POSTER ABSTRACTS

2016 Bay-Delta Science Conference

Abstracts for poster sessions presented at the 2016 State of the Bay-Delta Science Conference are compiled in this document. Abstracts are listed by Poster Topic and then sorted by the presenting author's last name. Though many posters have multiple authors, only the presenting author is listed in the table of contents. In the abstracts, names of presenting authors are underlined. Asterisks (*) indicate the poster is submitted by a student and eligible for the student poster awards competition.

Table of Contents – 2016 Bay-Delta Science Conference - Poster Abstracts

Listed by Presenting Author

Poster Clusters

Aquatic Invasive Species Activities in California/Bay-Delta: Threats, Prevention, and New Invaders

Marine Invasive Species in San Francisco Bay, Karen Bigham 1

Decreasing the Risk of Aquatic Species Invasion from Vessels Arriving at Bay-Delta Ports
Jonathan Thompson, Raya Nedelcheva 2

Invasive Watersnake Poses Threat to California Native Species, Louanne McMartin 3

Invasive Watersnakes (*Nerodia spp*.) in California: Monitoring, Detections, and Eradication,
Valerie Cook Fletcher 4

Assessing Invasiveness of Aquatic Plants to Facilitate Management in the Sacramento-San Joaquin Delta,
Helen Benson 5

Creation of Mercury Models for the Delta and Yolo Bypass: Linking Modeling and Delta Regulatory Decisions

An Overview of the Creation of Mercury Models for the Delta and Yolo Bypass: Linking Modeling and
Delta Regulatory Decisions, Carol DiGiorgio 6

Modeling Mercury in the Yolo Bypass, a Mercury-Contaminated Floodplain, Reed Harris 7

Progress on Extending a Delta Model to Include Mercury and Sediment, Jamie Anderson 8

Erodibility of Yolo Bypass Sediments as a Mercury Vector, Paul Work 9

Sediment – Water Exchange of Inorganic and Methyl Mercury in the Yolo Bypass,
Wesley Heim 10

Methyl Mercury Production from Senescence Vegetation During Flooding in the Yolo Bypass, Mark
Stephenson 11

Mercury and Methylmercury Mass Balance Estimates of the Yolo Bypass During Flooding Events,
David Bosworth 12

Methylmercury Imports and Exports of a Freshwater Tidal Wetland in the Yolo Bypass,
Petra Lee 13

Evaluating an Emergency Response: False River Drought Barrier Efficacy and Effects

The 2015 Emergency Drought Barrier: Huge Management Action, Huge Science Opportunity,
Karen Kayfetz 14

Setting the Stage for the Science: Planning and Implementing the 2015 West False River Emergency Drought Barrier Project, Jacob McQuirk 15

Water Quality Effects of the 2015 False River Barrier, Patrick Scott 16

Effects on Listed Fishes from the 2015 West False River Emergency Drought Barrier Project, Marin Greenwood 17

Headwater Mercury Source Reduction Strategies

Headwater Mercury Source Reduction Strategy in the Sierra Nevada, Carrie Monohan and Alexandria Keeble-Toll* 18

Sediment and Mercury Loads to Humbug Creek: A Sierra Nevada Tributary Impacted by the Malakoff Diggins Hydraulic Mine, Carrie Monohan 19

Mercury in Fish of the American and Bear Watershed Reservoirs: Baseline Conditions and Exposure Risk at Lake Clementine and Rollins Reservoir, CA, Alexandria Keeble-Toll* 20

Metal-Based Coagulant Effect on Dredged Sediment Slurry for Lake Combie Reservoir Sediment and Mercury Removal Project, Grass Valley CA, Nicholas Graham* 21

Shallow Subsurface Groundwater Quality and Flow Paths in the Malakoff Diggins Hydraulic Pit, Travis Moore* 22

Linking Sediment Dynamics to Long-Term Management Decisions

Assessing the Role of Sediment Supply in Mudflat Width at Decadal and Seasonal Time Scales, Bruce Jaffe 23

Climatology of Salinity and Suspended Particulate Matter in San Francisco Bay, Carlos Schettini 24

Sediment Flux Measurements at the Golden Gate: Progress toward Closing the Sediment Budget for San Francisco Bay, Maureen Downing-Kunz 25

