-based tool is available through SacPAS and allows users to interact with the models to make predictions of entrainment loss one week into the future, and explore the impacts of alternative management or environmental scenarios on entrainment risk.

038-FBEP: Validation and Application of Otolith Microstructure and Microchemistry Methods for Examining Growth and Life History Strategies in Delta Smelt

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Delta Smelt (*Hypomesus transpacificus*) play an important role in water management policies focused on the recovery of the species. These decisions impact freshwater exports for urban and agricultural use. A detailed understanding of the life-history strategies of Delta Smelt is essential to creating and implementing effective management efforts. We previously analyzed Delta Smelt throughout the upper San Francisco Estuary in the last decade using the salinity-strontium relationship and identified three distinct life-history strategies: freshwater residents, brackish water residents, and semi-anadromous fish. However, when examining life-history strategies, we need to evaluate our confidence in temporal, aging, and analytical resolution. We validated otolith-based aging techniques using known-age Delta Smelt to analyze age, increment periodicity, and constant proportionality, yielding high mean accuracy and inter-operator precision. Additionally, we experimentally assessed the accuracy and temporal resolution of otolith-based salinity reconstructions by manipulating salinity (0, 3, and 6 ppt) for cultured Delta Smelt, demonstrating our ability to reconstruct the migration history of wild Delta Smelt using otolith techniques. These validations contribute to our interpretation and understanding of life-history strategies and how they allow Delta Smelt to persist in a dynamic environment, which is critical for the management and conservation of Delta Smelt.

039-FBEP: Spatial Variation in Growth of Wild Longfin Smelt Larvae among Regions and Habitats of the San Francisco Estuary

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The Longfin Smelt (*Spirinchus thaleichthys*) is an important, threatened species in the San Francisco Estuary (SFE) which utilizes a diversity of the estuary's waterways, including smaller tributaries. How Longfin Smelt respond to different regions and habitats in these tributaries remains unknown. Successful management of this species relies on spatially and temporally detailed management plans which consider the needs of Longfin Smelt throughout their life and respond to the changing conditions of the environmentally complex SFE. Using wild Longfin Smelt larvae collected in spring of 2017, an otolith-based age and growth and geochemical analysis was used to investigate variation in growth and migration among regions and habitats across the SFE during an extremely wet year. Sagittal otoliths were collected from wild Longfin Smelt and analyzed for age and daily accretion rate from 5 independent readers using

ImageJ. Larval salinity history was reconstructed using an empirically-derived relationship between strontium isotope ratios (87Sr/86Sr) measured using Laser Ablation Inductively Coupled Plasma Mass Spectrometry. This work builds a more detailed understanding of the suitability of various regions, habitats, and salinity profiles for Longfin Smelt within the San Francisco Estuary and is key in the development of more precise and effective management practices.

040-FBEP: Development of a Laser-Timed Swim Tunnel for Measuring Anaerobic Swim Performance Across Species

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Fish swim performance can vary widely across species and under different environmental conditions. Therefore, it is imperative to incorporate a suite of physiological performance measures when determining swim performance. Past research has focused upon sustained, aerobic swim performance (e.g., critical swimming velocities (Ucrit), tail beat frequency, aerobic scope). However, anaerobic swim performance (i.e., burst swimming) may be an important predictor in ecological performance. We have developed a burst-swim performance chamber and protocol using computer monitored laser-gates to measure the velocity of a fish's burst performance. Our design allows for controlled, repeated trials that provide a proxy for exhaustion. It can also be used to evaluate changes in anaerobic capacity given past rearing histories (e.g., exposure to aquatic contaminants). We have measured burst performance among several species of resident California species (Chinook salmon, green sturgeon and largemouth bass) across ecologically relevant test temperatures to determine how thermal exposure or contaminant history influences anaerobic physiology and ecological outcomes. We believe this method of quantifying burst-swim performance is valuable for management of Delta ecosystems and in addition to determining burst velocity, can be employed to evaluate fish passage infrastructure and the effects of pollutants, disease and biotelemetry tags on fish performance.

Food Webs (FW)

041-FW: (*IEP) The Long and the Short of It: How Mixing and Geomorphology Affect Biogeochemical Processes.

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Water residence time – also called water age – can be defined as the amount of time water spends in an area before it is mixed out. Residence time is a major driver of biogeochemical processes in aquatic systems because it determines the amount of time over which processes such as nutrient uptake and phytoplankton growth may occur. Residence time in tidal environments is largely determined by local geomorphology, with one example being dead end channels having long residence times at their distal ends. Other examples are marsh and flood plains, which can detain water on scales from days to months. One of the greatest differences between the historical and present Delta is the near elimination of dendritic channel systems and marsh/flood plain connectivity, which once provided a wide range of residence times. The present Delta largely comprises dynamic channels with little appreciable residence time with a comparatively small number of long-residence-time areas. A continuum of residence times is necessary to connect longer-timescale biogeochemical processes such as phytoplankton production to shorter-timescale transport processes, but this continuum is largely absent in the present Delta.

Our study explored relationships between residence time, nutrient cycling and phytoplankton community structure. Evaluating effects of residence time in tidal environments is difficult because of the rapidly changing conditions. Thus, we a used method we developed previously to estimate residence time from the stable isotopes in water, which we measured continuously at high frequencies aboard a moving boat together with nitrate, ammonium, phytoplankton and water quality parameters. We used this technique to estimate net ecosystem uptake rates of nitrate, ammonium, and total inorganic nitrogen in the north Delta to provide information for current conditions and to provide landscape scale data useful for building and validating ongoing coupled physical-biogeochemical models.

042-FW: Monitoring, Modeling and Prediction Project - Enhancing Predictive Capability for Phytoplankton Response to Natural and Operational Induced Variability in the Delta

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This interdisciplinary, multi-institutional project, supported by CDFW as part of Proposition 1 funding, will support endeavors to improve food production for Delta Smelt by improving the existing ability to predict phytoplankton blooming by combining multidimensional modeling, high-resolution observations and phytoplankton productivity rate data to test two hypotheses. 1) Blooms occur when ambient ammonium concentrations decline and nitrate uptake by phytoplankton is initiated, and 2) Blooms observed at specific locations often result from advection of chlorophyll from upstream. The project goal is to help establish an open source 3-D coupled hydrodynamic ecosystem model (SCHISM-CoSiNE) to predict real-time biochemistry and bloom conditions of the Bay-Delta and for scenario testing. The objectives are to: 1) make observations to determine the effects of flow and nutrients on production of food in regions of the Bay/Delta critical to higher trophic levels, e.g. Delta Smelt; 2) improve the SCHISM-CoSiNE model with high frequency data from fixed stations and enhanced spatial coverage; and 3) develop links with potential users/clients. Field observations include weekly transects from Cache Slough to Grizzly Bay in spring and fall accompanied by high-speed mapping to collect nutrient, chlorophyll, primary productivity and nutrient uptake rate data to develop/validate the model as it is extended landward. Real-time ammonium, nitrate, chlorophyll and flow data from Rio Vista, the Confluence and Grizzly Bay will be used to predict the conditions for blooming and likely occurrence in the Bay-Delta using the SCHISM-CoSiNE model. This involves installing SUNA nitrate sensors and Timberline ammonium analyzers at existing instrumented sites and on research vessels. Fluorescence sensor data will be examined to assess advection of chlorophyll. The intended outcomes are to improve predictability of food production for upper levels of the food chain and effects of flow management and make available a validated, open source, 3-D coupled hydrodynamic-biogeochemical model of the Bay-Delta.

043-FW: Monitoring, Modeling and Prediction Project - Phytoplankton Response to Natural Variability in the Delta - Preliminary Observations from Fall 2020

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The goal of our Prop 1 funded project is to monitor, model and predict spring and fall phytoplankton production processes in the Bay-Delta ecosystem using field observations along transects, high speed mapping, moored instrumentation and ecosystem modeling. Being able to evaluate whether there will be increased food availability for the pelagic food web in the Delta is relevant to Bay-Delta management concerned with improving the conditions for Delta Smelt and other pelagic fishes. In-spite-of COVID lockdowns, SFSU and USGS were able to sample water for nutrients and chlorophyll along transects and with high speed mapping in fall 2020 and obtain chlorophyll and nitrate data at some fixed stations. Four downstream transects (carried out on 20 and 31 October; 6 and 13 November) were carried out from Lower Cache

Slough Complex, Rio Vista, the confluence and Grizzly Bay with underway SUNA nitrate data and chlorophyll fluorometry and vertical CTD profiles at 9 stations. Water from discrete samples from 10 stations was analyzed for nutrients, chlorophyll, primary productivity and phytoplankton uptake nitrate and ammonium with 15N. High speed maps were made on 10/20/2020. No phytoplankton blooms were observed with chlorophyll concentrations mostly <3.5 µg/L along all transects except on 10/31/2020 near the confluence (6 µg/L) and on 11/13/2020 downstream of Rio Vista (5.6 µg/L). Ammonium was >4 µM (and >6 µM on 11/13) along all transects except on 10/20/2020 where there was ~ 3 µM. Samples to evaluate phytoplankton rates of productivity and nutrient uptake are awaiting analysis. Modeling using these preliminary data has been started. The next steps are to install an underway ammonium analyzer to accompany the nitrate sensor for five transects to be visited in spring 2021. These will accompany the three nitrate and three ammonium analyzers to be installed at fixed locations.

044-FW: How an Estuarine Prey Field Changes with Managed Freshwater Outflow

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How does managed outflow affect the distribution and abundance of zooplankton across the estuary?

Increasing freshwater outflow to the San Francisco Bay Estuary-Delta is hypothesized to improve foraging habitat for endangered Delta Smelt, particularly during the important fall pre-spawning period. We examined how increasing managed outflow affected zooplankton communities, including important prey items for Delta Smelt.

We examined macro/microzooplankton communities using abundance/biomass measures in five regions (Suisun Bay, Suisun Marsh, Lower Sacramento River, Cache Slough and Sacramento Deepwater Shipping Channel) and three habitats (Channel Surface, Channel Deep and Shoals) of the Estuary using a Non-Parametric Multidimensional Scaling approach during the fall season of two different years, 2017 and 2018. 2017 was considered a “wet” managed outflow year with *X2* further west than in the “dry” 2018.

During 2017, zooplankton communities were more homogeneous across the Estuary (particularly Suisun Bay) while in 2018 they segregated into distinct low/ high salinity groups. Salinity was the primary factor underlying differences between the years. Deep channel habitat in 2018 had higher abundance/ biomass than near surface habitat in channels and shoals. Abundance/ biomass of zooplankton communities within Suisun

Bay differed between years, primarily driven by changes in salinity, dissolved oxygen, and temperature. Abundance/biomass of macrozooplankton communities (mysids and amphipods) were unaffected by changes in outflow in Suisun Bay.

Managed freshwater outflow during fall can affect distribution and abundance of zooplankton across the Estuary in ways which influence habitat dynamics of endangered planktivorous fishes. Salinity, dissolved oxygen, and temperature appears to influence the structure and composition of the lower trophic community in response to managed outflow in ways which provide insight to impacts from future sea level rise and an increasingly arid climate. Increasing outflow did not appear to affect the macrozooplankton community and thus other actions could be examined to increase abundance and biomass.

045-FW: (*IEP) Cage the Zoop: Do Delta Smelt Enclosures Alter Internal Zooplankton Composition and Availability?

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Delta Smelt (*Hypomesus transpacificus*) are a state and federally listed species experiencing extreme declines throughout the Sacramento-San Joaquin Delta. As a result, there is an urgent need to understand the ability of captive-reared Delta Smelt to survive in the wild under variable field conditions. Specific Delta Smelt enclosures were developed to meet two purposes: 1) help inform soft release protocols for supplementation and 2) use the enclosures as a tool to inform effectiveness of management actions. In previous studies, we found high survival of captive-reared Delta Smelt deployed in enclosures in the wild and that these fish successfully transitioned from hatchery feed to live zooplankton as a food source. However, it is unknown if enclosure mesh and biofouling alter the composition and availability of zooplankton inside the smelt enclosures. In this study, we ask if zooplankton composition and availability differ inside Delta Smelt enclosures when compared with adjacent areas? To address this question, we sampled zooplankton inside and outside the enclosures, after deployment in the Delta but before Delta Smelt were introduced. To do this, we designed and built a modified plankton trap-tube sampler, an instrument that is frequently used for shallow watersampling. The results of this study will help to validate stomach content results and provide a comparison with zooplankton samples collected outside the enclosures. Additionally, it will inform the utility of smelt diets from enclosure deployments for evaluating the effectiveness of management actions intended to benefit Delta Smelt.

