INTERAGENCY ECOLOGICAL PROGRAM

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SELECTED TALK ABSTRACTS*

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Listed alphabetically by presenting author

*IEP Speakers are invited and abstracts were optional. This booklet includes abstracts for a subset of talks from the full Workshop program.

An Update on the Flow Alteration Project Work Team, the 2017 Report and Beyond

Larry Brown

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Abstract: Management of water for human and environmental purposes can lead to conflict and is one of the most contentious issues in the Sacramento-San Joaquin Delta, California. The importance of outflow to Delta Smelt (*Hypomesus transpacificus*) remains one of the central questions for resource managers. In 2016, the Interagency Ecological Program established the Flow Alteration (FLOAT) Project Work Team as a forum for developing a better understanding of how flow management actions affect the San Francisco Bay-Delta ecosystem. Water year 2017 was characterized by historic winter precipitation and snowpack, resulting in high flows and expectations that the Delta Smelt population would increase; however, the population showed no apparent response. The FLOAT Management, Analysis, and Synthesis Team (MAST) identified warm summer water temperatures as a key factor limiting Delta Smelt growth and survival in 2017. However, the FLOAT MAST report is only now being completed and highlights the difficulty in completing large comprehensive reports in a timely manner. Future iterations of FLOAT MAST will likely incorporate annual updates of basic monitoring data, annual analyses of trends in monitoring data, and synthesis of the meaning of the trends combined with results from special studies. Moreover, this information needs to be reported in a timely and understandable manner. This strategy provides for a steady flow of information to resource managers rather than periodic large reports.

The Suisun Marsh: A Critical Wintering and Nesting Area for Pacific Flyway Waterfowl

Michael Casazza, Cory Overton, Elliott Matchett, Fiona McDuie, Mark Herzog, C. Alex Hartman, Rebecca Croston, Sarah Peterson, John Eadie, Desmond Mackell, Andrea Mott, Jeffrey Kohl, Daniel Smith, Jaqueline Satter, Robert Blenk, Cliff Feldheim and Josh Ackerman

Abstract: Situated between the Central Valley and San Francisco Bay, Suisun Marsh and its relatively stable water source is an historically important waterfowl use area, rising to even greater importance given the 90% reduction of freshwater wetlands in the balance of the state. Suisun Marsh is unique in that it is a valuable waterfowl wintering region but also serves as an important breeding area for mallards (Anas platyrhynchos), gadwall (Anas strepera) and cinnamon teal (Anas cyanoptera). We studied the use and importance of Suisun Marsh habitats for waterfowl across the annual cycle using telemetry, nest monitoring, bird banding, remote videography and other techniques from 2015 to present. We radio-marked individual waterfowl (7 primary species) with GPS/GSM transmitters and followed their movements at multiple scales. Individual waterfowl marked in Suisun Marsh distributed widely across North America over the course of the annual cycle with migration pathways and breeding regions common in Alaska, Canada and the U.S. Prairies. The Suisun Marsh provides critical wintering habitat for waterfowl breeding across much of western North America. Waterfowl in Suisun relied heavily on managed wetlands provided by state refuges and private duck clubs throughout the region and seldom used tidal habitats. In addition, we monitored breeding waterfowl including nesting hens through the breeding season and ducklings following hatch. Results from these intensive waterfowl studies can be used to guide management of Suisun Marsh habitats into the future.

Finding a Path Forward for Adaptive Management of Invasive Aquatic Vegetation Control in the Delta

Dylan Chapple, Louise Conrad, Eva Bush, Eddie Hard, Jeff Caudill, Wendy Pratt, Nick Rasmussen, John Madsen, Shawn Acuna

Abstract: Invasive aquatic vegetation (IAV) is a pervasive and urgent problem in the Delta, with impacts to endangered species, the local economy, recreation, and water project operations. Despite ongoing control efforts, recent estimates indicate that the total area invaded by aquatic plants doubled between 2004 and 2018 in surveyed areas. As EcoRestore and other restoration projects are completed, there is a high risk that sites will be invaded by IAV. Effective adaptive management of IAV control will be critical to fulfilling the requirements of the Delta Plan and protecting state investments in restoration. We review the current status of IAV control in the Delta, regional management practices, and the policies and resources influencing control efforts. We focus on submersed aquatic vegetation (SAV) because it is particularly costly and difficult to control. Additionally, SAV has been actively spreading in recent years, particularly in Delta regions that have traditionally been deemed most promising for native fish and contain major areas targeted for wetland restoration. We identify several critical needs for improving adaptive management and control outcomes. Specifically, our assessment suggests both policy and science needs that must be addressed in order to develop effective control tools and to generate a landscape-scale control plan for IAV. A significant uncertainty is where and to what extent control methods for SAV are effective, and what emerging tools may be useful in restoration areas. A science-based approach to identifying effective strategies for SAV control should be a priority for future research, and will require collaborative, interagency partnerships for active progress.

