INTERAGENCY ECOLOGICAL PROGRAM 2023 ANNUAL WORKSHOP

TALK ABSTRACTS

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Interagency Ecological Program

COOPERATIVE ECOLOGICAL INVESTIGATIONS SINCE 1970

This booklet contains the talk abstracts for the IEP 2023 workshop. Abstract submittals were optional and not all presenters provided one.

Abstracts are listed by session and speaker following the order shown in the Workshop Program. There are no abstracts for Session 1: Plenary Session. Abstracts for the posters Sessions 3 and 7 are included in a separate poster abstract booklet.

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Session 2: Delta Smelt Experimental Release

Fish Behavior During Delta Smelt Experimental Releases Inferred from ARIS Sonar

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Delta smelt (*Hypomesus transpacificus*) is a federally endangered fish species that is endemic to the Sacramento-San Joaquin Delta and has declined in population, increasing extinction concerns. This has led resource managers to pursue supplementation of the wild population with cultured delta smelt. Cultured delta smelt have never been released into the wild and there is uncertainty in how these released fish will behave and survive upon release. We conducted short-term underwater observations of delta smelt behavior and potential predatory fishes in the immediate vicinity of release using Adaptive Resolution Imaging Sonars (ARIS). The ARIS transforms sound waves into near-video quality images, making it possible to obtain continuous underwater observations that can be viewed in real-time and recorded for subsequent analysis. Fish behaviors and movements were recorded one hour preceding, during, and one hour following the release of cultured delta smelt during years one and two of this multi-agency collaboration. Preliminary results show a difference in potential predatory fish abundance across release locations and indicate that river velocity influences delta smelt behavior and their ability to actively move in a direction. Resource managers can use study results to design plans for future supplemental releases that maximize the likelihood of successful survival and recruitment of delta smelt.

** Denotes presenting author*

Session 4: Lightning Talks

Reintroduction of spring-run Chinook salmon in the San Joaquin River: evaluating efficacy of decision-making in the captive-breeding program

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Captive-breeding programs and reintroduction initiatives are increasingly implemented to combat population declines and extirpations. In implementing a captive breeding program, a number of decisions are made, including the source of the broodstock and mate pairing system. Captive-breeding programs are also known to induce selective pressures; therefore, it is critical to evaluate whether conservation goals are being met. Here, we evaluate the progress of a captive breeding program for a threatened salmonid in the San Joaquin River in the Central Valley, California, USA. Spring-run Chinook salmon were extirpated from the upper San Joaquin River following the construction of the Friant Dam in 1942. A captive-breeding program was established in 2012, in an effort to reestablish spring-run Chinook salmon in the San Joaquin River using fish from extant populations in the Central Valley. Each year, eggs are subsampled from crosses performed at the nearby Feather River Hatchery. Through an analysis of ~ 10 years of genetic monitoring and phenotypic data, we asked whether the program has minimized inbreeding and selective pressures induced by captive breeding. Phenotypic data included traits of the adult broodstock (e.g. age-at-maturity, body size) and early-life history survival of captive progeny. We found that the breeding program has adequately captured the genetic diversity of the source population and that mate pairings guided by kin relatedness reduced inbreeding. We also found that traits of the female parent influenced the survival of their offspring; survival of captive progeny was lower when female parents were older or when egg size was smaller. More broadly, these findings provide a case study for how to evaluate the success of captive-breeding programs given the challenges associated with conserving small populations.

** Denotes presenting author*

Examining phenological shifts and potential for trophic mismatches across multiple estuaries

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Many species are shifting phenologies in response to changing climates. In some cases, these shifts might lead to trophic mismatches if the timing of peak abundance between predators and prey becomes asynchronous. In estuaries, fluctuations of temperature and salinity often govern population dynamics, but climate change can disrupt these patterns. Here, we analyzed >2000 monthly time series of phytoplankton, zooplankton, fishes in addition to key environmental variables (salinity, temperature) over 10-40 years for the Chesapeake, Massachusetts, and San Francisco Bays. We fitted trivariate mixed-effects models to estimate linear relationships between phenology, climate, and time, allowing for comparisons of phenological patterns within and across systems. We observed phenological shifts in many taxa (approx. 23%), and organisms across trophic levels responded differentially–increasing potential for mismatches. We also found that the proportions of shifting species, and the role of climate in influencing those shifts, varies across estuaries. Most of the shifts in the SF Bay are driven by temperature (87.5%), however, temperature only influenced 27%-41% of shifts in the Massachusetts and Chesapeake Bays. Comparative examinations like ours could help identify and prevent phenological disruptions in estuaries that face changing climates.