046-FW: (*IEP) Insights into Dietary DNA of Juvenile Longfin Smelt and Northern Anchovy

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Food limitation is a likely constraint on the abundance of several fish species in the San Francisco Estuary. We used DNA metabarcoding analysis (COI gene) on the guts of co-occurring planktivorous juvenile longfin smelt (*Spirinchus thaleichthys*) and northern anchovy (*Engraulis mordax*) to assess the relative level of dietary overlap between these two co-occurring species in the northern San Francisco Estuary, collected in summer-fall of 2017. Preliminary analysis of our dietary DNA (dDNA) data supports previous assessments that suggest the two species have different diets (Shoener's Index of Dietary Overlap = 0.43). We also found northern anchovy consumed a wider range of zooplankton prey than the longfin smelt, which supports prior knowledge of the anchovy being a filter feeder. We found some overlap in the zooplankton prey types that were more frequently consumed (FO%) by the two fishes. Both species had higher FO of the copepods *Tortanus* spp., *Acartia californiensis*, and *Paracalanus* sp., the amphipod *Monocorophium acherusicum*, the polychaete (larvae) *Polydora cornuta*, and the barnacle (larvae) *Amphibalanus improvisus*. The most abundant DNA types found in the longfin smelt diets were from an unidentified arthropod (33% overall), the amphipod *M. acherusicum* (15%), and unclassified DNA (21%). Conversely, the most abundant DNA in the northern anchovy was from the copepod *Limnoithona tetraspina* (16%), an unidentified insect (11%), and unclassified DNA (37%). Our dietary DNA results will not only provide genetic identification of the taxa important to the diets of these fishes, they may also be useful to infer life history differences among species which can help inform managers on the most important food and habitat resources that are being provided to fishes in the estuary.

047-FW: Dark Carbon: Assessing How Detrital Food Resources Move Up the Food Chain

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Due to reclamation for agricultural and urban infrastructure, only five percent of California's historic floodplain and wetland habitat remains in the Central Valley. Thus, the remaining riverine, tidal, and wetland habitats have shifted from a mixed detrital and autochthonous to a primarily autochthonous system. Previous studies in the California

Delta and floodplains have shown that phytoplankton is a significant source of carbon for grazing zooplankton and ultimately relayed to higher level consumers. Currently, how detrital food resources contribute seasonally and across various habitats is not well quantified. In order to better understand basal carbon contribution to the aquatic food webs in the North (Yolo Bypass downstream) and Northeast Delta (Cosumnes River and downstream), we conducted monthly water quality and zooplankton sampling May-November and weekly sampling December-April. We combined field data with laboratory incubation experiments to assess the metabolic and carbon cycling rates throughout the year. Additionally, through the use of light stable isotopes, we investigated the spatial and temporal variability in zooplankton community composition and food web structure in our study sites. Understanding the interplay between physical processes and resulting food webs within these habitats can help guide restoration and management actions to benefit aquatic ecosystems.

048-FW: Evaluating the Role of Particulate Wetland Organic Matter to Support Pelagic Food Webs

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The Sacramento-San Joaquin Delta management is heavily driven by declining native fish populations, with stressed lower food web suspected as a primary culprit. Food web limitations in the Delta are caused by a drop in primary productivity coinciding with an increase in filter feeders that has reduced particle concentrations and accompanied a decline in zooplankton. Solutions to increase available food are an obvious management target with the needed emphasis on particulate material composed of detrital remains. These remains of wetland vegetation can help to enhance copepod survival in the presence of low algal concentrations. The need to restore Delta wetlands in a way that supplies detrital material to recover declining fish species in pelagic systems establishes wetlands as a critical but underappreciated feature in Delta food webs. However, little is known about the forms of exported wetland detrital material, the wetland systems most related to that export, or how such particulates are distributed through the Delta's pelagic habitats. In this study, we collected particulate samples across the Sacramento-San Joaquin Delta in the summer of 2020 in order to characterize and quantify export of wetland detrital particles and link these measurements to the lower food web. Lignin biomarkers and chlorophyll concentrations were used as the primary tools to distinguish between vascular plant and algal organic matter. Other measurements in our dataset include fatty acids, isotopic ratios, and optical characteristics. Ratios of lignin to chlorophyll may be indicative of food quality, acting as possible predictors for utility and availability of wetland detrital material. This study is an assessment regarding the potential for restored tidal wetlands to support the lower food web and can provide guidance for future wetland restoration activities that can be implemented in a way to maximize support for pelagic aquatic habitats.

049-FW: The Influence of Resource Availability and Composition on Copepod Growth and Survival in the Sacramento-San Joaquin River Delta

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Resource availability affects organism growth and survival, with the potential to impact consumer populations and broader food web dynamics. In the Delta, phytoplankton are considered a dominant energy pathway for the pelagic food web, but pelagic primary consumers are often considered food-limited due to low primary production. Detrital inputs of terrestrial vegetation provide an alternate energy source, with a recent lab study documenting that mixed diets of phytoplankton and detritus yield higher copepod survival compared to phytoplankton alone. Thus, investigating how resource composition affects consumers is critical for understanding food limitation in the Delta. We examined how resource composition affects copepod growth and survival using field water from sites that we expect vary in detrital inputs. Copepods were exposed to water collected from open and shallow water habitats at Liberty Island (LI) and Ryer Island (RI), with or without the addition of phytoplankton as food. Survivorship was relatively high, but shallow-LI had reduced survival without phytoplankton addition. Phytoplankton supplementation positively affected growth; however, effects of feeding treatment and habitat differed between sites. For LI, growth rates were marginally lower for the shallow habitat. The benefit of phytoplankton was weaker for shallow-RI, wherein growth rates without phytoplankton addition were statistically similar to those from a phytoplankton control treatment. In general, field water receiving phytoplankton supplementation supported higher growth rates than the control phytoplankton treatment, suggesting that field-specific resources further enhanced copepod growth. Work is ongoing to characterize particle composition using a diverse suite of molecular (metagenomics) and biochemical (lignin, fatty acid profiles) approaches. We are particularly interested in understanding which dimensions of resource availability were associated with low copepod survival and growth (e.g., shallow-LI) versus high growth (e.g., shallow-RI). Understanding how resource composition affects copepods may illustrate which resources (e.g., phytoplankton, detrital inputs) most strongly support the Delta's pelagic food web.

050-FW: Phytoplankton and Nutrient Relationships in Wetlands of the Northern San Francisco Estuary Ahead of Large-Scale Nitrogen Reductions

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The role of nutrients on phytoplankton growth and diversity is well-established across nutrient gradients in aquatic ecosystems from the oligotrophic ocean to culturally eutrophic lakes and estuaries. On one end of the nutrient gradient, where nutrients are low, their concentrations often limit the magnitude of phytoplankton biomass and constrain food webs. In contrast, when nutrients are found in excess, the magnitude, form, and ratio of nutrients may influence the structure of phytoplankton communities and promote blooms that are detrimental to other ecosystem processes. Because of changes in wastewater management, the San Francisco Delta is poised to shift substantially along the nutrient gradient from a condition of excess to moderate or low concentrations. The impact of the nutrient shift within the diverse hydrodynamic habitats of the Delta needs to be constrained in order to best manage aquatic resources into the future. We characterized baseline conditions in sloughs and three wetlands prior to nutrient reductions (2017-2018), measuring nutrients, phytoplankton biomass and community composition, and rates of phytoplankton carbon and nitrogen uptake. Locations within the north Delta and Suisun Marsh were surveyed based on the varying influence from wastewater-derived nutrients. We found consistent spatial patterns in phytoplankton biomass and community composition across gradients in total inorganic nitrogen and the ratio of nitrate to ammonium. Consistent with previous work, the presence of ammonium suppressed nitrate uptake across the landscape. At the wetland site with relatively warm water and abundant ammonium, we found that phytoplankton communities were dominated by picocyanobacteria. In the wetland\ with relatively low nitrate and ammonium, green algae dominated while at wetlands with lower water temperature and low ammonium but abundant nitrate, diatoms were dominant. These findings provide a basis for hypotheses about future shifts in phytoplankton communities in response to managed alteration of nitrogen concentration and form in the Delta.

051-FW: Growing Fish Food in Duck Ponds: Food Web Support in Suisun Marsh

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Mesozooplankton are important prey for pelagic fishes in the San Francisco Estuary. Mesozooplankton have declined in tidal waterways of the San Francisco Estuary over several decades, and this trend has likely contributed to recent fishery collapses. However, new evidence suggests that managed wetlands (ie duck clubs) in Suisun Marsh produce exceptionally high concentrations of mesozooplankton when flooded. This talk will (1) highlight zooplankton density trends in several managed wetlands and adjacent tidal waterways in Suisun Marsh and (2) explore drivers of zooplankton

production in managed wetlands including seasonal management regimes, water age, benthic community structure, and vegetation structure. Our ongoing research in managed wetlands provides an opportunity to identify novel ecological conditions that will promote mesozooplankton in today's changing estuary. Our findings have direct implications on future restoration and reconciliation practices such as the integration of diked wetland habitats and existing infrastructure in fisheries management.

052-FW: A Story of Resistance: Exploring Evolutionary Mechanisms and Implications to Extreme Insecticide Exposures Throughout the Bay-Delta Region of California

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For almost a decade, we have been monitoring the levels of insecticide resistance that evolved in the sediment-dwelling crustacean Hyalella azteca, throughout California, but especially within the Bay-Delta Region. We have shown that resistance has developed to multiple insecticide classes, is widespread in waterways draining both agricultural and urban areas, and is often effectively fixed within many populations. We have revealed that mutations in the target site genes for pyrethroid (voltage-gate sodium channel; VGSC) and organophosphate (acetylcholinesterase; AChE) insecticides confer tolerance up to 500 times greater than wild-type individuals. In this presentation, we will review what is known about the evolutionary and molecular mechanisms involved in the higher tolerance to insecticides and specifically focus on the Cache Slough complex. Within this area, 93% of animals collected are resistant to pyrethroid insecticides, 50% are resistant to organophosphate insecticides, and individuals which are wild-type for both the insecticide target genes are rare. During storm events, the presence of resistance mutations within the VGSC allow H. azteca to survive extreme insecticide exposures, while animals without these mutations perish.

In addition to the high occurrence of resistance mutations in H. azteca populations, our work has also suggested population and community level implications associated with the resistance populations. These individuals have lower tolerance to other environmental stressors including climate change-related stressors of temperature and salinity. Even more concerning, these populations have the ability to accumulate insecticide concentrations far higher than their wild-type counter parts, allowing for trophic transfer to fish species of concern. Future work is directed toward understanding the overall prevalence of resistance in macroinvertebrate communities in the Bay-Delta region. As we begin to see the scale of this issue, it is important to ask, "What role are we playing in this story of resistance?"

053-FW: North Delta Food Subsidies Study - Evaluating Baseline Phytoplankton Condition Using Bioassays During 2020, a Non-Action Year.

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The North Delta Flow Action (Action) is a managed flow pulse (i.e., an above-average flow) that is intended to improve downstream transport of plankton in the North Delta, where seasonally low and reverse net flows may limit food subsidies to downstream habitats. Our study examined the effects of the Action on the food web in the Yolo Bypass and Sacramento River downstream to assess any enhancement in quantity and quality of food for Delta Smelt in the North Delta and lower San Francisco Estuary. Three different flow actions (natural in 2011, construction induced in 2012 and using diverted Sacramento River water in 2016) resulted in increased productivity in the Yolo Bypass and food subsidies downstream. However, the 2018 and 2019 actions using agricultural return flows resulted in local productivity in the Yolo Bypass but no increase in chlorophyll in the lower Sacramento River at Rio Vista. A managed flow action was not planned for 2020, but one using diversions of Sacramento River water is being considered for summer of 2021. In 2020, we conducted monitoring and experimental bioassays from July to late October to provide baseline conditions of a non-managed flow year for comparisons with conditions resulting from previous and future managed flow actions. Monitoring activities for 2020 were reduced due to COVID and wildfires but showed that chlorophyll was low, < 3 µg/L at Rio Vista. Even so, 5-day bioassays carried out throughout the study indicated the phytoplankton were able to grow, accumulating chlorophyll up to 40 µg/L, similar to observations made in 2019. Hence, there was no evidence that phytoplankton growth was suppressed during the study period. This contribution is relevant to Bay-Delta management as it provides baseline data against which to judge the efficacy of past and future flow actions.

Global and Watershed Perspectives (GWP)

054-GWP: Comparison of Salt Ponds Transformation and Low Lands Coastal Management: Lessons from Experience in San Francisco Estuary and Shandong Laizhou Bay

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San Francisco Estuary (CA, USA) and Laizohu Bay (Shandong, China) are highly economic developed and urbanized coastal area from three continent with long environmental changing due to salt ponds and coastal industry history. The research try to look into the management of the San Francisco Estuary to see which could be improved by learning from diverse experiences globally, by comparison study with Laizohu Bay.

We use historical and GIS mapping to compare costal land use changing among two coastal area. Comparing policy and legal framework changing base on time line background analysis. And how effective of the result of coastal management nowadays, and how to improve by learning from each estuary and bay area. Especially Laizhou Bay has long period changed and undermined coastal wetlands ecosystem by driven salt ponds and port industry economic. By legislative coastal protection approach from 2018, started a sign of slightly improving amount of tidal salt marsh, mud flat wetland restoration and the awareness of coastal ecosystem protection. But still should have stronger legal framework, enforcement and build up partnership among central, local government and society. In order to protect and restore more healthier bay area in advance of prevention of multiple climate change disasters.