Open Science tools for collaboration and synthesis (What we learned at NCEAS)

Maggie Christman*, David Bosworth*, Sam Bashevkin, Pascale Goertler, George Isaac, and Rosemary Hartman

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Abstract: Many of you may have heard of the “reproducibility crisis” in science. Scientists often cannot replicate others’ studies, and sometimes cannot even replicate their own studies. This is especially problematic for synthesis projects using data collected by multiple different groups. Several members of the IEP Synthesis Team recently attended a training in reproducible research at the National Center for Ecological Analysis and Synthesis (NCEAS), and report back on what they have learned. Conducting research in a reproducible way involves rigorously documenting every step in your data collection and analysis workflow. Data must be preserved in a data repository with exhaustive metadata. The analysis code and data provenance should be published along with the data and the final paper in a “data package” that allows another user to replicate the work. Dissemination of results can go beyond the traditional peer-reviewed journal, and include data packages, code packages, data papers, web applications, and social media. New tools such as GitHub, RMarkdown, Shiny applications, Leaflet maps, machine-readable metadata, and automated reports can help IEP adopt these principals for reproducible research. Through these methods we can increase IEP’s capacity for synthesis, save time, and allow our research to reach a wider audience.

Modeling juvenile Chinook Salmon growth response to off-channel food production

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Abstract: Off-channel production of invertebrates in managed wetlands (e.g. rice fields) is currently being considered as an approach to subsidize in-river food supply for juvenile Chinook Salmon in the Central Valley, California. However, it is unclear at what scale off-channel subsidies would produce a biologically significant response in juvenile growth. While conceptual models and existing empirical evidence suggest off-channel food production can benefit growth of salmon the extent of this benefit is still uncertain, both in terms of habitat area and population level outcomes. We propose a framework for evaluating these potential benefits using a hydrological mixing model coupled with a bioenergetic growth model, which together describe the growth response of juvenile salmon based on food density and mix rate of subsidy and river water. This can then be modeled under different levels of flow, suitable river habitat, and flooded acreage. This approach, based on first principles, will allow estimation of benefits for salmon at a broader spatial and temporal scale than empirical studies, and we can use the model to assess underlying assumptions and identify where additional research is needed to make robust management decisions.

Is the SFE Monitoring Program Really Unique? A Close Look at Monitoring and Synthesis Across Six National Estuaries

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Abstract: Ecological monitoring has been underway in the San Francisco Estuary (SFE) since pre-1960. The Interagency Ecological Program (IEP) and additional monitoring networks collectively form what is likely one of the longest standing and most robust estuarine monitoring programs in the nation. However, a close comparison of monitoring programs across national estuarine systems has not been done, even though this exercise is likely to be valuable for providing perspective on the SFE program. How does the SFE sampling program compare with other United States estuaries? And importantly, how are long-term monitoring data summarized, reported, synthesized, and communicated? What practices from monitoring and synthesis programs in other estuaries can we learn from. Does this evaluation suggest new approaches for the SFE? In a pilot approach to addressing these questions, we compared the SFE monitoring program with programs in the Puget Sound, Columbia River Estuary, Galveston Bay, Chesapeake Bay, and Massachusetts Bay. We cataloged number of sampling locations by decade for water quality, nutrients, contaminants, chlorophyll, phytoplankton, zooplankton, benthic invertebrates, and fish in each estuary. We also developed an inventory of data reporting approaches by thoroughly reviewing web content and communicating directly with program managers. We present a visual comparison of the six estuarine sampling programs and provide perspective on our current approach the SFE. While some estuaries have monitoring programs dating back longer than the SFE, most started scientific monitoring in the 1970s or 1980s, and monitoring has increased in scope over time. Monitoring metrics are generally tied to major regulatory drivers, which differed between estuaries. Most importantly, other estuaries have diverse and unique ways of synthesizing and communicating the results of their monitoring, and IEP can learn from many of their successes and failures.

North Delta Flow Action 2019: Flows, Food, and Fish

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Abstract: The San Francisco Estuary has poor pelagic biomass and primary productivity with a long-term decline in phytoplankton and effects on other trophic levels (contributed to water exports, invasive clams, etc.). However, the Yolo Bypass has shown to be a significant source of productivity, leading to adaptive management actions such as the North Delta Flow Action (NDFA), whereby a moderate flow pulse is proposed to enhance the quantity and quality of food for Delta Smelt in the North Delta and lower estuary. Similar to 2018, the 2019 NDFA redirected agricultural drainage water from rice-fields in the Colusa Basin into the Yolo Bypass from Aug 26 to Sept 21, a total of 31 TAF, and average daily flow of 750 CFS. Monitoring of the water quality and plankton took place before, during, and after the flow pulse at 12 sites along the bypass, in addition to special investigations into the source water including pesticides and the influence of aquatic weeds on productivity. Like 2018, an acute increase in chlorophyll was observed and was transported down the Yolo Bypass Toe Drain after 3-4 days, but the bloom did not reach Rio Vista. Varying levels of productivity were observed before, during, and after the pulse across the regions likely driven by high bacterial decomposition, algal productivity, and water quality conditions. Phytoplankton limitation for resources via competition with aquatic weeds was not evident suggesting other environmental factors are likely influencing the reduced productivity and/or "seed" in the bypass. High levels of pesticides in the pulse water and persistent detections in zooplankton suggest potentially contaminants could negatively affect productivity. Although 2019 productivity was lower than expected, moderate transport of zooplankton to downstream regions was observed demonstrating increased food availability.