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Primary productivity below the surface

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In the spring of 2016, a massive phytoplankton bloom (max. ~75µg Chl L^{-1}) was observed in the northern San Francisco Estuary (nSFE) and persisted through the late-summer. The dominant taxa of the bloom was the diatom *Aulacoseira granulata* (Jungbluth et al. 2021). The life history of *A. granulata* is distributed throughout the water column (tycho-) and is characterized by a cycling between vegetative states in surface water and resting states in sub-surface water. This cyclic life history is an adaptation to substantial variability in nutrient conditions and in light availability, the latter being especially important in the nSFE. Other notable examples of tycho-phytoplankton taxa in the nSFE exhibiting this life history include*, Cyclotella, Thalassiosira, and Fragilaria* (Montresor et al. 2013, Kraus et al 2017, Lehman 2022). Historical vertical profiles of the nSFE (Cloern and Schraga 2016, Schraga et al. 2020) support the concept that phytoplankton are consistently distributed throughout the water column. Despite this, the study of phytoplankton productivity *in situ* at depths greater than 2 meters in the nSFE is limited. Several questions emerge from these facts: Do resting states contribute to primary productivity? If so, how much do they contribute? At what timescales do phytoplankton enter and emerge from resting states? At what depths are resting states observed? My talk will cover how I plan to begin addressing these questions.

A multi-parameter approach to modeling light attenuation in the Sacramento-San Joaquin Delta using commonly available data

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Modeling productivity in aquatic habitats requires information about available light, which is variably attenuated because of the presence of particulate and dissolved materials. The exponential decrease in light with depth is commonly estimated as a function of the amount of light hitting the water surface and the diffuse attenuation coefficient of photosynthetically active radiation (K_{dPAR}), which is an inherent physical property. K_{dPAR} is difficult to determine in real time because measurements of light with depth are needed. In this study, we assessed if K_{dPAR} may be modeled using real-time surface-water measurements commonly collected throughout the Sacramento-San Joaquin River Delta (Delta). Traditional K_{dPAR} models are based on open-ocean environments where phytoplankton abundance (as measured by chlorophyll) is the main factor affecting light attenuation. However, elevated suspended sediments and dissolved organic materials may also affect K_{dPAR} values of inland water bodies and estuaries. We collected in situ light data to compute K_{dPAR} along with surface-level water quality parameter data and combined open-sourced data from several studies across the Delta to create a Delta-specific model for predicting K_{dPAR} from commonly available data. The best performing model used only surface-level turbidity and demonstrated high predictive power (R^2 = 0.91). The simplicity of the best model facilitates use of K_{dPAR} estimates for a variety of purposes throughout the Delta including euphotic depth calculations and as inputs to productivity and habitat suitability models.

** Denotes presenting author*

Should IEP use ExCell Plus as a fixative?

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We tested the long-term effects of a new fixative "ExCell Plus" on the body metrics (i.e., length and weight), otolith structure and trace elemental chemistry of Delta Smelt (*Hypomesus transpacificus*). ExCell Plus fixative performance was compared to Liquid Nitrogen, Formalin, and Ethanol. We found that the change in fish weight and length using ExCell Plus was comparable to that of other preservatives but that it corroded otoliths and yielded unrealistic otolith elemental ratios after six months of preservation, compared to all other preservatives. ExCell Plus performed similarly to Ethanol when it came to changes in fish body weight and had relatively stable shrinkage rates across the experiment duration. We therefore conclude that ExCell plus is a suitable fixative for preserving fish body metrics but is inappropriate for otolith chemistry applications, which is key for the reconstruction of fish migration and habitat use.

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Near-term prediction of fish movement, guidance, and entrainment in water management operations across different reservoir and tidal river environments

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The decisions of volitional, freely moving fish frequently dictate the success of engineered structures and management actions. In managed waterways supporting the needs of human society, structures are often used to facilitate the safe travel of fish around obstacles such as dams or diversions that can hinder their movement or survival. In other cases, structures are used to facilitate the capture or limit the spread of invasive species. The engineering design of waterways infrastructure designed for fish typically involves some form of build-and-test. The ability to predict fish response to infrastructure during the engineering design phase has the potential to save time and money as well as living resources. Research in decision-making, perception, and fish-flow interaction dates back more than a century. A numerical model simulating a reduced form of animal cognition and perception, using algorithms dating back (in some cases) more than a century, can reproduce fish movement patterns observed near infrastructure. For the past 25 years, the U.S. Army Corps of Engineers, Research and Development Center (ERDC), has been working on a management tool that can hindcast and predict near-future fish response to infrastructure designs and management actions. Development of the tool – a Eulerian-Lagrangian-agent Method (ELAM) - has leveraged over $65 million dollars worth of river and fish movement/passage data near infrastructure. The model is not perfect, and limitations will be discussed. However, the ELAM model has achieved unique success in predicting future 3-D/2-D fish movement, guidance, and passage/entrainment and also has accurately predicted patterns prior to the availability of field data in some cases. Further, the ELAM has performed well on out-of-sample data where the future condition was different from the calibration conditions. The model does not attempt to represent the true cognitive architecture of fish; rather, the decision-support tool attempts to leverage researched non-linear relationships between stimuli, perception, and action to make predictions of what fish will do at the scale of river infrastructure. Central to model performance is the notion that fish are attuned to more than one environmental signal and more than one timescale. Emerging theoretical developments suggest the potential exists for inverting downstream-moving behavior rules to describe upstream-moving fishes. Fish movement depends on the species, but work unifying past data into a common framework – and advanced by a growing community of ELAM users – facilitates value-added benefits to existing data, the ability to understand fish behavior more quickly, and the ability to better incorporate animal behavior into the fast-paced nature of engineering design projects.