Integrative Applied Science (IAS)

055-IAS: (*IEP) Feelin' 22, Time for a Review: A Programmatic Review of the Yolo Bypass Fish Monitoring Program

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The California Department of Water Resources (DWR), in cooperation with the Interagency Ecological Program (IEP), has operated a fish and aquatic ecology monitoring program, the Yolo Bypass Fish Monitoring Program (YBFMP), since 1998. In its 22-year history, the program has not undergone any comprehensive internal or external review, either from a scientific design or a programmatic perspective. Regular reviews are a critical element in keeping monitoring programs adaptable and efficient, and also to ensure accountability and the highest quality science to meet management goals. We initiated a two-phased comprehensive internal review of the program, with the first phase being a programmatic review and the second being a scientific monitoring design review (planned for 2021). The programmatic review, completed in 2020, involved a comprehensive review of all existing program documentation, policies, and procedures. Staff identified 27 program elements for review, covering the range of YBFMP sampling activities, and the logistical, operational, and regulatory components of the program. In total, we reviewed 75 existing program documents such as standard operating procedures, metadata, safety plans, and training materials. The evaluation of this documentation allowed us to identify gaps and needs in the program. This review

led us to archive 16 documents, edit 17 documents, and create 24 new documents. In addition to these updates, we identified 92 recommendations to improve operations and accountability that we will continue working on implementing in the coming year. The results of the review enhanced our YBFMP documentation, procedures, and accountability to various stakeholders while simultaneously preparing the program for future external reviews. Finally, this review also motivated YBFMP to develop a plan for annual check-ins on program documentation and to conduct internal reviews on a more frequent basis. We hope this review structure can provide a model to other monitoring programs seeking review.

056-IAS: Integrating Science and Models to Provide Management Solutions to Control Methylmercury in the Yolo Bypass

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Methylmercury (MeHg) is a potent neurotoxin that bioaccumulates and biomagnifies up the aquatic food chain. The Yolo Bypass, under high floodwater conditions, can be the largest tributary source of MeHg to the Delta. Under the Delta Mercury Control Program, the Department of Water Resources (DWR) is tasked with reducing open water sediment flux of methylmercury from the flooded Yolo Bypass, however, finding management solutions to reducing MeHg loads requires an understanding of why the Yolo Bypass is a source.

DWR and a multidisciplinary team conducted field/technical studies and applied a mechanistic mercury model to further understand MeHg dynamics in the Yolo Bypass and evaluate management strategies to reduce MeHg in the flooded Yolo Bypass.

In water year 2017, the flooded Yolo Bypass was a net source of MeHg. Most of the supply occurred above Liberty Island. Spatially, MeHg concentrations increased along the flow path and became more associated with particles. Temporally, it took approximately 4-5 weeks of Bypass inundation, before we observed an increase of MeHg on solids. On average, the upper reach of the Yolo Bypass generated an additional 14 g/day of MeHg. Rough extrapolations from laboratory experiments suggested that sediment-water flux from all land uses could account for only part of this load. Vegetation senescence experiments suggested that inundated, dying vegetation could contribute substantially to MeHg production. Exploring possible control measures, disking vegetation into the soil resulted in significantly less filtered MeHg concentrations than inundated rye grass, suggesting vegetation control could reduce MeHg exports. Extrapolated field/laboratory loads and model results compared favorably with actual loads measured in the Yolo Bypass, providing multiple lines of evidence that our work

captured important drivers of MeHg production. More work is needed; however, our work provides managers and regulators with a possible strategy to reduce MeHg loads originating from the Yolo Bypass.

057-IAS: Improvement of WARMF Model to Simulate Wetland Processes Leading to Increased Salinity

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Export of a salt from seasonally managed wetlands in the San Joaquin River (SJR) basin is a significant source of water quality impairment to the Delta when combined with agricultural salt export. High salinity can negatively impact both moist soil plant and agricultural crop germination. The Watershed Risk Management Framework (WARMF) model has been used extensively to provide Total Maximum Daily Load (TMDL)-related decision support for real-time salinity management in the SJR. Realistic simulation of wetland drainage electrical conductivity (EC) is critical if credible simulations of conservative and non-conservative constituents are to be achieved. The WARMF module for simulating wetland processes was recently updated with a "bathtub" analog that is better suited to track observed wetland hydrology during dynamic conditions. Simulations of two instrumented WARMF model catchments representing wetlands in the Grassland Water District were performed to address current limitations of WARMF model performance. The two catchments are irrigated with water supplied from different sources. Monitoring data was used to compile a more accurate estimate of water supply EC. Improved time series inputs were developed and assumptions were assessed by comparing simulation output with wetland drainage export and salt load measured at each wetland catchment outlet. Agreement between observed and simulated drainage salinity improved when the wetland model was adjusted to mimic the combined drainage outflow from multiple wetland impoundments. Knowledge from the two simulated catchments will be applied to improve simulation of salinity in all wetlands in the Grassland Ecological Area. The presented upgrade of WARMF's wetland module represents an important improvement of simulated hydrology and salinity which will allow better assessment of management practices and more precise forecasting. The improvement will aid managers that want to use WARMF to reach compliance with the salinity TMDL.

058-IAS: Collaboratively Identifying Science Actions to Meet Management Needs – Developing the 2022-2026 Science Action Agenda

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Unique for the Delta science enterprise, the Science Action Agenda (SAA) prioritizes and aligns science actions to meet management needs. This four- to five-year iterative agenda, developed by the Delta Stewardship Council's Delta Science Program, supports the vision of *One Delta, One Science*—an open Delta science community that works together to build a common body of scientific knowledge. The SAA is organized around pressing management needs and the highest priority science actions responsive to those needs. The next iteration of the SAA will include a list of top management questions to better link broader management needs to science actions. The content of the SAA is created through an iterative and collaborative process of engaging participants through meetings, workshops, and surveys. The update of the 2022-2026 SAA began in early 2020 with the engagement of over 30 collaborative groups, to develop the list of top management questions. Stakeholders, managers, and scientists submitted nearly 1,300 management questions to the Delta Science Program. The questions were sorted into themes and merged, edited, and discussed at a public workshop with 85 participants, and rated twice by workshop participants via online surveys. Topics of the resulting list of roughly 70 top Delta management questions range from modeling and monitoring needs, to strategies for addressing climate change, to approaches for integrating social science and traditional ecological knowledge. These management questions are the foundation for the 2022-2026 SAA. Created for and by the Delta science community, the SAA is currently and will continue to be used to foster collaborations and guide science and funding priorities in the Delta.

059-IAS: Exploration of the Features of the Delta Plan Performance Measures Dashboard

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The Delta Stewardship Council unveiled the Delta Plan performance measures dashboard in spring 2019. The dashboard is a website that reports 32 performance measures information related to the health of the Delta and 122 administrative measures tracking management actions led by implementing State and Federal agencies. Delta Plan performance measures integrate scientific findings into decision-making and adaptive management processes, assessing progress toward achieving the

coequal goals of a reliable California water supply and a healthy Delta ecosystem. The performance measures cover broad Delta Plan topics: Delta as an Evolving Place, Water Quality, Water Supply Reliability, Delta Ecosystem, and Protect People and Property. The performance measures serve multiple purposes: define measures of success relative to the coequal goals, assess how well Delta Plan strategies, policies, and recommendations are working, providing a tool for communicating with Delta managers and interested public, and supporting decision-making in the Delta. Since the release, the dashboard has been updated several times to include new features such as: data schedules, updated visualizations, and recent scientific or management actions under several performance measures. The dashboard will continue to provide new relevant information and details about agency actions as they relate to the specific performance measures. This virtual poster will showcase findings from 2019 and 2020 water years, and guide viewers to the different features of the dashboard.

060-IAS: Bay-Delta Data Sandbox: A Web-Based Analytics and Visualization Environment for Experimenting with Integrated Bay-Delta Data

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A multitude of scientific efforts collect ecological and water quality data to improve our understanding of the Bay Delta, often at great effort and financial cost. The value of these data sets grow as more results are published, allowing future comparisons and analyses. However, a perennial problem with integrating data from different sources is that time scales, geospatial resolutions, types, formats, and even units are often incompatible for immediate analysis, leaving these data integrations the province of programming experts or, worse, not done at all. Our data team at the USGS California Water Science Center is piloting an experimental data integration effort to combine diverse sources of Bay-Delta data in an interactive web-based portal, making them immediately available to users of any technical ability for dynamic visualization and analytics. The visualizations in this 'data sandbox' are integrated spatially and temporally across projects, agencies, and scientific disciplines, allowing users to: a) obtain data from multiple sources in a single portal, b) view and manipulate those data in an interactive environment suitable for exploratory data analysis, and c) dynamically filter data sets to suit the user's needs and download the filtered dataset as a single, flat table. We support the portal's front-end functionality with a data pipeline using commercially available and custom software to process, warehouse, relate, and serve these data sets. In conjunction with the pipeline, we developed a common geospatial framework to relate any data with latitude and longitude to polygons, allowing the user to dynamically assign varying resolutions (e.g., 0.1 mile, 0.5, mile, 1 mile, 5 miles, etc.) or scientifically-meaningful aggregations (e.g., Delta region, reach, slough, etc.) to their visualization. The accessibility of the portal means that users of varying backgrounds

can perform on-the-fly analytics on real-time data, improving access for both Delta scientists and ecosystem managers.

061-IAS: Who you Gonna' Call? the Importance of Centralized Early Detection and Rapid Response to Control Invasion in the Sacramento-San Joaquin Delta

Rachel Wigginton[1], Elizabeth Brusati[2], Rachael Klopfenstein[3], Nicholas Rasmussen[4]

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Early detection and rapid response (EDRR) are some of the most effective ways to limit the ecological and economic impacts of potentially invasive, non-native species. Though the San Francisco Bay-Delta Estuary is considered one of the most highly invaded systems in the world, there is no comprehensive EDRR Plan for the Sacramento-San Joaquin Delta region. We summarize the current EDRR efforts in the Delta, which are largely taxa specific. We then propose a conceptual framework for developing an EDRR Plan for the Delta. We hope to engage conference attendees for feedback on this draft framework.

The Delta Interagency Invasive Species Coordination (DIISC) Team has been identified by the Delta Independent Science Board as a key actor in facilitating the creation and execution of an EDRR Plan for the Delta. We worked with the DIISC Team to convene a panel of Delta resource managers to discuss their EDRR efforts, covering taxa ranging from submerged aquatic vegetation to nutria. The panel discussion demonstrated the lack of a centralized reporting structure for observations of novel introduced species. In response to this panel, we met to develop a conceptual framework to support the development of an EDRR Plan for the Delta. Our conceptual framework was designed to identify the scale and importance of different ecological drivers and management interventions. We also propose a list of key actors to bring about the development and implementation of an EDRR Plan based on this conceptual framework.

Physical Processes (PP)

062-PP: Settling Velocity Variation Induced by Flocculation Dynamics: Exploring Channel and Shallows in San Francisco South Bay

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When fine suspended particles aggregate (or flocculate) in the water column, their settling velocity varies proportionally: primary mud particles settle slower than 0.1 mm/s, whereas large aggregates can settle faster than 20 mm/s. Temporal changes in the settling velocity (w_s) of suspended sediment are a primary driver for sediment fluxes, yet this mechanism is unaccounted for in numerical sediment transport models. Although the dynamics of flocculation and w_s have been extensively studied in the channel in South San Francisco Estuary (SFE), measurements on the shoals of South SFE are lacking, and existing work suggests that particle dynamics may differ between the shoals and the channel.

We performed a 2-week deployment in South SFE in July 2020, collecting continuous near-bed velocity, turbulence, salinity, and particle size information; vertical profiles of velocity and turbulence; and measurements of tidal stage and wave statistics at a site in the channel and a second site in the shallows. We also collected vertical profiles of particle size and salinity during four separate 6-hour periods during the deployment at the two sites and discrete samples for independent analysis of particle size with the FlocCam.

Preliminary results suggest that two dominant particle classes (70-100 μm and 200-400 μm) vary in relative concentration through the tidal cycle and through the water column, particularly in the channel. Future analysis will investigate the roles of turbulence, advection, and settling in yielding these profiles. This detailed analysis of particle flocculation and w_s can support numerical model development in SFE and in estuarine systems around the world as the models attempt to address the role of flocculation and breakup in sediment fluxes.

063-PP: Biological Effects on Particle Properties in South San Francisco Bay

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The physical properties (e.g., size, density, fractal dimension) of suspended sediment aggregates (flocs) largely determine their settling rates. Therefore, reliable numerical models of estuarine sediment transport require a detailed understanding of how floc properties vary with physical, chemical, and biological forcing mechanisms.

We present results from three field campaigns (one month each in the summer, winter, and spring) in South San Francisco Bay. During each season, we deployed a suite of instrumentation to characterize flow statistics, particle properties, and water column conditions. We also conducted floc cam sampling during each deployment, obtaining simultaneous measurements of particle size and settling velocity. Combining the moored time series and floc cam data, we examined the mechanisms affecting particle size variability across timescales ranging from hours to months.

Guided by a Lasso regression analysis, we found distinct seasonal differences in the drivers of floc size variability. During the summer and winter, dense minerogenic flocs were broken up by wave shear stress. Less dense, biogenic flocs also experienced wave-driven breakup during the spring productive period, though that trend was superimposed with floc growth correlated to increased water temperature and chlorophyll concentration, highlighting the importance of water column biology in setting floc properties. We also used Vectrino Profiler data to estimate the inverse turbulent Schmidt number, ß, in the bottom boundary layer. A preliminary analysis showed that ß does not always decrease, as is commonly assumed, with increased ratio of friction velocity to floc settling velocity. Due to the inherently noisy measurements used to estimate ß, however, further research will be required to elucidate precisely how floc size and settling velocity affects floc dispersion.