Egeria densa (Brazilian waterweed) Patches as "Blue Carbon" Sinks in the Delta

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Abstract: The globally invasive, submerged aquatic plant *Egeria densa* Planch. has long been recognized for altering sediment dynamics in freshwater ecosystems, yet its direct impact on sedimentation processes has yet to be measured. In this study, we compared inorganic sedimentation and carbon accumulation rates (CARs) in sediment cores collected in invasive *E. densa* patches and adjacent tidal freshwater marshes. Study sites were chosen along a range of hydrodynamic conditions in the Sacramento-San Joaquin Delta of California, where *E. densa* covers ~3000 ha and infestation has been widespread since 1990. Cores were analyzed for bulk density, % inorganic matter, % organic carbon, ^{210}Pb, and ^{137}Cs. Our results show that invasive *E. densa* patches are new sinks for blue carbon and inorganic sediment on the landscape, distinct from marshes and unvegetated channel beds. Specifically, *E. densa* patches have inorganic sedimentation rates (*E. densa*:1103 – 5989 g m^{-2} yr^{-1}, marsh: 393 – 1001 g m^{-2} yr^{-1}, $p < 0.01$) and vertical accretion rates (*E. densa*: 0.4 – 1.3 cm yr^{-1}, marsh: 0.3 – 0.5 cm yr^{-1}, $p < 0.05$) greater than adjacent marshes, but CARs that are quite similar to marshes (*E. densa*: 59 – 242 g C m^{-2} yr^{-1}, marsh: 109 – 169 g C m^{-2} yr^{-1}, $p > 0.05$). The mean CAR in *E. densa* patches (116 ±75 g C m^{-2} yr^{-1}) is comparable to global mean CARs for seagrasses. Despite its ability to store carbon, *E. densa* does not constitute a practical approach for mitigating carbon pollution due to its harmful ecosystem engineering traits. However, *E. densa* in previously invaded aquatic habitats may represent a meaningful contribution to regional carbon budgets. Overall, our results across a range of hydrodynamic conditions strongly suggest that *E. densa* patches are carbon sinks throughout *E. densa's* global range, raising questions about how this species is altering biogeochemical cycling in aquatic systems.

The Suisun Marsh, History, Management, and Working Towards a Future of Managing for Waterfowl Hunting and Native Fish

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Abstract: The Suisun Marsh (Marsh) is comprised of about 158 duck hunting clubs with some clubs dating back to the 1870's. The Marsh supports up to 75% of the Pacific Flyway's population of Canvasback and Scaup, and with its connection to the Central Valley is an integral component of the habitat provided to millions of waterfowl every winter. The Marsh also supports more than 50 species of fish including at least 10 Special Status species. In 1974, the state Legislature passed the Suisun Marsh Preservation Act which declared the need to preserve waterfowl carrying capacity. Since 1974, 7 species of wintering waterfowl have shown significant population declines (24 to 83%). DWR maintains water distribution facilities that provide water to over 15,000 acres of managed wetlands. Additionally, the salinity control gates reduce the salinity on more than 50,000 acres of tidal habitat and an additional 10,000 acres of managed wetlands. The rich history of hunting and land management has led to club owners who rank invasive species and sea level rise as 2 of their 5 biggest concerns for their club, and management of listed species as one of their most important land management considerations. Understanding this history, the water management requirements, and maintaining waterfowl populations is key to implementing actions to benefit Special Status Species and ultimately facilitate implementation of fish food production actions across the Marsh on private lands.

The morphometric, biochemical, histological, and immunohistochemical responses of Delta Smelt (*Hypomesus transpacificus*) to fasting: A time series experiment

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Abstract: There is an extensive literature establishing, validating, and quantifying a wide range of responses of fishes to fasting. Our study complements this work by comparing fed and unfed treatments of hatchery raised Delta Smelt—an imperiled fish that is endemic to the San Francisco Estuary and its tributaries in California, USA—over a two-month time series. The experiment was conducted at 15.9 °C, and individuals were sampled at 12 time points as starvation became increasingly severe. We found that hepatosomatic index and condition factor were relatively sensitive to starvation, becoming significantly depressed after 4 and 7 days of fasting, respectively. Of four antioxidants measured, one decreased rapidly (glutathione after 4 days), two increased more slowly (superoxide dismutase and catalase), and one was not affected by starvation (glutathione peroxidase). The net result was a ~2-fold increase in lipid peroxidation (malondialdehyde) in fasted fish, although it was highly inconsistent through time. Histological analysis of liver showed elevated cytoplasm inclusion bodies after 4 days, followed by increased glycogen depletion, single cell necrosis, and lipidosis at 14, 21, and 28 days, respectively. RNA/DNA and triglycerides in muscle were surprisingly insensitive to starvation, only consistently decreasing with fasting after mortality was induced, 21 days into the experiment. Together, these results suggest that Delta Smelt mobilize hepatic energy stores far more rapidly than lipids in muscle when subjected to fasting, leading to rapid atrophy of liver and development of cytoplasm inclusion bodies in hepatocytes. It also reconciles seemingly inconsistent nutritional biomarkers measured on wild Delta Smelt in a previous publication, strengthening our conclusion that the species is under regionally specific nutritional stress in the wild.

The Tidal Parr Studies: Pre-smolt Salmon Distribution, Residence Time, and Growth in Habitats West of the Delta

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Abstract: Estuarine habitat use by juvenile Chinook Salmon (Oncorhynchus tshawytscha) in the Upper San Francisco Estuary, and the benefits that accrue from this habitat use, are arguably the most poorly understood aspects of juvenile salmon life history in California's Central Valley. Yet this information is critical to building effective decision support tools to guide management of water resources and habitat restoration. As part of a three-year suite of coordinated studies to address these questions, known as The Tidal Parr Studies, we are conducting a trawl survey, and parallel eDNA survey, a cage growth study, a diet study, and an otolith and soft tissue microchemistry/isotope study in shallow-water marsh and shoal habitats across Suisun Marsh and Bay, and San Pablo Bay. A study overview and first year results will be presented in this talk.