Session 5: Synthesis Team

The Phytoplankton Enumeration Synthesis Project: Synthesizing Phytoplankton Datasets in the San Francisco Bay Delta

Sarah Perry

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An overview of the Phytoplankton Enumeration Synthesis Project, including the overall plan, methods of synthetization, and current status.

Invaders from Suisun – Reponses of *Maeotias* and *Potamocorbula* to Flow and Drought

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Aquatic invasive species have drastically changed how the San Francisco Estuary functions. During the past two decades, the impacts of invasive species in the estuary may have increased in response to frequent and severe drought conditions. The invasive overbite clam (*Potamocorbula amurensis*), and the Asian Clam (*Corbicula fluminea*) have had well documented consequences on the estuarine food web, but their responses to drought are not well understood. Another invasive species, the jellyfish *Maeotias marginata,* has the potential to further impact the food web, but these impacts have not been studied. We investigated the population responses of these invasive species to dry years and their potential effects on the pelagic food web using data from Interagency Ecological Program's monitoring surveys. We found *Maeotias* rapidly moves upstream with changing salinities during dry years, though it sees its highest abundance during high-outflow years in Suisun Bay and Suisun Marsh. Grazing rates of *Maeotias* in the estuary have not been quantified but have the potential to be significant during localized blooms. The two invasive clams overlap in distribution, but have opposite population responses to drought, with increases in *Potamocorbul*a densities and decreases in *Corbicula* densities in dry years. With increasing *Potamocorbula* densities, the clams' combined annual grazing rates increase somewhat during drier years in the Confluence and Suisun Marsh. Like Maeotias, *Potamocorbula* also shifts upstream during droughts, but because adults cannot move immediately with a change in salinity, the center of distribution of the population shifts upstream the year following a dry year due to juvenile recruitment. If multiple dry years occur in a row, and both *Potamocorbula* and *Maeotias* move upstream together, their effects on the food web could be compounded and phytoplankton and zooplankton biomass could steeply decline in the Confluence, impacting higher trophic levels in the estuary.

** Denotes presenting author*

Ecosystem Restoration Progress Review for the Delta and Suisun Marsh

Daniel Constable*, Delta Stewardship Council
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Abstract coming soon.

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Structured Decision Making for Delta Smelt Habitat – Synthesizing Multiple Streams of IEP Data to Inform Management

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The Delta Smelt Summer Fall Habitat Action (SFHA) is intended to improve growth, survival, and recruitment of critically endangered Delta Smelt (*Hypomesus transpacificus*) by enhancing habitat and food availability through coordinated management actions. In 2022, the Delta Coordination group identified a suite of actions to recommend for June to October 2022, using a series of quantitative models and expert elicitation leveraging IEP monitoring data and scientific expertise. Actions included various operations of the Suisun Marsh Salinity Control Gates and the North Delta Food Subsidy action. Changes to Delta Smelt habitat were modeled using three-dimensional hydrodynamic model. Changes to zooplankton were modeled using salinity-biomass relationships parameterized with IEP zooplankton monitoring data. Changes to Delta Smelt growth were modeled using the Delta Smelt Individual-Based Model in R. Results showed that operating the Salinity Control Gates to a lower salinity trigger produced better results for Delta Smelt, and a Sacramento River North Delta Food Subsidy Action produced better results than an agricultural action. In the end, 2022 was critically dry, so no action was possible, but the Delta Coordination Group used the 2022 process as a pilot effort to evaluate actions in future year.

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Session 8: Zooplankton in the San Francisco Estuary