These results can inform parameterizations of sediment settling velocity and turbulent diffusion, allowing for improved numerical modeling of large-scale sediment transport processes, e.g., net fluxes and deposition rates, in San Francisco Bay.

064-PP: Bed-Sediment Property Dynamics in San Pablo and Grizzly Bays

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The bed in San Francisco Bay serves as a crucial component of the sediment budget through the Bay-Delta system. The physical and biological properties of the bed sediment control the erodibility of the bed and ultimately affect the transport patterns of sediment throughout the system. Sediment transport models— which are used in policy- and decision-making pertaining to land and water-way development, fate of contaminants, and more—often assume invariable bed properties. However, bed properties can be influenced by hydrodynamic and biotic changes, creating temporal and spatial variation. To investigate the variation of sediment properties within Grizzly and San Pablo Bays, we conducted 15 surveys between June 12th 2019 and September 23rd 2020. We collected box cores, and subsampled the top 5 cm using push cores, which were sectioned by depth into 6 subsamples to analyze for bulk density and grain size distribution. We also conducted biological surveys of both bays every two weeks, providing the abundance of benthic infauna. Between summer 2019 and winter 2020, surface sediments in Grizzly Bay fined, from a mean D50 of 10.3 µm to 7.9 µm, and decreased in bulk density, from 1.31 g/cm^3 to 1.22 g/cm^3. By summer 2020, Grizzly Bay coarsened to a mean D50 of 9.0 µm, and increased in bulk density to 1.25 g/cm^3. San Pablo Bay, conversely, had relatively consistent bulk densities (1.26-1.27 g/cm^3) and grain sizes (D50: 8.0-8.5 µm), showing no substantial seasonal change. We investigate mechanisms for the observed changes, including seasonal differences in freshwater input, wind patterns and benthic biotic activity that influence the nature of the bed sediments. This work is part of a larger investigation of physical and biological controls

on sediment erodibility in San Francisco Bay, funded by the USGS Priority Ecosystems Program for San Francisco Bay.

065-PP: Rapid Geophysical Characterization of Levee's Internal Structure using Streamer-Based Multi-Method Geophysical Approaches

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The Delta's levees, which were mostly built in the early to middle of the last century to no geotechnical standards, protect us from floods, but also divert water for agricultural and potable use, and given their age, represent various levels of risk. The 2017 California Flood System Status Report shows 60% of levees having high potential of failure. The American Society of Civil Engineers estimates that investments of $45 billion are required to improve the Californian levee system, particularly in light of increased protection needs due to climate-change related sea level rise. Hence, there is a need to develop tools that can rapidly characterize internal conditions of levees. As part of the Next Generation Multi-Hazard Levee Assessment project, we are developing geophysical imaging techniques to be used as such a tool. Seismic techniques, which are sensitive to the elastic properties of the levee's materials, and electrical techniques, which are mostly sensitive to variations in moisture and clay content, have been shown to provide detailed images of levee's internal conditions that can be indicative of the levee's structural integrity. Yet, most studies have focused on small study areas and have lacked coupling both techniques effectively. We have developed a towed streamer deploying both techniques that can be used to rapidly acquire data across kms of levees. Having co-located data allows us to combine the methods' sensitivities, increasing the reliability and detail of the resulting subsurface property distributions. Using this approach, we intend to show that regions of anomalous internal levee conditions can be identified. This will confirm that this approach can be used as a reconnaissance and assessment tool for targeted mitigation and levee upgrade measures, thereby reducing the levee's lifetime cost. Due to its rapid and comparably low-cost deployment, this approach can also be used in a temporal monitoring scheme.

066-PP: Tidal Pumping of Sediment in Estuarine Channels with Lateral Bathymetric Variation

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Sediment plays a critical role in estuarine physical and biological processes, such as shaping the topographic characteristics of wetlands, regulating phytoplankton growth by light attenuation, and affecting the transport and fate of aqueous pollutants. In this study, the residual sediment transport in tidally energetic estuarine channels is investigated by means of idealized cross-sectional modeling. The lateral bathymetric variation follows a Gaussian profile, assuming longitudinal uniformity. The total along-channel residual sediment flux is decomposed into contributions from an advective flux and a tidal pumping flux. Two important mechanisms are found to modify the tidal covariance between sediment concentration and current velocity, thereby contributing to the tidal pumping of sediment. First, longitudinal and lateral straining of salinity leads to tidal asymmetries in stratification and thus sediment resuspension. Second, lateral circulations directly redistribute suspended sediments within the cross section, which are then differentially transported by the along-channel tidal currents. A general relationship between the phasing of the lateral circulations and the resulting lateral-advection-driven tidal pumping is proposed. Reduced-physics experiments with lateral sediment advection turned off provide the first evidence that lateral-advection-driven tidal pumping plays a leading role in sediment transport for tidally energetic estuaries with nonnegligible lateral depth gradients. Additionally, a temporal decomposition breaks down the cross-sectionally averaged tidal pumping flux into individual contributions from different tidal phases (early tide, peak tide, late tide), providing a new perspective on tidal asymmetry in sediment resuspension and settling. The direction and strength of tidal pumping (both stratification-driven and lateral-advection-driven) are shown to depend on lateral bathymetry, sediment grain size, and longitudinal buoyancy gradient forcing. The insights gained are expected to expand our knowledge of sediment-transport pathways in different estuarine systems, which can aid us in making management decisions regarding estuarine morphodynamics and ecosystem.

Resource Modeling (RM)

067-RM: (*IEP) Statistical Model of Delta Flow and Exports Factors Affecting Salmonid Salvage at SWP and CVP Pumping Plants

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A Delta Salmonid Salvage Model (DSSM) was developed by relating the response of the October-June total monthly salvage of Chinook salmon and Steelhead to a variety of flow related factors affecting the occurrence of salmonids in the interior Delta. The explanatory variables included the combined State Water Project (SWP) and Central Valley Project (CVP) monthly export pumping as well as flows in tributaries that are sources of salmonids entering the interior Delta. These tributaries included the Sacramento, San Joaquin, Mokelumne, Cosumnes and other minor eastside tributaries. The DSSM also included flows into Georgianna Slough-Delta Cross Channel (GS-DCC), Old and Middle River (OMR) flows and X2 salinity as indicators of

interior Delta flow conditions contributing to entrainment of salmonids at the SWP and CVP fish salvage facilities.

The DSSM is a multiple linear regression (MLR) model that was developed by rigorously meeting the assumptions of MLR including independence, normal distribution and constant variance of residuals. These assumptions were met by employing a fifth-root transformation of the response and explanatory variables. A subset model selection procedure was employed to determine which explanatory variables should be retained in DSSM. The Akaike Information Criteria (AIC) was employed as a measure of goodness-of-fit because it is considered a reliable indicator of predictive capability. The model with the lowest AIC (best model) included total exports, San Joaquin flow at Vernalis, Mokelumne flow at Woodbridge, Cosumnes flow at Michigan Bar, Yolo Bypass flow near Woodland, GS-DCC flows, OMR flows and X2 location. All the explanatory variables with the exception of Yolo Bypass had regression coefficient p-values of less than 0.05 indicating their importance in the DSSM. The Cosumnes River flows had a significantly lower p-value than the other explanatory variables indicating its important as a source of salvage fish.

068-RM: (*IEP) Assessing Spatial Variability of Nutrients, Phytoplankton and Related Water Quality Constituents using Python and GIS for Spatial Analysis of High-Resolution Data Across Scale in the California Sacramento-San Joaquin Delta

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Scientists are increasingly using Geographic Information Systems (GIS) and open source code libraries for their data analyses of hydrologic processes and patterns in the Bay-Delta. The data collected often takes place across a wide range of scales, from local to regional. Therefore, changes in hydrologic processes may be scale dependent and spatial data models and analyses should consider different spatial resolutions. Correct interpretations of the data can be achieved using GIS software and open source code that integrate sound geographical and spatial analytical principles.

To appropriately assess the variability of nutrients, phytoplankton and related water quality constituents across scales, the data were spatially [rbzelt1] aligned to a common spatial framework to facilitate comparisons between dates and to minimize the effects of differential data density on the spatial interpolation calculations. The spatial alignment was performed using the geopandas software library in python, which assigned median-filtered data points to polygon shapefiles spaced at approximately 150 m intervals. Spatially aligned data were then aggregated by polygon shapefile to calculate summary

statistics of all median-filtered data within a polygon. Interpolated water quality maps were created from the spatially aligned data using ArcGIS Pro Spline with Barriers tool and interpolated values were extracted to the spatially aligned points to create continuous spatially aligned data across the mapping domain.

The methodology allowed us to create water quality maps depicting the concentration and spatial distribution of major nutrient forms and related information regarding phytoplankton classes and associated water quality conditions. Results showed an astonishing degree of variation across space and time, providing a snapshot of dynamic environmental processes that shape ways nutrients interact [rbzelt2] with Bay-Delta aquatic habitats.

069-RM: *Poster withdrawn*

Social Sciences and Human Dimensions (SSHD)

070-SSHD: What's the Buzz All About? a Historical-Ecological Examination of Mosquito Abatement in the Bay-Delta

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PROBLEM STATEMENT: Mosquito management in the Bay-Delta mirrors human relationships with mosquitoes globally. As human populations grow, mosquito control continues, often with little public awareness. After *Silent Spring*'s 1962 publication spotlighted the impacts of chemical pesticides, use of biologically-based biocides increased. Characterizing how these biologically-based biocides impact target and non-target populations will help refine abatement practices and our understanding of how people interact with nature.

APPROACH: We combined historical and ecological datasets to examine mosquito populations and county management responses in Stanford University's Jasper Ridge Biological Preserve (JRBP), part of the San Francisquito watershed. We gathered recent records of mosquito sampling and abatement procedures from San Mateo County Vector Control District (SMCMVCD) and JRBP. We used rank-abundance, rarefaction, and linear regression analyses to observe mosquito abundances since 2003. We also collected historical reports to examine trends in mosquito management since 1970.

RESULTS: We found SMCMVCD has used 21 different biocides to control mosquitoes at JRBP. 70.49% of applications since 2003 were bacterial biocides, while 28.91%

involve the insect hormone methoprene,. Methoprene has the longest history of applications at JRBP, corresponding with the growth of 1970s environmentalist movements. Current abatement primarily uses *Lynsibacillus sphaericus*, a parasitic bacterium with little-understood non-target impacts. Though this abatement appears to effectively reduce yearly peaks of mosquitoes, overall abundance follows classical logarithmic distributions and non-biocide drivers. Community composition, in particular, tracks water availability rather than abatement practices. Drought conditions tend to favour invasive mosquitoes such as *Aedes*.

CONCLUSIONS/RELEVANCE: Our results have implications for mosquito management across the Bay-Delta region. The study of non-target impacts has not kept pace with the intensifying use of biologically-based biocides. Our preliminary results suggest mosquito populations follow water levels. If climate change causes droughts to intensify, protecting human populations from disease vectors like *Aedes* may require shifts in abatement protocols.

071-SSHD: Community and Economic Enhancement Grant Program: Supporting Environmental Education, Recreation, Tourism and Historical and Cultural Preservation in the Delta

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The Sacramento-San Joaquin Delta Conservancy's Community and Economic Enhancement Grant Program provides funding for projects that keep the Delta's history, culture, and recreational opportunities accessible to all.

The Program is currently funded through Proposition 68, the California Drought, Water, Parks, Climate, Coastal Protection, and Outdoor Access for All Act of 2018. Consistent with the bond language, the program focuses on three priority areas: recreation and tourism, historic and cultural preservation, and environmental education. As a General Obligation Bond, Proposition 68 funding must be used for capital outlay projects.

Since the program opened in January 2020, the Conservancy has received 11 concept proposals. Thus far, these proposals are focused in two of the priority areas: recreation and tourism and historic and cultural preservation. They are a mix of planning and implementation projects. Applicants range from larger, local, public agencies to small, volunteer-led nonprofits and include both urban and rural parts of the Delta.

As a non-competitive grant program with no application deadlines, Conservancy staff may interact with applicants before the final proposal is submitted and before an award is made. This allows us to provide feedback on proposal materials and assistance to ensure that projects are successful. Having an open submission process also means that we accept concept proposals on a continuous basis, allowing applicants to submit

when they are fully prepared. This collaboration with the community ensures that funding is afforded to projects that are of most importance to the residents and businesses of the Delta.

Species and Communities (SC)

072-SC: Abundance and Diversity of Mysid Communities Through Time in Northern and Southern Wetlands of the San Francisco Estuary

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Mysids shrimps (e.g., *Neomysis mercedis*) historically provided most of the nutrients to juvenile fishes in wetland habitats of the San Francisco Estuary (SFE), the largest partially enclosed coastal body of water on the US Pacific coast. In the 1990's, however, mysid populations declined dramatically and have remained depressed in the eastern SFE, impacting many endangered and threatened fish species including Delta Smelt (*Hypomesus transpacificus*), Longfin Smelt (*Spirinchus thaleichthys*), Chinook Salmon (*Oncorhynchus tshawytscha*), and Steelhead Trout (*Oncorhynchus mykiss*). Little is known, however, about the dynamics of mysid populations in wetland habitats of the northern and southern Estuary (e.g., San Pablo Bay and Lower South San Francisco Bay). Here we examined temporal and spatial patterns in mysid abundance and community structure in northern and southern tributaries and wetlands of the SFE, including the Napa, Sonoma, Petaluma and Alviso Marsh Complexes. From November 2015 through May 2019, we conducted ~860 monthly zooplankton trawls and quantified the abundance of all mysid species in each sample. Our results give a glimpse into the status of these forgotten marshland mysid populations. As more and more human-derived pressures have been placed on the SFE and its associated marshlands, these data are important for assessing prey availability for our local fish species of concern.