Ecosystem resilience to fire disturbance in Suisun Marsh

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Abstract: Hydrologic regime can exert strong control on tidal wetland ecological function by altering soil biogeochemistry and influencing plant community dynamics. In Suisun Marsh, hydrology and salinity of many former tidal wetlands are manipulated to provide seasonal habitats for migratory waterfowl. Management intervention can shift ecosystem function directly, but indirect impacts on emergent ecosystem processes such as resilience are less well known. To better understand how tidal wetland resilience is influenced by water management, we used a natural experimental approach using fire disturbance. We quantified marsh platform elevation, soil properties and biogeochemical processes, and vegetation community responses to the Branscombe Fire that burned portions of Suisun in October 2018. We measured paired burned-unburned patches in both tidally-influenced and seasonally-impounded wetlands.

In these mineral-rich marshes, marsh platform elevation was resistant to fire disturbance in both wetland types. Tidal wetland soil processes were more resistant to fire than impounded wetland processes; tidal wetlands released a pulse of nitrate (> 100 mg $N\text{-}NO_3^-$ $kgdw^{-1}$) and retained their ability to carry out nitrification immediately after fire while impounded wetlands did not release nitrate after the fire disturbance (< 1 mg $N\text{-}NO_3^-$ $kgdw^{-1}$) and lost the ability to carry out nitrification. Both wetland types recovered nitrification potential 1 year post-fire. Fire increased beta diversity in both wetland types, but altered species richness only in the impounded wetland. Overall, impounded wetlands were more sensitive to fire disturbance initially, while both wetland types showed resilience after 1 year. Impounded wetlands, however, were starkly different than tidal wetlands for most ecosystem components regardless of fire; lower nitrate and potential nitrification rates, altered species composition, fewer rare species, and a loss in elevation may be signs of reduced ecosystem function in impounded wetlands.

Landscape-scale multi-year efficacy analysis for herbicide treatment of weeds in the Delta

Shruti Khanna, J. Louise Conrad, and Jeffrey Caudill

Abstract: Submerged Aquatic Vegetation (SAV) in the Sacramento-San Joaquin Delta has been increasing in extent since 2004. The SAV community consists of many native and non-native species but non-native *Egeria densa* is the dominant species comprising an estimated 66% of the SAV cover. *Egeria* has been actively managed in the Delta since 2001, but only limited evaluations of the efficacy of SAV control has been done at the landscape scale. We examined SAV treatment records provided by the California State Parks Division of Boating and Waterways in conjunction with the SAV maps produced using hyperspectral imagery data collected between 2014 and 2019 to investigate the role of chemical control on SAV distribution. Our results suggest an advantage to treating the same location for 2-3 consecutive years rather than just a single year. There were no significant differences between treated and untreated sites in annual SAV cover but using "number of consecutive years of treatment" as a predictor indicated that the treatment had a significant impact on the SAV. This result is important because it suggests that investment in SAV treatment is most worthwhile if there can be commitment to multiple years of treatment. This study also illustrates the value of comparing treated and untreated sites to rigorously understand control efficacy. This point is informative towards development of science-based, adaptively managed control program for invasive vegetation, and is particularly notable in light of current uncertainties regarding the efficacy of SAV control.

Suisun Marsh Salinity Control Gate Management Action: Results and Paths Forward

Michael Koohafkan; Water Resources Engineer

Abstract: The California Department of Water Resources operates the Suisun Marsh Salinity Control Gates (SMSCG) facility near the eastern outlet of Montezuma Slough to reduce salinity in Suisun Marsh, one of the largest contiguous tidal marshes on the west coast of the United States. The SMSCG has traditionally operated in fall and winter to improve habitat for waterfowl. During summer 2018 we used this unique water control structure to direct a managed freshwater flow pulse into Suisun Marsh to support habitat conditions for the endangered Delta Smelt Hypomesus transpacificus, a small osmerid native to the upper San Francisco Estuary. The basic approach was to operate the SMSCG to direct a pulse of 130,000 acre-feet of Sacramento River water into Suisun Marsh during August, a critical time period for juvenile Delta Smelt rearing. We provide an overview of the SMSCG facility operations and the 2018 action, using historical and recent monitoring data, fish catch records, and hydrodynamic modeling of the estuary to provide context for the observed changes in habitat condition.

These results provide insight into the potential use of targeted flow to support endangered fishes such as Delta Smelt, and to the general response of estuarine habitat to a managed flow pulse.

Food Web of Liberty Island and the Larger Cache Slough Complex

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Abstract: Collapse of pelagic fish species in the Sacramento-San Joaquin Delta has been linked to multiple stressors that include tidal wetland habitat losses and reduced primary productivity. The Cache Slough Complex has recently become a primary area of interest for management because it contains the recently inundated Liberty Island and is targeted for multiple tidal wetland restoration efforts. To examine how the food web in Liberty Island and the Cache Slough Complex helps support native fishes such as the Delta Smelt, Longfin Smelt, and Sacramento Splittail, our study conducted in 2015-2016 evaluated the larval fish assemblage, prey availability, and organic matter sources within the region. Combined results from larval fish, zooplankton, fish diet, and organic matter source analyses describe a complex food web supporting diverse assemblages of planktivorous fishes in Liberty Island and the Cache Slough Complex. The diversity and differences in fish, prey, and diet were primarily driven by season; with some variability across regions and years. Larval fish assemblage transitioned from dominance by one species (Prickly Sculpin) in February and March, to combination of species in May and June, the most abundant of which was Threadfin Shad. Diets of larval fishes were largely reflected by the relatively consistent availability of the non-indigenous calanoid copepod *Pseudodiaptomus forbesi*. However, reliance on copepod appeared to vary somewhat by fish species. Splittail had a more diverse diet with contributions from multiple organic matter sources, whereas Threadfin Shad and Delta Smelt seem to forage on species that depend primarily on phytoplankton.