Zooplankton Transport in the Cache Slough Complex

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This project is part of an ongoing effort to assess the transport of zooplankton between the Cache Slough Complex (CSC) and surrounding habitats in the northern Delta. Wetlands such as the CSC provide habitat for various fish species, but may also provide food subsidies to adjacent habitats of delta smelt and other fish species that feed on zooplankton. Although net fluxes of zooplankton out of wetlands has been suggested as a reason to restore wetlands, there is little evidence to show that such fluxes occur. This project focuses on *Pseudodiaptomus forbesi*, an introduced copepod that is very abundant in the CSC and important food for small fish. Previous studies in the CSC have found that tidal fluxes of this copepod were highly variable, and net fluxes were therefore indistinguishable from zero. However, the day/night vertical migration behavior of *P. forbesi* may play a role in the net transport of this species: adult copepods are abundant in shallow water only at night and remain on the bottom during daylight. In the small Wildlands wetland in the northern CSC, this pattern interacted with a strong summertime asymmetry in the tidal currents, which have stronger floods in the daytime and stronger ebbs at night. Thus, on average in summer, copepods in the water column at night were more likely to encounter a current that would move them into the wetland. If this pattern applies to the rest of the CSC as well as other wetlands, the hoped-for flux will be minor. In this talk we will extend the previously published results to investigate how general the tidal pattern is, and how in vertical migration could cause a net copepod flux into the entire CSC. Subsequent work will use hydrodynamic modeling and behavioral studies to quantify fluxes and investigate their spatial and temporal variation.

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Session 9: Tidal Wetlands

If you build it, will they come? Controls on salmon use of estuarine habitat downstream of the Delta

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We conducted a four-year study (2018-2021) investigating juvenile salmon use of tidal marsh and shoal habitat from Sherman Lake in the western Delta to San Pablo Bay, which included trawl and eDNA surveys, a cage growth study, and a stable isotope study. Of 136 juvenile salmon caught, the majority (101) were caught in the wet year of 2019, and few during the other drier years. Multilevel modeling and geospatial techniques indicated salmon use of estuarine habitat downstream of the Delta was primarily controlled by outflow along the main migration corridor through the Delta, which determined overall salmon movement into and abundance in the estuary. Once in the estuary, salmon distribution across habitat was mainly a function of habitat distance downstream along the mainstem migration corridor, and distance off the mainstem migration corridor, which modulated longitudinal and lateral spread of juveniles entering the estuary. The overarching influence of these landscape level controls, made it difficult to clearly establish localized habitat conditions preferred by salmon, although salmon were more likely detected adjacent to natural marsh edges compared to channels edged by rip-rap, levees, and vegetation. Stable isotope analysis of otoliths, tissue, and gut contents showed little evidence of extended estuarine rearing, although estuarine isotopic signatures may have been muted by freshening of our study area by high outflow. Caged salmon growth in the estuary ranged from negative growth (fish shrank) to rapid growth similar to floodplains, with highest growth rates consistently occurring, regardless of water year type, in small sloughs connected to large off-channel water bodies. Considered together, our findings provide clear and compelling evidence that the absence of juvenile salmon in estuarine marsh habitat during dry years is not a reflection of poor rearing conditions (such as due to low flow), but rather a consequence of poor flow-related connectivity between upstream riverine and downstream estuarine habitat.

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Session 10: Established and New Aquatic Plant Invaders in the Bay-Delta

Ecosystem Engineering Impacts of Water Primrose in the Delta

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Water primrose is a highly invasive, non-native floating macrophyte in the Sacramento-San Joaquin River Delta that has recently started to encroach into marsh habitat, replacing native vegetation and jeopardizing the success of restoration efforts. This presentation will first provide an overview of the objectives for our CDFW-funded Proposition 1 Research Project entitled “Ecosystem Engineering Impacts of Water Primrose in the Delta”, which aims to identify whether the growth strategy of water primrose, its allelopathic properties, or factors related to plant community structure are the cause of marsh loss following water primrose invasion. The project supports and evaluates habitat restoration activities by quantifying marsh loss, the spatial trajectory of water primrose invasion, and identifying marsh invasion vulnerability. The presentation will then present results on the analysis of water primrose persistence, marsh landscape characteristics, and remote sensing-change detection, which reveal that 1) marshes with large perimeter-to-area ratios provide more opportunities for water primrose to persist and invade marshes, 2) the more time water primrose persists within a marsh, the greater amount of marsh is replaced with water primrose, and 3) since at least 2014, water primrose has successfully established itself throughout the Delta and replaced ~200 hectares (7.3%) of native marsh habitat. The results of this project are improving our understanding of the invasion ecology and dynamics of water primrose as well as helping to develop methods to successfully manage it and prevent biodiversity loss in the Delta.

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Spilling the Allelopathic “Tea”: The Potential Role of Allelochemicals in Water Primrose Invasion of the Delta