Primary Sediment Supply, Pathways and Transport Mechanisms to the Central Sacramento-San Joaquin Delta, Tara Morgan-King 26

Wave Attenuation Across China Camp Tidal Marsh, Madeline Foster-Martinez* 27

Mapping the Invasive Plant *Arundo donax* and Prioritizing it for Eradication in the Legal Delta

Invasive Plant *Arundo donax*: Mapping and Prioritizing Its Eradication in the Sacramento-San Joaquin Delta Region of Northern California, Alex Young 28

Index-Based Multispecies Conservation Value (IMCV) Model for Prioritizing Invasive Weed Eradication, Alex Young 29

Microcystis Drought Response Program Collaborative Research

Microcystis Drought Response Program Collaborative Research Summary, Peggy Lehman 30

Sampling and Analyses Conducted for the 2014 and 2015 *Microcystis* Drought Response Program, Mary Xiong 31

The Impact of Successive Drought Years on *Microcystis* Blooms in San Francisco Estuary, Peggy Lehman 32

Rates of Primary Production for the 2015 *Microcystis* Bloom in the San Francisco Estuary, Sarah Blaser 33

Abundance of Key Cyanobacteria Species and Cyanotoxin Concentrations During Severe Drought Years, 2014 and 2015, Tomo Kurobe..... 34

2014 and 2015 Critical Drought Effects on Zooplankton Composition during *Microcystis* Blooms, Sarah Lesmeister 35

Characterizing Biodiversity and Relative Abundance of Cyanobacteria by Shotgun Metagenomic Sequencing Analysis, Tomo Kurobe 36

Non-Native Predator Fish Research in the Sacramento-San Joaquin Delta

Water Quality in the Delta and Chinook Salmon: a hot issue with murky consequences, Brendan M. Lehman..... 37

Seasonal Movements and Distribution of Central Valley Striped Bass (*Morone saxatilis*), Megan Sabal* 38

Examining the Spatial and Temporal Distribution of Striped Bass within the Delta in Wet vs. Dry Years, Joseph Smith 39

General Sessions

Bird Biology, Ecology, & Protection

Phoning It In: A New Approach to Tracking Movement Patterns and Habitat Nuances of Diving Ducks, Mason Hill 40

Factors Influencing the Abundance of Wintering Western Snowy Plovers at Crown Beach State Memorial Park, David Riensche..... 41

Fish Biology, Ecology, & Protection

Estuary Monitoring Platform: Standardized Biological Sampling Across Habitat Types, Jesse Anderson..... 42

Effects of Bifenthrin on the Estrogenic and Dopaminergic Pathways in Embryos and Juveniles of Zebrafish (*Danio Rerio*), Luisa Bertotto* 43

Examining Effects of Wastewater Effluent upon Growth Rates of Inland Silversides in San Francisco Bay Tributaries, Zachary Bess 44

Hydraulic Conditions Near a Model Louver System in a Laboratory Flume, Kara Carr 45

Behavior of Green Sturgeon *Acipenser medirostris* Near a Model Louver System in a Laboratory Flume, Dennis Cocherell 46

Developmental Toxicity of 2- and 6-Hydroxychrysene in Zebrafish Embryos, Graciel Diamante* 47

Understanding Catch Patterns of Invasive Catfish Species in the Yolo Bypass, Mary Jade Farruggia 48

Effects of Temperature on the Endocrinology of Smoltification in Juvenile Rainbow/Steelhead Trout (*Oncorhynchus mykiss*), Marissa Giroux* 49

Migratory Behavior of Acoustically-Tagged Adult White Sturgeon and Chinook Salmon in the Yolo Bypass, 2012-2016, Myfanwy Johnston* 50

Inter-population Differences in Osmoregulation of Sacramento Splittail, Paige C. Mundy* 51

Temperature and Feeding Rate Interact to Impact Growth and Survival of Larval Green Sturgeon, Trinh Nguyen 52

Efforts to Conserve Pacific Lamprey, Alicia Seesholtz 53

Lots of Data without the Fishy Smell: Application of Acoustic Imaging to Evaluate Fish Behavior near Tidal Wetlands, Collin Smith 54