Pathogens in the Delta: Fate and Consequences on Chinook Salmon Health

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Abstract: The recent resurgence of ecological physiology into conservation physiology aimed at applying physiological concepts, tools, and knowledge to understanding how organisms, populations, and ecosystems respond to environmental change and stressors. In that context, one challenge is to assess species and populations' coping ability and resilience. In Human medicine, the notion of health is defined as the ability of one patient "to do what it has to do". Health is the integrative outcome of earlier-life environment, exposures and experience and it informs about the patient's vulnerability and resilience to challenges and changes. Our study aimed to apply the notion of health to fish, to assess the effect of pathogens naturally present in California Rivers. We applied high-throughput, non-lethal challenge tests on a population of 300 juveniles of Chinook salmons 2 weeks before, 1 week after, and again 1 month after a 2-weeks period of caging in the Sacramento River at Rio Vista and Hood. Fish screening for 47 pathogens reveals that fish transferred into the river were infected by two myxozoans parasites: *C. shasta* and *P. minibicomis.* However, the presence of pathogens was not associated with reduced performances in the challenge tests, suggesting that the infection did not affect organisms coping ability with natural contingencies. This study highlights that health is an integrative concept that can evaluate the resilience of a species in the presence of disease causing agents. To better assess the ecological consequences of pathogen infections to fish, we recommend the inclusion of ecologically-relevant performance traits and behavioral measurements to supplement current monitoring strategies.

Enhanced Delta Smelt Monitoring (EDSM) and Chinook Salmon

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Abstract: The Enhanced Delta Smelt Monitoring program (EDSM), a spatially and temporally intensive sampling effort for the endangered Delta Smelt (*Hypomesus transpacificus*), was initiated in late 2016 in order to better assess the abundance and distribution of the species throughout multiple life stages. Although Delta Smelt is a highly important species to manage due to its recent precipitous decline and impact on California's water management it would be ideal if EDSM bycatch data can be leveraged to monitor other species of concern such as the Chinook Salmon (*Oncorhynchus tshawytscha*). Here we evaluated how EDSM as a monitoring program can better serve salmon management in the San Francisco Estuary by (1) quantifying how various fish sampling methods commonly used in the Estuary, including EDSM Kodiak trawling, differ in their efficiency at detecting juvenile salmon, and (2) examining how EDSM can be leveraged to enhance the Interagency Ecological Program's salmon monitoring network. To compare sampling methods we fit occupancy models using data from seven monitoring programs: EDSM Kodiak trawl; the Delta Juvenile Fish Monitoring Program's beach seines,

Chipps midwater trawl, Mossdale Kodiak trawl, and Sacramento Kodiak trawl; the Yolo Bypass Fish Monitoring Program's beach seines; and the California Department of Fish and Wildlife's Spring Kodiak Trawl Survey. We found that EDSM sampling helped increase detection of Chinook Salmon, particularly in the lower part of the Estuary (Suisun Bay, San Pablo Bay), in both drought and non-drought years. As a result, the availability of EDSM data will allow us to better understand size variability and relative abundance of salmon in this understudied part of the migratory pathway. EDSM could potentially provide more complete information on outmigrating salmon by extending Kodiak trawling through early June.

Environmentally Relevant Pesticide Concentrations Impact Behavior of Delta Smelt Yolk-sac Larvae

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Abstract: Behavioral tests can be a powerful tool for screening the neurotoxicity of compounds. Here we describe the development of a high-throughput system to evaluate contaminant impacts on the critically sensitive early-life stages of Delta Smelt (*Hypomesus transpacificus*), an endangered teleost species native to the California San Francisco Bay Delta (SFBD), USA. Leveraging the natural behavior of larval Delta Smelt, whereby they increase movement in bright light and decrease movement in the dark, we developed a test using a cycle of light and dark periods in a closed chamber, to test hyper- or hypoactivity. We used this test to evaluate the effect of three commonly used pesticides (bifenthrin, permethrin, and chlorpyrifos) at environmentally-relevant concentrations, varying 100-fold in concentration. Larval behavior was tracked using EthoVision software in each period for distance moved, velocity, turn angle, meander, angular velocity, and number of rotations. Time spent in the border vs. the center of the well was also tracked. The measured velocities were binned by speed into several categories including Cruising (5mm – 20mm /sec), Bursting (>20mm/sec), and Freezing (<5mm/sec). At 96 h of exposure, all concentrations of bifenthrin caused hyperactivity defined by increased distanced moved. At 48, 72, and 96 h of exposure, the highest concentration of permethrin caused a hyperactive state in which the larvae spent more time in the center of the well, quickly turning and rotating in bursts of increased velocity. In response to the highest concentration of chlorpyrifos, the larvae exhibit hyperactivity characterized by increased duration of Bursting during the dark periods of 72 h exposure, and increased frequency of Cruising during the light periods of 96 h exposure. These results indicate that this behavioral test is highly sensitive in determining the impacts of environmentally relevant pesticide concentrations on this endangered species. Behavioral tests on Delta Smelt larvae have the potential to greatly inform conservation management strategies for this critically sensitive life stage.