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Water primrose (*Ludwigia* spp.) is an invasive aquatic vegetation that has rapidly increased in coverage throughout the Sacramento-San Joaquin Delta (“the Delta”). Water primrose has invaded wetlands and may contribute towards mortality in tule (*Schoenoplectus* spp.) and cattail (*Typha* spp.). Little research has been completed on the mechanisms responsible for marsh loss, but previous studies have suggested that water primrose contains allelopathic chemicals that could cause plant mortality. Three major allelopathic polyphenols (myricitrin, prunin, and quercitrin) previously identified in *L. hexapetala* leaves were measured in leaf, water, and soil samples from Delta marshes infested with water primrose (Big Break, Latham Slough, Liberty Island, and Sherman Lake). Samples were collected at the interface between water primrose and the marsh and within the patch of floating water primrose. Concentrations of myricitrin in leaves were significantly greater in the patch versus the interface in summer ($p < 0.001$, $\alpha = 0.05$) and fall ($p = 0.012$), but were not significantly different in spring ($p = 0.975$). Concentrations of quercitrin in leaves were not significantly different between the patch and interface in summer ($p = 0.057$) and spring ($p = 0.797$), but levels were significantly greater in the patch versus the interface in fall ($p = 0.046$). In analyzing leaf samples by liquid chromatography tandem mass spectrometry, ion ratios and retention times of the prunin reference standard did not align with the analyte in the samples (*i.e.*, prunin was not detected water primrose from the Delta). Further analysis by high resolution mass spectrometry and library matching resulted in a tentative identification of salipurposid, a structural isomer of prunin, as the potential third major polyphenol expressed by water primrose in the Delta. Analysis of water samples for polyphenols found the highest number of detections in summer, with many non-detects in fall and spring. Polyphenols were detected in soil samples throughout the year. Quercitrin was the most frequently detected polyphenol in water (37%, 3.89-3660 ng/L) and soil (69%, 10.7-1770 ng/g). The proliferation of water primrose likely threatens the Delta ecosystem. Additional studies could help improve understanding of how water primrose affects native marsh habitat and causes mortality of emergent macrophytes.

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Session 11: Sturgeon

2016-2019 Upper Sacramento River Juvenile Green Sturgeon Outmigration Investigation

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A benthic trawl and rotary screw traps were used to collect and tag age-0 wild juvenile Green Sturgeon in the upper Sacramento River to determine their temporal and spatial distribution patterns, observe and analyze outmigration attributes, and estimate annual survival rates to the legal Delta, rkm 170. Detections of juvenile sturgeon were used to confirm release, residence time, travel velocity, and estimated survival rates within the freshwater portion of the Sacramento River. Over the four years of study, a total of 98 juvenile Green Sturgeon were implanted with JSAT's micro acoustic tags. Median residence time was highest in the upper reach, followed by the middle reach and lower reach. Reach-specific median velocities were lowest in the upper reach and increased an order of magnitude as fish migrated through the middle and lower reaches. Comparisons of relocation velocity models indicated a significant interaction of gear type and reach, indicating dependence on both gear type and reach, with juveniles captured in the rotary screw trap having significantly higher upper reach velocities than any other gear and reach combinations. Survival estimates of age-0 juvenile Green Sturgeon to rkm 170 ranged from 36.4 to 94.5%. Across all years and river reaches, arrivals at a downstream receiver gate appeared to be correlated with increases in discharge and associated turbidity events. The distribution of arrivals was highest around the first few flow events of each season. Numerous juvenile Green Sturgeon were detected making a continuous migration from the upper river to rkm 170 during early fall and winter discharge events. Multiple juveniles made stepped migrations, stopping in the middle (n=11) and lower river reaches (n=4) before continuing their successful outmigration to the legal Delta.

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Annual Recruitment and Movement Patterns of Juvenile Southern Distinct Population Segment Green Sturgeon in the Lower Sacramento River and Sacramento-San Joaquin Delta

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Beginning in late 2015, California Department of Fish and Wildlife (CDFW) staff began a multi-year effort to capture juvenile Green Sturgeon within the Lower Sacramento River and tag them with 69 kHz acoustic transmitters. To date, CDFW staff have captured and tagged 184 juvenile Green Sturgeon with acoustic transmitters. Catch per unit effort (CPUE) was nearly 10-fold higher for Age-0+ juveniles following wet water years compared to CPUE following below normal, dry, or critically dry water years. Although these records are insufficient to produce an annual abundance index, this suggests that high Sacramento River outflows are an important factor in annual recruitment to the juvenile life stage. An array of 69 kHz acoustic receivers deployed throughout the lower Sacramento River, Sacramento-San Joaquin Delta, and at the Golden Gate Bridge records detections of passing tagged fish. Analysis of the detection data is used to determine movement patterns, rearing habitat utilization, migratory behavior within the Delta, and outmigration to the Pacific Ocean. Telemetry detections suggest that juvenile Green Sturgeon range widely throughout much of the region, moving both up and downstream in the Delta including south into the lower reaches of the San Joaquin River, through the bays, and making forays into the ocean. These observations are valuable for species management and should be considered when planning water diversion operations, work windows for dredging operations, in-water construction projects, and potential habitat restoration projects.