Occurrence of Large-Scale Loach (*Paramisgurnus dabryanus*) in the Sacramento-San Joaquin basin, CA, Ronald Smith 55

Reconstructing Fish Life History using Strontium Isotope Laser Ablation MC-ICP-MS Analysis of Scales, Spines, and Fin Rays as a Non-Lethal Alternative to Otolith, Malte Willmes 56

The Effect of Chlorpyrifos on Salinity Acclimation of Steelhead Trout: Changes of Serum Hormone and Gene Expression in Liver, Gill and Rosette, Elvis Xu 57

Time- and Oil-Dependent Genomic and Physiological Responses to Deepwater Horizon Oil in Mahi-Mahi (*Coryphaena hippurus*) Embryos, Genbo Xu 58

Fish Biology, Ecology, & Protection: Salmon

Aerobic Scope Reveals High Thermal Performance in Juvenile Chinook Salmon, *Oncorhynchus tshawytscha*, Sarah Baird 59

2016 South Delta Chinook Salmon Survival Tag Retention Study: Increased Tag Burden Results in Increased Tag Expulsion, Denise Barnard 60

Calculating Potential Fish Benefits from NMFS Delta Actions, Russ Brown 61

Dynamic Visualization of Tethered Salmon Smolt and their Predators in San Joaquin River Habitats, George Cutter 62

Monitoring for Pathogens and their Effects on Out-Migrating Chinook Salmon in the Delta, Matthias Hasenbein 63

Emigration Rate and Survival of Winter-run Chinook Salmon, Jason Hassrick 64

Differential Impacts of Outmigration, Survival, and Biocomplexity for the Central Valley Chinook Salmon Population, Sebastien Nussle 65

Central Valley Passive Integrated Transponder (PIT) Tag Array Feasibility Study, Dave Rundio 66

Migratory Behavior and Survival of Reintroduced Spring-Run Chinook Salmon Smolts in the San Joaquin River and Delta, Gabriel Singer* 67

A Brief History of Central Valley Hatchery Releases in Time and Space, Anna Sturrock 68

Fall Run Chinook (*Oncorhynchus tshawytscha*) Salmon Upstream Migration Behavior in San Joaquin River Basin, H. Steve Tsao 69

Fish Biology, Ecology, & Protection: Smelt

Growth Rate Comparison of Longfin Smelt (*Spirinchus thaleichthys*) Between Wet and Dry Years Through Otolith Analysis, James Chhor 70

Temperature Tolerance and Metabolism of Threatened Smelt, Brittany Davis* 71

Putting Extreme Drought into a Long-Term Context: Growth Rate Variability and Recruitment Success in Response to Environmental Conditions, Mackenzie Gilliam 72

Growth and Life History of Delta Smelt Utilizing the Yolo Bypass, Brian Healey 73

Development and Evaluation of Using Environmental DNA Sampling to Detect and Monitor Wild Delta Smelt, Ann Holmes* and Ted Sommer 74

Phenotypic Effects of Domestication on Captive-Bred Cultured Delta Smelt, Tien-Chieh Hung 75

The Search for the Spawning Habitat of Delta Smelt, Rob McLean 76

Maternal effects on egg quality in Delta Smelt (*Hypomesus transpacificus*),
Meredith Nagel* 77

Longfin Smelt Distribution, Abundance and Evidence of Spawning in San Francisco Bay Tributaries,
Christina Parker..... 78

Field Calibration of the SmeltCam, Oliver Patton 79

Identification of Individual Cultured Delta Smelt Using Visual and Automated Analysis of Natural Marks,
Marade Sandford 80

Can We Tag Delta Smelt? Feasibility of PIT and Acoustic Tagging of Cultured Adults,
Rick Wilder 81

Food Webs

Trophic Ecology of Zooplankton and Larval Fish the Cache Slough Complex, Jeff Cordell..... 82

Are there Non-Target Impacts of *Eichhornia crassipes* Management on Aquatic Invertebrate
Communities?, Erin Donley Marineau* 83

Response of the Yolo Bypass Floodplain to a Spring Flow Pulse,
Jared Frantzich and Rachel Fichman..... 84

What's For Dinner? A Compositional Study of Particulate Organic Carbon in the San Francisco Bay-Delta,
Jennifer Harfmann* 85