Terrestrial Mesopredators in the Marsh

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Abstract: Predation, particularly by mammalian mesopredators, often is the primary cause of duck nest failure. Understanding how individual predators move across habitats and interact with duck nests may inform habitat management practices and improve nest success. We used GPS collars to quantify movement and habitat use of raccoons (*Procyon lotor*; n=29) and striped skunks (*Mephitis mephitis*; n=25), the main egg predators of waterfowl that nest in upland fields of the Grizzly Island Wildlife Area (California). Mesopredators were collared prior to duck nesting (2016–2019), with locations recorded during the nesting period every 15 min (raccoons) and 7.5 min (skunks). At monitored nests, iButton temperature dataloggers recorded temperature every 8 min. We used a camera-validated algorithm to identify temperature decreases associated with hen departure from a nest. Nocturnal hen departures likely indicate response to a predator, allowing us to use them as further evidence for the timing of depredations. Furthermore, we quantified total mercury (THg) concentrations in the hair of all animals as a potential ecological tracer, and we tested whether THg concentrations in hair differed among species, year and sex. Raccoons and skunks differed in upland habitat use, although all mesopredators were captured within or along the edges of upland fields. Raccoons and male skunks primarily moved along habitat edges, specifically roads, levees, and canals. Raccoons spent most of their time in managed wetlands adjacent to, and occasionally within, upland fields. Female skunks remained almost entirely within upland fields. Furthermore, raccoons demonstrated a high level of territoriality, with limited overlap between individuals of the same sex. Depredations occurred at 28% of nests where collared raccoons were observed < 25m from a nest and 53% of nests where collared skunks were observed < 25m from a nest. We revealed sections of upland nesting habitat more commonly frequented by mesopredators, which can inform habitat management to potentially decrease encounters between mesopredators and duck nests.

Growing Fish Food in Duck Ponds: Food Web Support in Suisun Marsh

Kyle Phillips, Alice Tung, Sharon Lawler, John Durand

Abstract: Mounting evidence suggests that managed wetlands (ie duck clubs) in Suisun Marsh produce very high concentrations of mesozooplankton. Mesozooplankton are an important food resource for pelagic fishes in the San Francisco Estuary and have been declining throughout much of the system in recent decades. This talk will explore a variety of potential mechanisms underpinning productivity in managed wetlands including seasonal management regimes, water age, benthic community structure, and vegetation structure. Studying production in managed wetlands and adjacent tidal habitats provides a unique opportunity to address which ecological conditions are important for zooplankton production in today's estuary.

Findings from the Delta Smelt Resiliency Strategy Aquatic Weed Control Action

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Abstract: Aquatic vegetation now covers approximately 30% of the Sacramento-San Joaquin River Delta. Dense non-native vegetation renders large areas of aquatic habitat unusable by the endangered Delta Smelt *(Hypomesus transpacificus)*. As part of the Delta Smelt Resiliency Strategy, we conducted a two-year pilot study (2017-2018) to investigate the ecological effects of both submerged aquatic vegetation (SAV) and treatment of SAV with the herbicide fluridone. We studied two pairs of sites in the Delta, with one treated and one untreated site within each pair. In the North Delta, we studied Little Hastings Tract (treated) and French Island (untreated). In the Central Delta, we studied Decker Island (treated) and Fisherman's Cut (untreated). Throughout the study, we monitored SAV, water quality, phytoplankton, and zooplankton at all sites. At the two North Delta sites, we also monitored fish communities. Despite several rounds of fluridone application at the treated sites over a two-year period, we did not observe significant, lasting reductions in SAV biomass. Fluridone accumulated in the sediment at high concentrations, but concentrations in the water column were typically below those required for effective vegetation removal by this slow-acting herbicide, likely because of dilution from tidal action. We did not observe significant differences in water quality, plankton, or fishes between treated and untreated sites, suggesting that there were not strong ecological effects of fluridone use. Our ecotoxicology experiments on the effects of fluridone on selected plankton species also suggest that fluridone does not have negative impacts at concentrations found in the field. Taken together, our findings clearly indicate that removing SAV to restore open water habitat for Delta Smelt is difficult using existing tools. There is a great need for research and development of new tools, technologies, and techniques for SAV management in the Delta.

Where Will All the Turtles Go? Western Pond Turtle Movement and Habitat Use in Suisun Marsh

Melissa Riley

Abstract: The Western Pond Turtle (*Actinemys marmorata*) - California's only native freshwater turtle - is listed as a species of special concern, in California. Western Pond Turtles face a variety of threats such as habitat loss and disease throughout much of their range, and populations have been declining. In the Suisun Marsh, observational data has shown that Western Pond Turtles are widespread. However, until recently there have been no formal studies to determine their population status and habitat requirements. Suisun Marsh consists of a mosaic of tidal and managed brackish water wetlands, with 5,000 - 7,000 acres of tidal restoration planned within the next 30 years. It is unknown how Western Pond Turtles will respond as tidal restoration projects are implemented. The objectives of this study are to characterize Western Pond Turtle movement and habitat use as well as understand how Western Pond Turtles will respond to impending changes in Suisun Marsh, using mark-recapture and GPS/GSM tracking technology. Preliminary results show that populations are large and healthy. In addition, Western Pond Turtles are using a variety of aquatic and terrestrial habitats within tidal and managed wetlands such as muted tidal ditches, ponds, mud banks, and levees. Insights gained from this project will aide managers in efforts to conserve Western Pond Turtles in this unique habitat.