073-SC: (*IEP) Go with the (High) Flow: Does Increased Spatial Sampling During Yolo Bypass Inundation Provide Unique Data to Our Monitoring Program?

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The Yolo Bypass is the largest Sacramento River floodplain, situated just north of the Sacramento – San Joaquin Delta. Since 1998, the California Department of Water

Resources has collected baseline data in the Bypass through the Yolo Bypass Fish Monitoring Program (YBFMP). The program produces data on hydrology, water quality, lower trophic organisms, and fishes in the Bypass and Toe Drain, a dead-end slough which runs along the bypass's eastern border. In 2010, the program established a set of core beach seine stations along the Toe Drain to be sampled bi-weekly, year-round. When the Bypass floods, the sampling increases to a weekly schedule and expands to include an additional five high flow stations. This is in attempt to better capture the response of resident and migrant fish species to flooding events. The extra sampling takes extensive manpower and time, leading us to ask: after 10 years, has the increase in sampling frequency and stations during flood events provided data not captured in the core beach seine stations? This presentation addresses the spatial component of this question by comparing species catch and composition between all stations during periods of flooding. Our results suggest that: 1. species composition at each station can be highly variable during inundation, 2. the high flow stations near the Fremont and Sacramento Weirs contribute the most to Chinook salmon catch, and 3. the additional northern sites display unique species assemblages compared to core sampling sites. In the Bay Delta ecosystem, monitoring programs such as the YBFMP are key to understanding the status and trends of native species, as well as managing for resiliency. Evaluating these program's sampling methods can validate procedures or highlight needed improvements, ultimately leading to more efficient monitoring programs and management-relevant data.

074-SC: Spatiotemporal Distribution and Nutritional Quality of Intertidal Biofilm Resources in South San Francisco Bay

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Microbial biofilm communities (comprised of bacteria, diatoms, protozoa, and fungi) are found on mudflat surfaces and can contribute up to 50% of estuarine primary productivity. These biofilms can also be directly consumed by shorebirds, providing them with substantial energy for spring migration. San Francisco Bay is an area of Hemispheric importance for migratory shorebirds and the location of the largest tidal wetland restoration project in the Western U.S., the South Bay Salt Pond Restoration Project. One of the project's key uncertainties is whether the restoration will impact mudflat and biofilm resources. To address this uncertainty, we are using a multi-scalar approach to assess the seasonal and spatial patterns of biofilm distribution and nutritional quality in the South Bay. We collected biofilm from 1-m^2 plots in 2019 and 2020 to evaluate biofilm quantity [chlorophyll-a (*chl-a*; mg/m^2; indicator of biomass)], community composition [pigments; indicator of phytoplankton biodiversity], nutritional

quality [total lipids, total organic carbon (TOC), fatty acid methyl esthers (FAME), carbohydrates (mg/g)], and mercury (methyl and total ng/g) concentrations. Total carbohydrates, TOC, lipids, and total FAME were all correlated, with the strongest relationship between total carbohydrates and TOC (R^2=0.78; $F_{1,30}$ = 100.9, p<0.0001). Methylmercury was strongly related to total fatty acids (R^2=0.81; $F_{1,15}$ = 58.1, p<0.0001), but not *chl-a* (R^2=0.01). To develop remote sensing capabilities, we analyzed biofilm samples and compared with *in-situ* mudflat and biofilm reflectance spectra. Preliminary results using an existing hyperspectral optical model to predict biofilm distribution using *chl-a* were promising (R^2=0.54, p=0.001). These relational models can be scaled up to remote sensing platforms (i.e. satellites) to map biofilm distributions and nutritional content. Ultimately, our results can help improve managers' abilities to measure and visualize mudflat habitat quality for migratory shorebirds.

075-SC: Salinity and Inundation Effects on Iris Pseudacorus (Yellow Flag Iris): Implications for Tidal Wetland Invasion with Sea-Level Rise

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Biological invasions are impacting the Bay-Delta ecosystem, and compromise regional tidal wetland restoration goals. Global environmental changes, including sea-level rise and frequent droughts, increase salinity and alter inundation regimes that also impact wetland biota. Establishment of new invasive plant populations will depend on their tolerance to these changing environmental stressors. Invasive populations of *Iris pseudacorus* (yellow flag iris) have long been present in Delta tidal wetlands. Recently, populations are spreading and increasing in abundance in brackish tidal wetlands of the Suisun Marsh ecoregion where they displace native species and habitat. To inform risk assessments of *I. pseudacorus* in the context of environmental change, we investigated the effects of salinity and inundation on germination and early life stages that are critical for population establishment. First, we experimentally exposed seeds from populations at extremes ends of the species' current distribution to four salinity and two water levels. Next, we exposed juvenile individuals from three populations (Delta, Suisun, Carquinez) to three salinity and two inundation levels. After 55 days in seawater, buoyant seeds of *I. pseudacorus* retained their ability to germinate, and germinated quickly with freshwater exposure. Exposure of pre-reproductive individuals to mid-brackish and marine salinity generated high physiological stress levels detrimental to growth. Greater inundation levels did not impact individuals grown in freshwater. Nonetheless, the high tolerance of *I. pseudacorus* to increased inundation was greatly compromised in brackish and marine salinity. Our results suggest that *I. pseudacorus* can colonize new

sites following potentially long-distance dispersal of buoyant seeds with tidal currents. However, vulnerability of pre-reproductive plants to increases in salinity despite inundation tolerance will limit their establishment during periods with high salinity exposure. Therefore, future environmental conditions will likely constrain new colonization of seedlings in downstream areas of the Bay-Delta that will be most impacted by drought-reduced freshwater runoff and sea-level rise.

076-SC: Waterbird Habitat Evolution of Breached Ponds in the Napa-Sonoma Marshes Wildlife Area

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San Francisco Bay (SFB) is critical for migrating and wintering Pacific Flyway waterbirds, and 15% of SFB waterfowl use former salt ponds comprising the Napa-Sonoma Marshes Wildlife Area (NSMWA). The NSMWA is the focus of multi-agency efforts to achieve tidal wetland restoration while maintaining open water habitat for waterbird populations. A central question is how waterbirds will use breached pond habitat as it transitions to vegetated wetland during restoration. Approximately 60% of NSMWA has been restored to tidal flow in stages, offering a unique opportunity to evaluate habitat evolution and waterbird response over time. Within our overarching 18-year research program in NSMWA, we examined vegetation colonization in three ponds breached at different times between 2002 – 2006. We used a remote-sensing approach to provide information on the vegetation density and distribution within the study area. A high-resolution multispectral image (0.67m pixels) of the area was collected by the Worldview 2 satellite on July 30, 2020. We used an RTK GPS (<1 cm accuracy) to collect data on vegetation species and percent cover in 270 1-m quadrats across the study area in August 2020. We used a supervised classification (ArcMap 10.7.1) to calculate Normalized Difference Vegetation Index, an index which uses near-infrared and red spectrums to detect live plants in multispectral data. Ground-truthed vegetation data was used to train the classification algorithm to differentiate among wetland plants, biofilm, algae, and exposed mudflat. Preliminary results indicated densely vegetated areas within all three ponds. Results will be compared with older multispectral data to conduct change analyses and calculate vegetation colonization rates. These data will be used in waterbird distribution modeling to help managers make restoration planning decisions, and understand how waterbird species in NSMWA and similar restoration projects like the South Bay Salt Pond Restoration Project respond to changing wetland habitats.

077-SC: Variation in Body Condition of Wintering Ducks in California

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During the fall and winter, waterfowl body mass changes considerably based on species-specific life history strategies and habitat conditions within California's Central Valley, Delta, and Suisun Marsh. Using 5 years (2014, 2015, and 2017-2019) of hunter-harvested ducks in 3 regions of northern and central California (Sacramento Valley, San Joaquin Valley, and Suisun Marsh) we evaluated body mass dynamics of 7 species of dabbling ducks and 6 species of diving ducks. For dabbling ducks, body mass varied among regions with ducks from the Sacramento Valley being consistently heavier than ducks harvested within Suisun Marsh or San Joaquin Valley. In Sacramento Valley, dabbling duck mass increased during early winter (October-early December; average = +3.0%), whereas little to no change in body mass was observed in San Joaquin Valley (average = +0.2%) or Suisun Marsh (average = +1.0%). From early December until the end of January body mass of dabbling ducks declined significantly, but the decline was similar among regions (average = -11.1%). In contrast, there were no regional differences in body mass among diving duck species. Diving ducks exhibited increases in body mass over the initial part of the season (average = +8.5%) and similar declines near the end of the season (average = -6.2%), ultimately yielding very little change in body mass from fall through winter. The higher initial body mass of dabbling ducks in Sacramento Valley relative to other regions and the consistent decline in late season body mass of dabbling ducks across all regions may represent differences in wetland habitat quality and availability among regions as well as declining food resources throughout the winter.

078-SC: (*IEP) Phytoplankton and Bacteria Communities Associated with Microcystis Blooms in San Francisco Estuary, 2014-2018

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Microcystis blooms have occurred in upper San Francisco Estuary since 1999, but only reached widespread dangerous levels in 2020. Understanding the causes and potential impacts of this new threat to the estuarine ecosystem is important for future management strategies. Although abundance has been monitored, the breadth of the impact of the bloom on upper and lower trophic communities of the estuary has not been fully quantified. Five years of field data collected from stations across the

freshwater reaches of the estuary were used to identify the bacteria, cyanobacteria, phytoplankton, zooplankton and benthic communities associated with *Microcystis* blooms using a suite of analyses including microscopy, qPCR and metagenomics. *Microcystis* formed close assemblages within the plankton community that was characterized by toxic and non-toxic cyanobacteria and green algae. The bacterium, Phenylobacterium, which obtains its energy exclusively from the breakdown products of herbicides was the bacteria most closely associated with *Microcystis*. A decrease in large zooplankton, and an increase in small zooplankton during blooms, suggests *Microcystis* influences ecosystem production through bottom-up controls and enhancement of the microbial loop. Importantly, the variation of *Microcystis* and its associated communities with wet and dry conditions and water temperature indicated climate was a significant driver of trophic structure during blooms.

079-SC: (*IEP) Zooplankton Trends in a Wetland-Slough Complex in Suisun Marsh

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Suisun Marsh has been dominated by seasonally flooded managed wetlands (ie duck clubs) for the past century. To date, research in managed wetlands has focused primarily on waterfowl, but planktonic communities remain poorly described. Zooplankton are essential food for rearing pelagic fishes in Suisun Marsh, yet we know little of zooplankton dynamics in managed wetlands.

We used a rapid assessment technique to estimate seasonal zooplankton densities in a managed wetland and adjacent slough in the Nurse-Denverton Complex for two hydroperiods between 2018 and 2020. We filtered 1-liter subsurface water grabs through a 153 um sieve and visually identified and enumerated daphnia and adult copepods at several stations along field transects. Zooplankton densities increased rapidly in the managed wetland after initial flood up in both years. Copepods (primarily *Acanthocyclops vernalis*) were dominant in Fall, while *Daphnia magna* were dominant in Winter and Spring. Zooplankton densities were consistently higher in the managed wetland than in the parent slough. For both years, the managed wetland was flooded from Fall through late Spring and kept dry in Summer.

These trends suggest that managed wetlands are important producers of zooplankton in Suisun Marsh and exhibit potential to subsidize pelagic food webs in winter months when food resources tend to be scarce in the estuary.

080-SC: (*IEP) Detecting Delta Smelt Environmental DNA with CRISPR-Based SHERLOCK

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Environmental DNA (eDNA) methods could support and augment IEP monitoring programs through sensitive indirect detection of listed species, such as delta smelt (DSM), from water samples. Environmental DNA sampling is possible in shallow, hard-to-survey regions and does not incur any incidental take. Most current eDNA approaches involve a multi-step process over several days, including sample collection, filtration, DNA extraction, and quantitative PCR (usually performed in a laboratory). A faster and more streamlined protocol could make eDNA data more accessible and useful to agency scientists, provided that it maintains high sensitivity and accuracy. Here we investigate the potential for a CRISPR-based method, SHERLOCK (Specific High-Sensitivity Enzymatic Reporter UnLOCKing), as a fast and streamlined eDNA detection tool for DSM. We previously created species-specific SHERLOCK assays that identify DSM, longfin smelt, and wakasagi. To maximize the potential for SHERLOCK to detect eDNA, we have increased the sensitivity of the DSM assay 300-fold to approximately one DNA copy per reaction. Using this high-sensitivity assay, we have successfully detected DSM eDNA from tank water, an important proof-of-principle for moving the assay to the field. Going forward, we will test SHERLOCK eDNA detection near DSM cage deployments in the estuary and in parallel with Enhanced Delta Smelt Monitoring (EDSM) surveys. Our long-term goal is a streamlined eDNA SHERLOCK assay that can be used in the field without the need for conventional DNA extraction or cumbersome equipment. This study is relevant to Bay-Delta management because it supports species monitoring with a fast, accurate, and sensitive eDNA-based method that does not incur species take. In addition, SHERLOCK can be used for detecting other species of management concern, including listed fish like longfin smelt as well as invertebrates and potentially zooplankton.