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Sturgeon Abundance Trends and Recent Mortality in the San Francisco Estuary

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The Sacramento-San Joaquin Watershed white sturgeon population has been actively monitored by the California Department of Fish and Wildlife (CDFW) since the recreational fishery reopened in 1954. CDFW conducts annual trammel net surveys of white sturgeon in Suisun and San Pablo Bays in which morphometric data is collected and high reward disk tags are applied. Originally designed using Lincoln-Petersen mark-recapture methodology, the survey now employs a harvest-based estimator to estimate the abundance of white sturgeon within the legal harvest slot (101.6-152.4cm FL) using angler tag and report card returns. Total annual fishing mortality is also enumerated from report card returns, and both annual survival and harvest rate are estimated. During normal trammel net operations in San Pablo Bay in the fall of 2022, a marked decrease in dissolved oxygen and water clarity was observed, along with numerous striped bass and sturgeon carcasses as the result of a harmful algal bloom (HAB) event. In response, the survey transitioned to documenting sturgeon carcasses throughout San Pablo Bay, the Petaluma River, and Napa-Sonoma Marsh. When combined with CDFW and Cramer Fish Sciences shoreline surveys and citizen-science reports, we enumerated a minimum count of 877 sturgeon carcasses, including 203 confirmed white sturgeon and 21 confirmed green sturgeon. Given the propensity of sturgeon to sink when dead and the wide expanse of shoreline that was not surveyed, this likely represents a gross underestimate of the total mortality. Estimates of “legal” white sturgeon abundance from the mark-recapture study indicate a long-term decline, further contextualizing the severity of this event.

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Diversity in Habitat Use by White Sturgeon Revealed using Fin Ray Geochemistry

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Understanding life-history diversity in a population is imperative to developing effective fisheries management and conservation practices, particularly in degraded environments with high environmental variability. Here, we examined variation in habitat use and migration patterns of White Sturgeon (*Acipenser transmontanus*), a long-lived migratory fish that is native to the San Francisco Estuary, CA, USA. Annual increment profiles were combined with respective geochemical (87Sr/86Sr) profiles in sturgeon fin rays to reconstruct annual salinity chronologies for 112 individuals from 5-30 years old. Results indicated a complex and diverse amphidromous life history across individuals, characterized largely by estuarine residence, a general ontogenetic trend toward higher-salinity brackish habitats, and high variability in habitat use across all age groups. Hierarchical clustering based on fin ray geochemistry during the first 10 years of life, prior to sexual maturation, indicated at least four distinct migratory phenotypes which differed largely in the timing and duration of juvenile to subadult movements between fresh- and brackish-water habitats. This study provides information regarding habitat use and migration in sub-adult fish that was previously lacking. Different migratory phenotypes vary in exposure to stressors across time and space and populations. Understanding White Sturgeon habitat distributions through space and time at different life stages can help identify areas where habitat restoration would be most effective and develop management actions to reduce stressors associated with specific areas where White Sturgeon are present.

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Session 12: Diversity of Fishes of the San Francisco Estuary

Variability in Coastal Habitat Available for Longfin Smelt *Spirinchus thaleichthys* in the Northeastern Pacific Ocean

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Oceanographic conditions and processes are well known drivers of marine animal distribution and population dynamics and understanding how they affect species of management concern is fundamental to the development of effective management and conservation actions. Longfin Smelt *Spirinchus thaleichthys* is a pelagic forage fish found in coastal and estuarine waters along the Pacific Coast of North America from Alaska to central California. Substantial declines in abundance in California's San Francisco Estuary, where Longfin Smelt is listed as Threatened under California's Endangered Species Act, have prompted evaluation of Longfin Smelt population trends and drivers. Estuarine factors associated with the decline have received extensive study in the San Francisco Estuary, but coastal factors that affect up to two-thirds of the Longfin Smelt life cycle are poorly understood and may be important drivers of population dynamics and connectivity. We examined the distribution and habitat associations of Longfin Smelt in the northeast Pacific Ocean to better understand coastal factors affecting Longfin Smelt populations. We compiled coastal observations from numerous sources, including non-profit, local, state, and federal entities to estimate the range-wide coastal marine distribution of Longfin Smelt. Longfin Smelt distribution was correlated with water depth, distance from the nearest estuary, sea surface temperature, and sea surface chlorophyll. Generally, Longfin Smelt were found in shallow, higher productivity coastal waters near estuaries, with bathymetry and temperature the most consistent factors influencing Longfin Smelt distribution. Habitat suitability was highly variable at the southern extent of the range, particularly off the coast of California, largely driven by habitat contractions associated with warm-water conditions. Study results provide insights into the habitat and range-wide distribution of an at-risk estuarine-reliant forage fish and are the first step towards identifying processes that affect the marine portion of the Longfin Smelt life cycle.