In-Seine: Littoral Fish Community Assemblages in the Yolo Bypass

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Abstract: Beach seining provides an effective means of monitoring species abundance and community dynamics of juvenile and smaller adult fish within the littoral habitat. The Yolo Bypass Fish Monitoring Program has been conducting beach seines within the Yolo Bypass since 1999. These sampling events occur primarily within the Toe Drain, a perennial riparian channel on the eastern edge of the Yolo Bypass. Beginning in 2010, core sample locations were added as sites designated by their position “Above Lisbon” or “Below Lisbon” to highlight the contrast in flow above and below Lisbon Weir, the Toe Drain’s main water control structure. Beach seine data from 2010 to 2018 were analyzed based on catch per unit effort (CPUE) of fish from the Cyprinidae and Centrarchidae families, two families which make up a large proportion of total seine catch. Overall, CPUE from 2010 to 2018 was greater at sites above Lisbon Weir, where invasive centrarchids dominated. CPUE below Lisbon Weir was lower, driven by decreased total catch of invasive centrarchids and invasive cyprinids. Years with higher precipitation often yielded higher CPUE, especially that of native and invasive cyprinids below Lisbon Weir. Notably, invasive centrarchid catch was reduced below Lisbon Weir during dry and critically dry years, while catch above Lisbon Weir was less affected. Changes in community structure of centrarchids and cyprinids between beach seine sites above and below Lisbon Weir and across water year types affirms that flow manipulation via Lisbon Weir and changes in annual watershed precipitation play important roles in the community assemblages of littoral fish in the Yolo Bypass Toe Drain.

Testing Managed Wetlands BMPs for Improving Water Quality and Achieving TMDL Objectives in Suisun Marsh

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Abstract: Suisun Marsh, in the northern reaches of San Francisco Bay, California, is a mosaic of over 100,000 acres of diked managed wetlands, tidal wetlands, bays and sloughs, and adjacent uplands, and supports a high diversity of resident and migratory terrestrial and aquatic wildlife species. Dead end sloughs in Suisun Marsh have historically experienced episodic low dissolved oxygen (DO) and high methyl mercury (MeHg) events, adversely affecting aquatic life and other beneficial uses. As a result, the Regional Water Quality Control Board added Suisun to the Clean Water Act Section 303(d) impairment list. To help address these problems, the State Board funded an investigation from 2007-2011 that identified a variety of best management practices (BMPs) that were implemented and monitored in selected managed wetlands over 2015-2018 under a USEPA grant. BMPs included structural and operational modifications and were coordinated by the Suisun Resource Conservation District. Water quality effects on wetland discharges and sloughs were field measured from 2016-2018 focused on Peytonia and Boynton sloughs. Monitoring included continuous wetland and slough stage and water quality (temperature, DO, conductivity, and pH) and discrete grab sampling for organic carbon, biochemical oxygen demand in water and sediment, and MeHg. Data collected through this project, combined with previous monitoring data, indicate that slough water quality has improved since BMP implementation, and DO levels—a key metric for aquatic beneficial uses— are generally higher than the new TMDL chronic and acute objectives. Modeling described observed changes in water quality across Peytonia and Boynton sloughs, representing a range of mixing conditions. Modeling explored the extent of DO improvement achievable through more extensive BMP implementation; in general significant improvements are possible, but limited by the level of tidal flushing in the upstream ends of sloughs and physical and environmental constraints. Field results from this study, its preceding study, and other regional field studies have identified a key DO level below which MeHg levels rise considerably, providing a management basis for reducing MeHg loading into aquatic and terrestrial food webs.

Salt marsh harvest mice in Suisun Bay: population substructure and the role of landscape.

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Abstract: Understanding how populations of endangered species are subdivided and which landscape features impede gene flow helps conservation practitioners make informed management decisions. The largest remaining tracts of historical habitat for the salt marsh harvest mouse (SMHM) are found around Suisun Bay, making this area critical to the conservation of the species. The primary objective of this study was to assess how populations were subdivided and the levels of gene flow among SMHM within Suisun Bay. The second objective was to assess the role played by habitat features in creating population substructure. We trapped and collected 538 SMHM genetic samples from 26 locations and genotyped them with 20 microsatellite loci. Using cluster analysis and a population tree we identified a large population across the northern marshes of Suisun Bay, and smaller distinct populations on the Contra Costa shoreline and at Ryer Island. Landscape genetics analyses identified that water and elevation >2m both constrained gene flow and mouse movement. This information can be used to help locate other potentially distinct populations of SMHM, both within Suisun Bay and elsewhere across the species range.