Sustainable Habitats and Ecosystems (SHE)

081-SHE: Disentangling Stationary and Dynamic Estuarine Fish Habitat to Inform Conservation: Species-Specific Responses to Physical Habitat and Water Quality

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Estuaries represent critical aquatic habitats which form connections between surface water distributed between Earth's land masses and oceans. They are dynamic transitional ecosystems which provide important habitat for fishes and other aquatic organisms. Effective conservation of species inhabiting estuaries requires knowledge of the habitat features which drive their abundance and distribution. We sought to elucidate how stationary (i.e., wetlands, shoals, and channels) and dynamic (i.e., salinity, temperature, turbidity, and chlorophyll concentration) habitat features drive distributions of individual fish species. The Pacific coast of the conterminous United States has over 400 estuaries of various types. The largest (historical surface area) is the San Francisco Estuary, California. We conducted extensive field observations of fishes in central San Francisco Estuary across a stationary habitat gradient (i.e., wetland, shoal, and channel habitat types) over a 19-month period encompassing substantial variability in dynamic water quality conditions. Most of the species observed, especially native species of special management interest, were most associated with tidal wetland habitat. Few species exhibited associations with water quality conditions driven by seasonal (temperature) or a combination of broad and fine scale ecosystem processes (salinity and turbidity). Our study provides: (a) an empirical demonstration of how researchers can deal with the complex and dynamic expressions of habitat in estuarine systems to address urgent natural resource problems, and (b) a clear demonstration of the urgent need for habitat restoration and its likely outcome in estuarine systems. Restoration of suitable tidal wetland habitat on the west coast of the United States is likely to be an effective conservation tool to support estuarine fishes given that over 90% of historical tidal wetland habitat in San Francisco Estuary and 85% of vegetated wetlands along the Pacific Coast of the United States have been lost due to human modification.

082-SHE: Bridging Working Lands and Environmental Restoration in the Delta: Highlighting a Role of the Delta Conservancy

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Working Lands is a term used to describe an array of lands managed for commercial uses including timber, farms, and ranches. In addition to their commercial value, these areas hold great potential to support habitat for populations of a wide range of native species. The Sacramento-San Joaquin Delta Conservancy's (Conservancy) Ecosystem Restoration and Water Quality Proposition 1 Grant Program (Proposition 1) provides an opportunity to facilitate the coordination and collaboration between managers of working lands and environmental restoration projects. The examples showcased in this presentation highlight past and present projects that intersect habitat restoration and working lands while simultaneously illustrating both ecological and economic benefits.

Opportunities for integrating working lands and habitat restoration holds tremendous potential, particularly given the large area of the Delta that working lands comprise. The Conservancy is poised to lead these efforts because of our roles as a lead state agency in the implementation of ecosystem restoration in the Delta and a lead agency for efforts to protect, enhance, and restore the Delta's economy, agriculture and working landscapes. To date, the Conservancy Proposition 1 Grant Program has funded 29 projects, 11 of which have a significant overlap with working lands.

083-SHE: Assessment of the Control Program for Aquatic Invasive Species in the Delta using Remote Sensing Imagery

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Invasive aquatic macrophytes are a major threat to estuarine ecosystems globally. In the Sacramento – San Joaquin Delta, Floating Aquatic Vegetation (FAV) impacts water quality, ecosystem services, navigation, and recreational activities. California State Parks, Division of Boating and Waterways is the agency charged with controlling the spread of these species in the Delta. Currently, glyphosate (and historically, 2,4-D) has been used to treat two major invasive FAV species in the Delta with the cost of control approaching millions of dollars. This study examines the efficacy of this treatment program to control FAV using herbicides in this hydrologically dynamic ecosystem. The objectives of the study are to determine if fractional cover of FAV was lower in treated sites compared to reference sites, if this effect was still apparent a year after treatment, and if two consecutive years of treatment were more effective than a single treatment year. This study combines multiple datasets to examine the efficacy of the FAV treatment program at the ecosystem scale over five years. FAV fractional cover derived from annual spectroscopy data from 2014 to 2018 are used in conjunction with herbicide application data from the same period. Study results will directly inform potential adaptive management approaches for the long-standing control program for FAV in the Delta, making it more agile and responsive to climate change.

084-SHE: Living Pilings: Evaluating a Novel Approach to Subtidal Habitat Restoration

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Artificial structures, like derelict piers and pilings, are common along the San Francisco Bay shoreline. While removal of these structures is preferred, there are some areas where pilings are not eligible for removal because they occur in sensitive habitat, are important to wildlife or have historical value. These remnant pilings continue to leach creosote-derived contaminants (polycyclic aromatic hydrocarbons, PAHs) known to affect the growth and survival of herring roe and shellfish, break and become marine debris, and pose a navigational hazard to boaters. With rising sea levels, these pilings will become an even greater hazard as they become less visible at the surface. We are evaluating commercially available piling-encapsulation techniques to determine their potential to eliminate contaminant leaching and provide a non-toxic surface for fish and invertebrate populations. In November 2020, we installed piling-repair jackets made of fiberglass (n = 12) and PVC (n = 12, rated for potable water) using a randomized block design at the abandoned El Campo marina near Tiburon. To enhance surface area and encourage colonization by native species, we wrapped a subset of repair jackets treatments with a 1 mm mesh screen (fiberglass or aluminum). All pilings were capped with a platform to prevent fish entrainment and provide roosting substrate for birds. For each piling encapsulation treatment and unencapsulated controls, samples across three tidal zones (subtidal, lower and upper intertidal) are collected quarterly to compare colonization rates, biodiversity, biomass and invertebrate PAH concentrations. Our goal is to determine if using existing infrastructure and commercially available materials can provide a cost-effective and low maintenance restoration technique, that will have broad relevance for managers throughout the Bay and in other urban estuaries to advance subtidal habitat restoration and remediate derelict pilings.

085-SHE: Wetland Availability and Salinity Concentrations for Breeding Waterfowl in Suisun Marsh, California

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Waterfowl reproductive success and population recruitment are influenced by the availability of suitable brooding habitat near nesting areas. In brackish diked systems like Suisun Marsh, the amount and salinity of water available depends to a large degree on management actions. Salinities as low as 2 ppt can impair duckling growth and influence behavior, with lethal effects occurring above 9 ppt. We used satellite imagery to quantify the amount of available water and conducted field sampling of surface water salinity on Grizzly Island, Suisun Marsh at three time periods during waterfowl breeding (April, May, and July) over four years (2016-2019). More water was available and salinity was lower during wetter years (2017 and 2019) than during drier years (2016 and 2018), and the amount of water in wetlands decreased by 73%-86% from April to July. At any given time, up to 41.9% of wetland area was above levels associated with duckling mortality (> 9 ppt). During peak duckling production in May, 81%-95% of water

had salinity above 2 ppt and 5%-21% was above 9 ppt. In May of the driest year (2016), only 0.5 km^2 of low salinity water (< 2 ppt) was available to ducklings in the study area, compared to 2.6 km^2 in May of the wettest year (2017). Private duck hunting clubs owned the majority of wetland habitat and consistently flooded a greater percentage of that area than publicly owned lands (California Department Fish and Wildlife), but private wetlands generally had higher salinity than public wetlands, likely because they draw from higher salinity water sources. By July, few wetlands remained flooded and most wetlands had salinity high enough to impair duckling growth and survival. Local waterfowl populations might benefit from management practices that provide fresher water near nesting areas, especially during peak duckling production in May.

086-SHE: Nutrient Conditions and Phytoplankton Productivity in Upstream and Downstream Slough Environments in Suisun Marsh

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Despite being characterized as a high nutrient estuary, San Francisco Estuary (SFE) exhibits low primary productivity. There are numerous wetland restoration activities underway in the SFE, many with the aim to improve the pelagic food web and ultimately pelagic fish survival. However little is known about the spatial and temporal variation of primary productivity supporting the food web within sloughs in the SFE, which is essential to evaluate the progress of restoration. Although agencies measure standing stocks of chlorophyll or concentrations of nutrients (that support primary productivity) in Suisun Marsh; both important to understanding pelagic food webs, there have been few rate measurements of phytoplankton productivity or nutrient uptake that help determine the standing stock of phytoplankton. Rate measurements help explain changes in nitrogen and carbon in estuaries by measuring differences in phytoplankton growth and make them more valuable than standing stock assessments. This study used isotopic tracers 13C and 15N to measure phytoplankton primary productivity and nutrient uptake rates at upstream and downstream slough environments in three adjacent tidal sloughs (First Mallard, Second Mallard and Hill Sloughs) with different physical characteristics in Suisun Marsh with a goal of understanding variability in their pelagic food webs. Preliminary data shows increased chlorophyll at landward locations in most sloughs and higher nutrients and nutrient uptake at recently restored First Mallard and at Hill Sloughs, an ongoing restoration site, compared to historic Second Mallard Slough. The results of this study -baseline rate measurements and comparative analyses in sloughs will help management agencies understand pelagic primary productivity and carbon and nitrogen fluxes in Suisun Marsh, in order to evaluate restoration outcome

087-SHE: Benthic Macroinvertebrate Abundance and Biomass Increases with Water Residence Time in Experimental Post-Harvest Rice Fields

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The Sacramento Valley has extensive rice agricultural fields which are harvested in the fall. The practice of shallow flooding of post-harvest fields facilitates the decomposition of remaining rice stubble. Studies have shown that post-harvest rice fields can be managed for the benefit of waterbird habitat and food production for fish. The Fish Food on Floodplain Farm Fields program (led by Caltrout and others) experimentally manipulated water residence times for zooplankton production at River Garden Farms (RGF) in Knight's Landing, CA. We leveraged this existing effort to determine the impact of water residence times on benthic invertebrate prey production, filling a crucial datagap for fish and waterbird consumers. Three replicated experimental treatment fields (Low, Medium, and High water residence times; n=3 each) were initiated at RGF in 2019. Seven benthic invertebrate cores were randomly collected in each treatment at the inception (Winter: Feb 7, 2019, n=63) and end (Spring: March 30, 2019, n=63) of the experiment. Macroinvertebrate abundance was low in Winter (70 individual invertebrates) compared to Spring (624 invertebrates). Spring invertebrates were comprised primarily of Chironomidae larvae (80%), a common prey source for both waterbirds and fish, followed by Nematodes (13%) and other invertebrates that comprised <2% of the total abundance. All pairwise comparisons of Chironomidae larvae abundance and biomass were significantly different between treatment types (all $p<0.05$), with Chironomidae larvae responding positively to increased water residence times. These pilot results indicate that the management of flooding-drawdown cycle on post-harvest agricultural fields in the winter can benefit prey resources for both waterbirds and salmonids. Additional experimental tests can help determine the flooding-drawdown cycle(s) to optimize invertebrate production and ultimately prey energy produced on shallowly flooded post-harvest rice fields.

Water and Sediment Quality (WSQ)

088-WSQ: Legacy and Current-Use Pesticides in Juvenile Chinook Rearing Areas of the Sacramento River Watershed, California – a Comparison of Riverine and Floodplain Habitats

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The Sacramento River watershed, California, provides a complex network of habitats for rearing juvenile Chinook salmon, *Oncorhynchus tshawytscha*, as they migrate downstream. In the lower reaches of the river, Chinook reside in either the Sacramento River or a corresponding floodplain, the Yolo Bypass. As a seasonally inundated habitat, the bypass represents a potential advantage as a nursery to residing fish, providing an increase in drift invertebrate prey availability and other favorable conditions corresponding to faster growth rates. However, this apparent habitat advantage may come with associated costs due to anthropogenic environmental stressors, such as legacy and current-use pesticides, which are widely applied throughout the watershed. These hydrophobic contaminants can concentrate in the benthos of aquatic systems and salmon prey items, and differences in basal energy sources in the system may affect exposure regimes to residing Chinook. To understand the potential for pesticide exposure in the Yolo Bypass and mainstem Sacramento River, pesticides were extracted from sediments and various food web components collected in 2019 and 2020 and analyzed using gas chromatography-mass spectrometry (GC-MS). Passive samplers were used to determine bioavailable concentrations in the pelagic and benthic zones of both systems. The contaminant concentrations detected in sediments were similar between years, with bifenthrin and p,p'-dichlorodiphenyltrichloroethane (DDT) metabolites being most commonly detected. The highest concentrations and frequencies of detection of p,p'-dichlorodiphenyldichloroethylene (DDE) were seen in the Cache Slough region. A similar pesticide fingerprint was seen in prey, but with an increase in the variety of pesticides detected in both zooplankton and macroinvertebrates. The comparison of detected pesticide concentrations in prey will help illustrate the potential benefits of rearing in either the Sacramento River or the Yolo Bypass floodplain before continuing downstream migration. This research was funded by a Prop 1 grant with supplemental funding from the Metropolitan Water District of Southern California.