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Session 13: Central Valley Steelhead Population Dynamics: Fishery Trends, Monitoring Insights, and Modelling

Trends in the Central Valley *Oncorhynchus mykiss* Fishery as Determined through Angler Derived Data

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Oncorhynchus mykiss, in both its anadromous and resident life forms, represent an important recreational fishery in Central Valley rivers. The California Department of Fish and Wildlife (CDFW) collects data on the *O. mykiss* fishery through two main methods, angler surveys, and the Steelhead Report Card Program. Angler surveys are a management tool that is commonly used to monitor sport fishes. In California, there has been a long history of angler surveys in the anadromous waters of the Sacramento River basin. Although survey objectives may have been slightly different, the methodologies and geographic scope has remained mostly unchanged. This has provided a robust study design, large data set, and created a strong baseline from which CDFW can assess trends in various sport fisheries. The current iteration of the angler survey is called the Central Valley Angler Survey. Data collected by the Central Valley Angler Survey can be used to answer questions about contact rates with natural origin *O. mykiss*, harvest rates, age structure, and spatial and temporal distribution of natural and hatchery origin *O. mykiss*. This presentation will review trends in the *O. mykiss* fishery including angler effort, catch, and harvest in the Sacramento, American, Feather, and Yuba rivers.

Use the Right Tool for the Job: Monitoring Focused on *Oncorhynchus mykiss* in the Stanislaus River Reveals Critical Life History Information

Steve Zeug*, Cramer Fish Sciences

Mike Beakes United States Bureau of Reclamation

Determining the status and trends of *O. mykiss* in Central Valley rivers is hamstrung by a lack of reliable data. Many monitoring programs designed to capture Chinook Salmon will also collect *O. mykiss*. However, life history differences between the species severely restrict the ability to make inferences with these data. To begin addressing this issue, we designed a monitoring plan specifically for *O. mykiss* in the Lower Stanislaus River and worked with state, federal and private partners to implement the plan. Our goal was to estimate the abundance of key *O. mykiss* life stages, and transition rates between life stages. Over time, these robust population data can be linked with water operations and environmental variation to inform actions that could affect life history expression and abundance. Using a combination of modern molecular methods and traditional fisheries techniques, we were able to generate inference on multiple population attributes including, spawner abundance, age and size at maturation, annual growth rates, frequency of iteroparity, migration frequency, egg-to-fry survival, and hatchery contribution. These data revealed a range life history strategies and produced a comprehensive picture of *O. mykiss* ecology in the Lower Stanislaus River. The combination of methods employed, and analysis strategy provide a framework for future monitoring in the Stanislaus River and could be applied to other Central Valley Rivers where data on *O. mykiss* populations is needed.

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Monitoring Steelhead in the Stanislaus River: Methods, Challenges, and Insights

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Passage monitoring to document upstream migration timing and spawner abundance of adult anadromous salmonids has occurred on the Stanislaus River for two decades. Migrating fish are guided through a passage chute equipped with an infrared fish counter device (Riverwatcher) at a resistance-board weir located 33 river miles upstream of the San Joaquin River confluence. When an object crosses the network of beams, the device is triggered and a passage event is recorded. Passage event data consists of a silhouette image and multiple still photographs of the passing object, in addition to body depth, time of day, and direction. A secondary underwater video system serves as backup in the event of outages in the Riverwatcher system. Past efforts were largely focused on Chinook salmon migration through the fall and did not consistently extend through the entirety of the *O. mykiss* migration period.

The main challenges associated with passage monitoring for steelhead are hydrology of the Lower Stanislaus River and the low abundance of migrating steelhead. Operation of the weir through planned flow pulses can be challenging but becomes impossible during high discharge periods associated with flood control releases exceeding 2,000 cfs. The propensity of the species to migrate during such periods of high flow, coupled with low abundance, typically in the magnitude of tens of fish, has mostly precluded formal data analyses focused on migration timing. However, long-term monitoring (2004–2020) has resulted in improved understanding of migration and population characteristics of steelhead: upstream movement of steelhead (>406 mm) is greatest from October to February, with peak passage in October (0.11 fish/day). Approximately 42% of steelhead were of hatchery-origin, 49% were of natural origin, and for 9% (n = 16) their origin could not be determined. Peak passage of smaller *O. mykiss*, which are mostly naturally produced (55%; compared to 26% hatchery origin and 19% undetermined), occurs from January through March (0.19 to 0.23 fish/day).

Since 2021, an effort led by the USBR to generate data to inform steelhead life cycle and decision-support models has permitted operation of the weir throughout the entire migration period (September – May) and includes the collection of biological samples from migratory individuals. In addition to regulatory constraints that prevent trap operation during the period associated with peak passage of Chinook salmon, collection of biological samples is complicated by steelhead behavior. Migrating *O. mykiss* that swim through the passage chute often exit the adjacent trap box in a downstream direction before the trap box can be closed. Recently implemented refinements include the installation of “trap fingers”, adding a behavioral deterrent that has increased the number of trapped fish. During the current monitoring season, all steelhead that have been recorded passing the Riverwatcher during active trap operation were successfully trapped, sampled, tagged, and released upstream of the weir.