Delta Smelt (*Hypomesus transpacificus*) health and condition: evaluating the hypothesized benefits of Delta outflow across multiple water years

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Abstract: This study evaluated the health and condition of the endangered Delta Smelt (*Hypomesus transpacificus*) under different flow conditions across multiple water years (2017-2019). This project was one of many as part of the larger Directed Outflow Project (DOP), which examined the concept of altering outflow conditions to benefit the rearing stages of Delta Smelt in order to promote Delta Smelt resiliency to drought conditions. However, given that the Sacramento-San Joaquin Delta is polluted from numerous anthropogenic sources, there is some uncertainty regarding the exclusively beneficial effects of a higher flow augmentation. This three-year study evaluated the water quality of Delta water with respect to contaminants with Delta Smelt toxicity testing and chemical analyses. Ambient samples were collected from six sites within the five sub-strata delineated in the larger DOP: 1) Toe Drain; 2) Cache/Lindsey Sloughs; 3) Sacramento River at Isleton; 4) Sacramento River at Decker Island; 5) Montezuma Slough; and 6) Grizzly Bay. Toxicity testing was conducted every two weeks in the fall of 2017, in the summer and fall of 2018, and in the fall of 2019. Biomarker analyses were conducted on surviving Delta Smelt and included those evaluating health, condition, and contaminant exposure. In 2017, lesion scores from histopathological analyses indicate potential metals, pesticide, and mixed contaminants exposure in the Cache Slough region, while enzymatic antioxidant assays indicate that fish exposed to water from Grizzly Bay and the Sacramento River at Isleton were being exposed to a higher load of unspecified organic compounds and were producing more reactive oxygen species. These changes were observed during Exposures 3 and 4, which were initiated in the month of November 2017. We will compare the results from 2017 to 2018 and 2019 data to assess if Delta outflow alteration water poses risks to fish health in the Delta.

Dataset integration: from water to zooplankton to fish

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Abstract: The biotic and abiotic conditions of the San Francisco Estuary have long been studied due to the economic, environmental, and cultural importance of this system. A breadth of agencies and universities have conducted long-term monitoring efforts that collect data using a variety of methods. Due to differences in the initial purpose and/or intensity of surveys, some of these datasets have gone on to become the de facto sources of data for particular topics, while others have gone largely overlooked and underused. By underutilizing these datasets for tracking trends in species abundance and environmental conditions, we severely limit our spatial and temporal resolution. In this presentation, we will discuss the value of integrating data from different sources, provide three different examples of how data integration is currently being performed, and identify problems and solutions in our integration workflow. Our integration of 14 long-term fish surveys highlights how patterns identified in a single dataset may conflict with those seen in other surveys and aggregative data. We also demonstrate how to approach quality control when integrating water temperature data from >100 stations throughout the estuary. Finally, our integration of zooplankton data provides an example of how to reconcile differences in taxonomic resolution among datasets. Our work complements the recent efforts by the Interagency Ecological Program to make data more easily accessible and interoperable, while highlighting the value in maintaining diverse surveys.

Climate change in California: A tale of shifting baselines, sharpening seasonality, and increasing precipitation whiplash

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Abstract: Climate change is no longer a hypothetical future threat in California--recent evidence demonstrates that it has already increased the severity of droughts, wildfires, and heavy downpours in the Golden State. But the changes so far are only a fraction of those which may arise with additional future warming, and there is growing evidence that biospheric and environmental impacts scale non-linearly with rising temperatures. In this talk, I will discuss recent insights from climate science that shed new light on the character of climate change in California--including findings pointing toward a shorter, sharper wet season, ever-wider swings between extreme wet and dry conditions, and the rising risk of "megafloods" in a warming world. I will also reflect on the transformative effects these shifts in physical climate will likely have in a region as geographically and ecologically diverse as California.

Session Introduction: Science Communication Beyond the Ivory Tower

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Abstract: As scientists, we have generally accepted and understood ways for exchanging information to other scientists. We present at conferences and symposia. We publish theses, dissertations, reports and peer reviewed manuscripts. But how can we effectively communicate to the expanse of audiences ***outside*** of the scientific community? In an era where growing scientific skepticism seems to be at odds with informed decision-making, the refrain, "Scientists must be better communicators," is ever more common. But what does this mean? What are the pathways and strategies for scientists to communicate beyond the ivory tower?

This session will explore potential techniques, opportunities, and information vehicles that science practitioners may consider in order to get the "scientific word" out to wider audiences. Speakers will delve into the world of social media, ideas for crafting messages, and will highlight an effort to bring relevant science directly into a locally affected community.

Current Progress in the Development of a Captive Culture for the Threatened Longfin Smelt (*Spirinchus thaleichthys*)

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Abstract: Over the last two decades, the abundance of longfin smelt in the San Francisco Estuary has plummeted to historical lows and has triggered discussion of their potential for extinction. While clear that drastic action must be taken to conserve the species in the wild, our lack of knowledge of the basic biology of longfin smelt limits our ability to make informed conservation management decisions. To combat this, the Fish Conservation Culture Laboratory (FCCL) affiliated with UC Davis has attempted to develop a captive culture to serve the dual purpose of providing researchers with a sustainable source of individuals to conduct the mechanistic studies necessary to determine their tolerance to environmental stressors and to serve as a captive population for reintroduction efforts as necessary. However, mass mortality during the larval stage in captivity have so far hindered the full development of a captive culture, prompting studies to identify best culturing methods. Here, we present the first series of experiments to identify optimal larval longfin smelt rearing conditions. We focused on three environmental factors that correlate with longfin smelt larval abundance in nature: temperature, salinity, and turbidity. In the 2018-2019 season, we assessed how temperature and salinity affected growth and yolk resorption rates of longfin smelt yolk-sac larvae. We discovered that prior FCCL methods of rearing larvae at 12°C were optimal but the use of freshwater rather than lightly saline water hindered larvae. In the 2019-2020 season, we used our newfound knowledge and reared larvae at 12°C and 2ppt but at different turbidities to identify how turbidity affected survival, growth, and feeding rates. Preliminary results suggest that longfin smelt larvae may prefer higher turbidities. Though we are far from developing a captive culture for the species, we find it hopeful that minor changes to rearing conditions can improve the longfin smelt culture.