089-WSQ: Lateral Heterogeneity in Water Quality Between Nearshore and Open-Bay Regions of San Francisco Bay

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Estuarine water quality can vary significantly between open-water and nearshore areas due to the differential influence of physical and biological processes between these regions. Localized nearshore dynamics are particularly variable through time and can affect open-water dynamics, especially in tidal systems like the San Francisco Bay (SFB). Despite the potential significance of nearshore regions, long-term monitoring

efforts in SFB have largely focused on the open-bay channel rather than the surrounding nearshore and shoal habitats. To resolve water quality patterns in these less-studied regions, we examined discrete measurements of key environmental parameters (including chlorophyll-a, nitrate + nitrite, ammonium, phosphate, silicate, temperature, and salinity) collected during biweekly bay-perimeter sampling trips between August 2018 and February 2020. We interpret these data in the context of the channel data collected as part of on-going, long-term open-bay monitoring efforts.

Although environmental conditions at the nearshore sites tracked the broad seasonal and spatial patterns seen at adjacent channel sites, noteworthy offsets in nutrient and chlorophyll-a concentrations were evident. Nitrate + nitrite, ammonium, and phosphate levels were generally 25-50% lower at nearshore sites, and there were sustained phytoplankton growth-limiting concentrations during spring 2019. Bloom events were apparent earlier and at greater magnitude at several nearshore sites compared to the adjacent channel sites. This lateral heterogeneity in water quality points to ecologically meaningful spatial differences that are not captured by routine monitoring of the deep channel. These findings informed the SFB Nutrient Management Strategy's decision to expand nearshore water quality monitoring, including the installation of two high-frequency mooring sites on the eastern shoal of South SFB (established in October and November 2020). High-frequency monitoring of water quality in the peripheral regions is expected to provide further insights into the spatial extent of phytoplankton blooms and periodic nutrient limitations that could inform future wastewater management policies.

090-WSQ: Mercury from Space: Mapping Water Quality Parameters

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The San Francisco Bay-Delta is a complex aquatic system where water quality parameters such as total suspended solids (TSS) and colored dissolved organic matter (CDOM) provide insight into the health of Delta ecosystems, as well as provide potential optical proxies for total mercury (THg) and methylmercury (MeHg). THg and MeHg contamination and bioaccumulation in fish populations has been a persistent problem, particularly as Delta fish provide a source of food for local disadvantaged communities. Previous studies have focused on sampling THg and MeHg in discrete locations but a comprehensive understanding of mercury (Hg) species fate and transport throughout the entire Delta is lacking. This project integrates satellite-based remote sensing with field-based sampling and monitoring and seeks to map surface water quality parameters and Hg species using multi-variable proxy relationships. Satellite-based sensors enable landscape-scale monitoring at high temporal and spatial resolutions. To the extent that the proxy relationships are successful, these high-resolution maps will contribute to a better understanding of the fate and transport of THg and MeHg as well as the impact of large-scale wetland restoration projects within the Delta.

This work shows the first steps of this project: the validation of surface reflectance retrievals using field data, as well as the generation of high-resolution maps of TSS and CDOM from imagery acquired by Landsat 8 and Sentinel-2. We also present the initial comparison of these maps of TSS and CDOM retrievals to concurrent in situ particulate and dissolved THg, MeHg and other water quality measurements. These high-resolution TSS and CDOM maps form the basis for developing a model linking visible water column constituents to 'invisible' Hg species in the Delta.

091-WSQ: Photosensitivity and Predator Avoidance in Pyrethroid-Resistant Hyalella Azteca

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Hyalella azteca is a species of freshwater invertebrate and a vital component to many aquatic ecosystems, serving as an epibenthic detrivore, a primary food source, and an indicator species in environmental toxicology. One such ecological problem, and the central focus of our research, is pesticide exposure. Increased pesticide use in agricultural and urban landscapes has caused certain *H. azteca* populations to develop resistance to pyrethroid pesticides, which may have adverse effects on *H. azteca*'s chemosensory and photic reflexes. In addition, a genetic bottleneck can be created due to these elevated exposures that decreases the population's diversity and stability. Our research explores how resistance mutations in *H. azteca* alter their responses to certain stimuli by comparing how resistant and non-resistant populations react to light, chemical predator cues, and a live predator (fathead minnow, *Pimephales promelas*). Tests were conducted in circular dishes with a diameter of 15.24 cm containing 100 mL of moderately hard water and 10 *H. azteca* (either non-resistant or resistant) in each trial. A lightbox was used for the stimuli, while L-histidine and L-serine were used as chemical stimuli. Another chemical cue used water which housed a fathead minnow for one day. The expectation is that the *H. azteca* will avoid the various stimuli. These experiments were repeated using pyrethroid-dosed resistant and non-resistant animals. Each test was paired with a respective control trial to account for random behaviors unassociated to the experimental element. Our preliminary lightbox results suggest that resistant populations have significantly faster reactions compared to the non-resistant populations, suggesting that the pesticide resistant animals have better anti-predatory responses than the non-resistant clades. As we continue to collect data and draw conclusions, we are focused on how the changes in behaviors caused by resistance mutations can affect *H. azteca* populations and their ability to respond to threatening stimuli.

092-WSQ: (*IEP) Validating the Use of a Novel Spectrofluorometer During High-Resolution Mapping Surveys in the Northern Delta

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Traditional laboratory methods that exist for the measurement of phytoplankton abundance and taxonomic distribution are costly and can take several months to produce results due to extensive processing times. Optical sensors that measure fDOM and chlorophyll-a provide rapid results in the field and are increasingly being used as a water quality measurement technique. Measuring the fraction of light absorbed at specific wavelengths and subsequently released at longer wavelengths (that is, fluorescence) is a diagnostic key to DOM type and abundance. Spectral fluorometers measure the relative abundance of phytoplankton pigments by emitting various wavelengths of light at a time and measuring the resulting fluorescence. Fluorometers, such as the bbe FluroProbe (bbe Moldanke, GmBH, Germany) were designed for the analysis of chlorophyll-a with instantaneous determinations of algal class and abundance, thus, reducing the need for traditional multiday laboratory processes. The objective of this study is to validate the use of the bbe FluoroProbe during high-speed mapping surveys in the Sacramento -San Joaquin River Delta. We hypothesize that the data generated by the bbe FluoroProbe is highly correlated [rbzelt1] to data collected using traditional microscope counts for taxonomical analyses. If so, this will reduce the need for discrete sample collection, lab analysis, and overall sampling expense. Lastly, this study will improve our ability to make accurate and/or precise phytoplankton measurements[rbzelt2] with the bbe FluoroProbe and enhance our understanding of the Bay-Delta's phytoplankton dynamics in time and space.

093-WSQ: (*IEP) Micro- And Nanoplastics: Effects of Environmentally Relevant Tire Wear Particles on Estuarine Indicator Species

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Plastic debris is a ubiquitous source of pollution in estuarine ecosystems. Micro and nanoplastics (< 5 mm) are known to have adverse effects on the habitats, diets, and physiologies of aquatic organisms, but questions remain about the relative risk across salinities, polymer types, concentrations, and sizes. Studies confirm that high concentrations of microplastics can have deleterious effects on organisms, but gaps remain in species response to environmentally relevant concentrations. Further, less is known about the effects of tire wear particles (TWP), a particle type broadly defined as

plastic debris, as an organic aquatic contaminant. Generated from automobile traffic and composed of complex mixtures of oil, plastic, steel, and additives, there is an estimated 1,121,000 t/a of TWP in the United States alone, frequently detected in the coastal environment. The estuarine indicator species inland silverside (*Menidia beryllina*) and mysid shrimp (*Americamysis bahia*) were exposed to three concentrations of TWP (60, 6000, and 60000 particles/mL) at two size fractions (1 - 20µm and < 1µm) across a salinity gradient (5, 15, and 25 ppt for *M. beryllina* and 15, 20, and 25 ppt for *A. bahia*). Additionally, both species were exposed to TWP leachate matching the highest particle concentration treatment. *M. beryllina* individuals (n=6) were exposed at 5 – 7 days post fertilization for 96 hours. *A bahia* individuals (n = 9) were exposed at 7 days old for an additional 7 days. Responses in *M. beryllina* suggest that TWP size influenced swimming behavior. Altered behavior resultant from aquatic contaminants may lead to increased risk of predation and foraging challenges. While response data in mysid shrimp remains to be analyzed, the presence of adverse effects in *M. beryllina* indicates that even at current environmental levels, which are expected to continue to increase, aquatic ecosystems are likely experiencing impacts from plastic pollution.

094-WSQ: Potential Consequences of Pesticide Resistance in the Bay-Delta Region

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Sustained pesticide exposure can lead to genetic changes that cause pesticide resistance in some non-target aquatic species. When pesticide pressure persists, these changes may affect the fitness of these populations. In addition, development of resistance may enable pesticide bioaccumulation in resistant macroinvertebrate prey species, resulting in pesticide exposure due to trophic transfer to predator species, such as fish. In this project, we examined the costs of pyrethroid resistance of a detritivore, *Hyalella azteca,* aiming to 1) estimate the potential of life-cycle effects under future climate scenarios and 2) assess pyrethroid bioaccumulation by pesticide-resistant *H. azteca* in Bay-Delta watershed. Thermal tolerance and life-cycles tests were conducted on pyrethroid-resistant and non-resistant *H. azteca* at elevated salinity (0.2 and 6.0 practical salinity units). We found that resistant *H. azteca* had reduced thermal tolerance at elevated salinity and produced more offspring at either salinity condition in comparison to non-resistant *H. azteca*, and non-resistant *H. azteca* grew larger at higher salinity in comparison to resistant *H. azteca*. In addition, resistant *H. azteca* had lower survival at higher salinity, indicating the potential for competing effects. To assess the potential of pyrethroid bioaccumulation by resistant *H. azteca*, a survey of field-

collected pyrethroid-resistant *H. azteca*, sampled in streams in or near Stockton, Sacramento, and Vacaville CA in 2018-2019, was conducted. Despite these streams having pyrethroid sediment concentrations that would be toxic to non-resistant animals, pyrethroids were detected in every field-collected *H. azteca* (N = 18). Bifenthrin concentrations reached 813 ng/g lipid (at Bear Creek in January 2018), and seasonal differences were observed. These findings indicate that the development of pesticide resistance has the potential to lead to effects on resistant species and the predators that consume them. This research was funded by a Prop 1 grant, aimed at evaluating the risk posed by pyrethroid resistance to Bay-Delta organisms.

095-WSQ: (*IEP) Effects of Pyrethroid Pesticides Across a Salinity Gradient on Behavior in an Endangered Fish Species and a Model Organism

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Recent studies have shown that pesticide toxicity can change across a salinity gradient; this is of concern in the San Francisco Bay Delta (SFBD) since the California Central Valley Water Board has recently put into place a Total Maximum Daily Load for six pyrethroid pesticides. As climate change progresses and salinity intrusion worsens, the potential for differences in toxicity across a salinity gradient is becoming increasingly important in assessing risk to estuarine fish species, yet data in this area is lacking. Therefore, we have exposed Delta smelt (*Hypomesus transpacificus*), an endangered species, and Inland Silverside (*Menidia beryllina*), a model estuarine organism, both of which are found in the SFBD, to environmentally relevant concentrations (0.1, 1, 10, and 100 ng/L) of pyrethroids with established TMDLs at three SFBD relevant salinities (0.5, 2, and 6 PSU). After exposure, changes in behavior and gene expression will be analyzed between species, salinity, and chemical. Additionally, we will rear Inland Silverside in clean water to spawn and further evaluate the effects of early life exposure in the parent (F0) generation on the offspring (F1). Here we present our results from behavioral analysis of *Menidia beryllina* parent generations exposed to pyrethroids. Preliminary results indicate some significant behavioral changes with pyrethroid exposure and increasing salinity. These data will provide knowledge to managers and environmental planners to help further protect threatened and endangered fishes in the SFBD.

096-WSQ: Developing Corrections for Observed Biases of in Situ Chlorophyll Fluorometers Used in Real Time Monitoring

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Continuous in situ measurement of chlorophyll-a fluorescence is a fundamental tool we use for evaluation of aquatic habitat quality in the California Delta and across the nation. Chlorophyll-a fluorescence provides information about beneficial and harmful algal blooms, biological oxygen demand, pelagic habitat quality, and ecosystem productivity. High quality in situ chlorophyll-a fluorescence measurements are therefore critical for evaluation of aquatic ecosystems in the Delta and nationally. Our recent field data as well as some preliminary laboratory testing have revealed the current generation of chlorophyll fluorometers are susceptible to optical interferences and the resulting data must be corrected to provide accurate values.

The objective of this study is to improve our ongoing in situ measurements of chlorophyll-a fluorescence by (a) characterizing sensor performance in laboratory experiments; and (b) developing correction algorithms.

Testing was conducted in the laboratory to characterize sensor response under a range of concentrations and combinations of interfering substances, using a YSI EXO multiparameter sonde fitted with Total Algal Sensors, fDOM, and turbidity sensors. Chlorophyll-a fluorometers were challenged with algal cultures (*Nannochloropsis* and *Spirulina* genera) in buffered solutions at an ambient measured concentration of 10 mg/L chlorophyll. Interfering substances used for the experiment included Elliot Silt Loam Standard, which is used to generate turbidity interference, and Pahokee Peat Humic Material, to generate dissolved organic matter (DOM) interference.