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Session 14: From Monitoring to Management of Central Valley Spring-Run Chinook Salmon

Juvenile Spring-Run Chinook Salmon Feeding and Growth Patterns in the Butte Sink and Sutter Bypass

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In this presentation for the Interagency Ecological Program workshop, we will be exploring the mechanisms by which juvenile spring-run Chinook Salmon achieve a growth benefit from connected wetlands of the Butte Sink and Sutter Bypass. The direct surface water connection between Butte Creek and productive off-channel habitats has been hypothesized to be the driver of increased somatic growth rates and a contributing factor to the relative success of the Butte Creek spring-run population. However, until recently the productivity and functioning of this important component of the Central Valley salmonscape has been largely unexplored. Our research is focused on the ambient invertebrate food resources, prey utilization, and resulting somatic growth patterns of natural and enclosure-reared juvenile Chinook Salmon in the lower portion of the Butte Creek watershed. These patterns are contextualized under a range of hydrologic conditions to provide managers with an understanding of when and where observed ecological processes are resulting in high growth potential for juvenile spring-run. The Butte Creek system can be viewed as a microcosm for other threatened and endangered salmon populations of the Sacramento River which stand to benefit from increased opportunities to access off-channel resources.

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Collaborating, Coordinating, Compatibilizing, and Computing: Progress Toward Producing a Spring-Run JPE

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A multi-agency, multi-faceted collaborative effort is underway to develop an approach for producing an annual spring-run Chinook Salmon juvenile production estimate (SR-JPE) for the Sacramento River and its tributaries. The primary purpose of the SR-JPE is to support development of one or more measures to minimize the impact of water project operations on the spring-run population, although the effort is also providing valuable information on various components of the population which may support development of additional targeted conservation actions. The SR-JPE program includes enhanced and coordinated monitoring of both adult and juvenile life stages, a comprehensive data curation and data management system to ensure data compatibility and accessibility of both existing and future generated data across monitoring programs, a valley-wide run identification program combining new genetic tools and probabilistic length-at-date models, new and advanced juvenile and adult abundance modeling to support stock-recruitment models and multiple predictive JPE modeling options, and a structured decision-making process to select a final recommended SR-JPE approach. Although numerous obstacles have been encountered, progress has been swift, and the effort is on track to produce a recommended SR-JPE approach by the spring of 2024.

Genetic Monitoring of Central Valley Chinook Salmon: Patterns, Challenges, and Opportunities

Jeff Rodzen*, PhD. and Joy Gaines

California Department of Fish and Wildlife, Genetics Research Laboratory

We present our genetic monitoring results from the ongoing Central Valley spring Chinook Salmon juvenile production estimate program. Significant hybridization exists between the historic fall and spring run Chinook Salmon genetic stocks in many Central Valley systems which presents challenges to current and future management of Chinook Salmon in the Central Valley. We present data comparing and contrasting historic genetic stock identification with patterns of distribution of Chinook Salmon chromosome 28 migration timing genetic variants within and between juvenile sampling locations and its implications for management.

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Session 15: Preying for a Meal: Predation Studies in the Delta and Its Watersheds

Understanding Predators to Better Understand Predation

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Nonnative sport fishes provide economically important fishing opportunities to the Sacramento-San Joaquin Valley. Yet, as apex predators, they create challenges for the recovery of a declining native fish fauna. Balancing competing interests of nonnative fisheries with the need to reduce predation pressure on native species will require novel and flexible management strategies and increased data on sport fish populations. In response to the Water Infrastructure Improvements for the Nation (WIIN) Act (2016), we worked with NOAA Fisheries and California Department of Fish and Wildlife to develop and implement a predator study on the Stanislaus River. The overarching goal of this program was to identify potential management strategies to mitigate Chinook salmon mortality from predation. Therefore, the study was designed to estimate predator demographic parameters (e.g., abundance, seasonal occupancy, and survival) and characterized predator trophic ecology under variable environmental conditions. Starting in 2018, we used boat electrofishing to sample native and nonnative piscivorous fishes in the lower 64 kilometers of the Stanislaus River. We collected biological samples such as scales for aging and stomach contents to characterize diets, in addition to using PIT Tags for mark-recapture analyses. Striped bass (*Morone saxatilis*) and black bass (*Micropterus* spp.) were responsible for > 95% of juvenile Chinook salmon and Pacific lamprey consumption, the two most frequent fish prey. Consumption rates were similar across years, despite experiencing both high and low flow conditions. Results from striped bass occupancy modeling suggest size-specific seasonal migrations into the Stanislaus River during the juvenile Chinook salmon emigration season. Although consumption rates were higher for striped bass, black bass were 2.5 times more abundant than striped bass. Black bass apparent survival across years was high ($\varphi > 0.8$) and size-at-age data suggest in-river recruitment of black bass is stronger during dry years. High spring flows in 2019 did not appear to displace black bass. Our research into the ecology of these predators is an important step in developing strategies to reduce predation pressure on native fishes.

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