Preliminary experiments show that our concerns are warranted: both turbidity and DOM substantially interfered with measurement of chlorophyll-a fluorescence in a distinctly positive correlation. The levels at which the interference was observed are particularly concerning for the Delta, where chlorophyll-a concentrations of 2-3 mg/L are common. Therefore, developing correction algorithms for chlorophyll-a fluorescence sensors is critical for the next generation of high-quality in situ monitoring data.

097-WSQ: *Poster withdrawn*

098-WSQ: (*IEP) Cyanotoxin Monitoring in the Delta: Leveraging Existing Efforts to Identify Cyanotoxin Occurrence, Duration, and Drivers

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A major impediment to improved understanding and prediction of harmful algal blooms (HABs) and associated cyanotoxin occurrence in the California Bay-Delta is the dearth of observational data across both space and time. In freshwater systems, HABs comprise mostly cyanobacteria, and can adversely affect drinking water supplies, harm aquatic organisms, and potentially harm humans, pets and wildlife. Given that not all species of cyanobacteria produce toxins, and that toxin-producing species may or may not produce cyanotoxins, monitoring efforts seek to combine cyanobacterial detection with measurement of the cyanotoxins themselves. Environmental factors that impact HABs and cyanotoxin concentrations include nutrient concentrations, light conditions, water temperature, salinity, hydrologic conditions, and water residence time. Thus, to fully understand HABs and cyanotoxin occurrence in the Delta requires investment in collection of a wide array of parameters. Due to the high costs of these efforts, there has been limited and sporadic cyanotoxin sampling in the Delta. In 2020, we added cyanotoxin sampling to several USGS monitoring stations and collected additional samples during our Delta-wide boat-based mapping campaigns. Samples collected every 2-4 weeks at our fixed stations provide temporally rich information at specific locations, while samples collected during our boat-based mapping campaigns in the spring, summer and fall provide spatially rich information across the Delta and Suisun Bay. Cyanotoxins are analyzed in whole water grab samples and in SPATTs (Solid Phase Extraction Toxin Trackers). Comparisons of cyanotoxin concentration and occurrence to cyanobacteria abundance, species abundance, and related water quality parameters provides insights into the prevalence and drivers of HABs in the Delta and helps inform future monitoring programs.

099-WSQ: (*IEP) Herbicides Effects on Growth and Acute Toxicity in Phytoplankton and Cyanobacteria

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Herbicides are common contaminants in the Bay-Delta system. Phytoplankton and cyanobacteria are microalgae that may be particularly vulnerable to toxicity from these contaminants. However, it is still unclear how the many diverse types of microalgal species will respond to herbicides and if this impacts cyanobacteria blooms in the system. The toxicity of four herbicides (diuron, fluridone, hexazinone and simazine), which are frequently detected in the Delta were assessed using microalgae. Ten different microalgae were obtained by single-cell isolation from the Sacramento-San Joaquin Delta to use in toxicity tests: the cyanobacteria (*Microcystis aeruginosa*, *Dolichospermum* sp., *Aphanizomenon* sp.), green algae (*Chlamydomonas debaryana*, *Closterium* sp., *Selenastrum* sp., Unknown coccoid), and diatoms (*Fragilaria* sp., *Navicula* sp., Centric diatom species). Toxicity testing using 96-well plate systems in the

lab was used to measure growth inhibition daily. Acute sublethal effects were measured using changes in photosynthetic activity (quantum yield of PSII) and esterase activity. The toxicity tests show that herbicide toxicity is species specific instead of class specific. In general, the order of toxicity was diuron> hexazinone, simazine > fluridone for the microalgae. This study will help advance understanding of contaminants impact on phytoplankton and cyanobacteria. Microalgae can both improve habitat quality as a food source and decrease water quality by producing toxins. Therefore, investigating phytoplankton and cyanobacteria responses to stressors are relevant for water and ecosystem quality.

100-WSQ: Can a Prehistoric Fish be Today's Canary of the Anthropocene? Evaluating the Utility of using Lamprey to Assess Water Quality

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Anadromous and semelparous, Pacific lamprey (*Entosphenus tridentatus*), is of immense cultural significance to Pacific Northwest tribes, an important tribal food source, a tribal trust species for the USFWS, and a species of concern for California. The Trinity River is the main source of drinking water for the Hoopa Valley Indian Reservation. Although once the largest flow source to the Klamath River, the Trinity River has been a major source of trans-basin water delivered to the Central Valley Project via the Sacramento River since 1963. Historically, the Trinity River was extensively mined for gold which later resulted in mercury (Hg) levels that exceed 303(d) water quality standards. It has been shown that larval lamprey can be used to detect Hg due to their multi-year, freshwater filter feeding juvenile phases. Our results demonstrate that larvae also accumulate pesticides and can be used to monitor longer-term water quality and adults can be used to assess contaminant and Hg presence in an important tribal food. Use of larvae as bio-indicators to monitor ecosystem health throughout Pacific lamprey range is a possibility. Contaminants (e.g., the insecticide bifenthrin and Hg) presence in Trinity River coupled with trans-basin water delivery to the Sacramento River may have implications on Bay Delta salmonid recovery efforts.

101-WSQ: (*IEP) Assessment of Organic Carbon and Food Resources Across Five Sub-Habitats in the Sacramento-San Joaquin River Delta, California, USA

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The Sacramento-San Joaquin River Delta (the Delta) exemplifies a system modified by anthropogenic activities and is highly vulnerable to climate change. Consequently, restoration throughout the Delta focuses on reestablishing ecosystem functions. Geochemical data from sites representing five Delta sub-habitats (i.e., riverine, floodplain, freshwater marsh, open water, and Tule marsh bordering the Suisun Bay) were used to evaluate the sources of organic carbon and food resources supporting these ecosystems. High quality food resources were characterized as organic matter (OM) with low C:N ratios, and a high relative abundance (e.g., >10%) of polyunsaturated and essential fatty acids (PUFA and EFA), indicators of fresh and nutritionally valuable OM. The relative abundance of PUFA and EFA were higher in particulate OM (POM) than in sedimentary OM (SOM). Additionally, C:N ratios were lower in dissolved OM (DOM) and POM than they were in SOM, suggesting that SOM provides a lower quality food resource than DOM and POM. The composition of DOM and POM remained relatively homogenous throughout the Delta. In contrast, non-metric multidimensional scaling analysis of *n*-alkanes and fatty acids (FA) in the SOM revealed spatial differences in organic carbon sources and food resources, consistent with differences in primary producer composition. Riverine and floodplain habitats had higher relative abundances of PUFA, short chain, and branched FA characteristic of microbial and algal sources whereas open water and Tule marsh habitats were characterized by long chain, saturated FA and medium- and long-chain *n*-alkanes typical of grasses, submerged aquatic vegetation and soils. Higher %PUFA characterized freshwater marshes, suggesting that SOM from freshwater marshes was fresher than SOM from other habitats in the Delta. As a result, efforts to restore and expand the area of freshwater marsh habitat may enhance the quality of SOM and provide habitat that is better able to support consumer organisms in the Delta.

102-WSQ: Synthesizing Long-Term Records of Particulate Organic Matter Stable Isotope Data to Untangle Dominant Particulate Organic Carbon Sources in the San Francisco Estuary

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Bulk particulate organic matter (POM) composition in estuaries can originate from a complex mixture of sources (phytoplankton, microzooplankton, bacteria, and detritus). In the highly altered San Francisco Estuary, POM source contributions shift temporally and spatially due to changes in dynamic upstream POM inputs from both natural and human-associated drainage and in situ cycling of organic matter. More generally, widespread changes in vegetation may have resulted in large-scale shifts in the dominant composition of detrital POM sources transported throughout this system as invasive aquatic macrophytes continue to increase in spatial cover. The complexity of this system has presented a number of challenges for interpreting bulk stable isotope data for biogeochemical studies, especially as past work shows many primary

producers overlap in their C and N stable isotope composition. Here we leverage existing long-term stable isotope records to show how these tracers can be useful tools for generating new insight into organic matter transport and sources in this data-rich complex system. This work supports efforts to better understand sources important to the bulk POM pool, which can contribute directly (primary producers and consumers) and indirectly (bacteria and cycling of detrital OM) to the base of the food web.

103-WSQ: (*IEP) Efforts to Document the 2020 Sacramento-San Joaquin River Delta Microcystis Blooms

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During a high-resolution mapping survey in the Sacramento-San Joaquin River Delta in June of 2020, a visually evident *Microcystis* bloom was captured by two fluorometers, the YSI EXO total algae sensor and the bbeMoldaenkeFluoroProbe. Subsequent surveys conducted in July, August, and October of 2020 included additional techniques used to quantify phytoplankton and harmful algal bloom (HAB) associated toxins; the added methods included using Solid Phase Adsorption Toxin Trackers (SPATTs), visual *Microcystis* ratings, and an additional fluorometer, the Turner Designs Phytofind. During each survey, discrete water samples were also collected at stations across the Delta which, among other constituents, were analyzed for chlorophyll-a, cyanotoxins, and traditional microscopy to enumerate specific species of phytoplankton.

With HABs increasing in duration and frequency worldwide, and with *Microcystis*, a HAB-forming phytoplankton genera, present in the Delta, rigorous continuous, accurate measurement of phytoplankton and habitat metrics are necessary to improve our knowledge of conditions that favor HABs. This knowledge is important for early detection and to facilitate management of HABs. We compared these various quantification methods spatially, temporally, and amongst each other to provide a better idea of the occurrence and extent of *Microcystis* in the Delta, and to identify which methods are the most reliable.

104-WSQ: Effects of Chlorantraniliprole, Imidacloprid and Agricultural Runoff on the Swimming Behavior of Daphnia Magna

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Aquatic ecosystems receive periodic influxes of runoff that often contain complex chemical mixtures. These dynamic mixtures often include chemicals known to have adverse biological effects in single chemical laboratory tests but understanding their effects in mixtures is less straightforward. Studies of multiple stressors often demonstrate nonlinear interactions which contrast with results from single stressor studies. Swimming behavior may be affected by pesticides frequently detected in the Bay Delta, but behavioral data for invertebrates are scarce. We tested the effects of single and binary mixtures of two such insecticides of concern: chlorantraniliprole (CHL) and imidacloprid (IMI) by conducting 96h exposure studies on *Daphnia magna* assessing environmentally relevant concentrations. We then collected water samples from agricultural ditches known to contain these and other pesticides, and repeated the 96h exposures using a dilution series. In the CHL and IMI tests, we found that behavioral responses (as measured by total distance moved per time period in light and dark conditions) were significantly reduced in CHL treatments, while IMI resulted in hypoactivity. These findings are consistent with previous studies showing that CHL is a known neurotoxicant which effects muscle contraction via interaction with the ryanodine receptor. In agricultural ditch samples, sites with higher concentrations and overall number of pesticides of concern showed greater effects on locomotor response and swimming activity. Our findings are relevant for understanding the impacts of complex chemical mixtures on fish prey. Both CHL and IMI are chemicals found in the Northern Delta for which there is limited effects data. Of concern is the potential bioaccumulation of these pesticides throughout the food web. Swimming behavior is a sensitive endpoint to assess the effects of complex mixtures that may impact the Delta ecosystem.

105-WSQ: PFOA, PFOS, and a Precursor in Sediment of Sonoma and Napa Marshes and Petaluma River, June 2019

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Perfluoroalkyl substances (PFAS) are surfactants that are water- and grease-repellant, highly stable, and widely used in industry and household products. They are introduced into the environment in wastewater, landfill leachate, by certain firefighting measures, and are redistributed globally through the atmosphere. PFAS are persistent and ubiquitous, have been linked to negative health outcomes in humans and wildlife, and have thus become contaminants of emerging concern. Less is known about PFAS associated with sediment than water, and to address this need, PFAS/precursors were characterized in surface sediment (0-2 cm) in the northern reach of San Francisco Bay; tidal reaches of Petaluma River, Sonoma Creek, Napa River, and Suisun Slough; and in marshes near the mouths of Sonoma Creek and Napa River (4 depth intervals each) in June 2019. The study explored export of sediment-bound contaminants from fire-impacted and urbanized Napa and Sonoma watersheds following a wet winter one and a half years post-wildfire. Of 33 PFAS/precursors analyzed at 19 sites, only PFOA

(n=3), PFOS (n=9), and precursor Et-FOSAA (n=2) were detected at 5 sites at low concentrations (maximum=0.34 ng/g dw, median=0.14 ng/g dw). Both PFOA and PFOS were detected in Sonoma marsh sediment and increased with depth below the surface, whereas only PFOS, the more toxic compound, was detected in Napa marsh sediment. Only 1 compound each was detected in sediment from Petaluma River (Et-FOSAA), Napa River at Hwy 37 (Et-FOSAA), and Suisun Slough (PFOS). PFAS are leached from sediments to surface and groundwater and can bioaccumulate in plants and animals through uptake or ingestion. Therefore, potential risks to biota from PFAS-contaminated sediment should be considered when planning tidal marsh restoration, a high priority in the San Francisco Bay-Delta [Abbreviations: PFOA, perfluorooctanoic acid; PFOS, perfluoro-octane sulfonic acid; Et-FOSAA, N-ethyl perfluorooctane sulfonamido acetic acid].