Is the Cache Slough Complex a Source Region for Zooplankton in the Upper San Francisco Estuary?,
Toni Ignoffo..... 86

Carbon Uptake by Single Celled Microalgae in the Benthic and Pelagic Zones of Historical Wetlands,
Tricia Lee 87

Phytoplankton Community Structure in the Lower South Bay Margins, Ryan Mayfield..... 88

Sacramento River Phytoplankton Growth: Relative Importance of River-Water Sources, Light, Nutrients,
and Clam and Zooplankton Grazing, Tim Mussen 89

The Molecular Ecology of SF Delta *Microcystis*, Timothy Otten..... 90

Are Current Sampling Programs Accurately Describing Zooplankton Distributions on Scales Relevant to
Feeding by Fish?, Anne Slaughter 91

Delta Boundary Conditions: Plankton Communities and Water Quality in the Sacramento River and its
Tributaries, Lisa Thompson..... 92

Habitat & Ecosystem Function Restoration

Comparative Restoration Attributes in the Cache Slough Complex, Nicole Aha* 93

Beyond the Levee: Strategies for Ecologically Functional High Tide Refugia in San Francisco Bay Tidal Marshes, Peter Baye 94

Testing a Novel Adaptation Strategy in a California Salt Marsh, Evyan Borgnis 95

Facilitating Salt Marsh Formation through Vegetative and Physical Barriers to Erosion, Margot Buchbinder* 96

Decker Island Restoration Project, Ling-ru Chu and Phillip Poirier 97

Giving Land to Water, Placemaking of An Experimental Flooded Polder in the Sacramento-San Joaquin Delta, John Durand 98

Comprehensive Ecology of *Schoenoplectus californicus*: Recommendations for Restoration of Tule Marsh, Mark Hester 99

Restoration approaches and planning for the Prospect Island Tidal Habitat Restoration Project, Noah Hume 100

Advancing Transition Zone Restoration: Application of Soil Amendments to Increase Vegetation Establishment, Nissa Kreidler and Rachelle Cardona 101

Climate Change Adaptations in a North Bay Centennial Marsh, Meg Marriott 102

A Storm Water Basin with Growing Diversity, Mary Helen Nicolini 103

The Oro Loma Horizontal Levee Demonstration Project - Scaling Up Native Species Propagation Methods to Accommodate Large Transition Zone/Ecotone Projects of the Future, Jessie Olson 104

Restoration Design in the Sacramento-San Joaquin Delta: Lessons from Case Studies, Bruce Orr and Amy Merrill 105

Invertebrate Responses to Eelgrass and Oyster Restoration in a San Francisco Estuary Living Shorelines Project, Cassie Pinnell 106

Coon Creek Watershed Assessment: An Interdisciplinary Approach for Evaluating Impacts and Developing a Restoration Strategy for a Foothill Watershed, Jai Singh 107

What do Skaggs Island and Sagrada Familia have in Common?, Renee Spenst and Russ Lowgren 108

Long-Term Changes in Spatial Structure of Restored Wetlands within the Sacramento-San Joaquin Delta of California, Sophie Taddeo 109

Field-Based Monitoring of Restoration Progress in Wetlands of the Sacramento-San Joaquin Delta, Sophie Taddeo and Kelsey Therese 110

Integrative Applied Science

Use of UAVs in the Design, Construction Observation and Post-Project Monitoring of Salmonid Rehabilitation Projects, Jesse Barker 111

SacPAS: Demonstration of a Real-time Decision Support System to Predict and Assess Operational Benefits and Risks to Central Valley Salmon, O. Towns Burgess 112

A Comparison of Two Sampling Gear Types in Liberty Island, Dave Contreras 113

Potential GHG Emissions Reductions on Agricultural Lands in the Sacramento-San Joaquin Delta, Steve Deverel 114

The Delta Research Station: A Glimpse at the Future Hub for Monitoring and Research in the Bay-Delta, Kevin Fisher 115

Raising the Bar and Dropping the Cost of Aerial Imagery for Monitoring and Assessment, Stuart Siegel 116

Modeling

Spatio-Temporal Ecological Modeling of Water Hyacinth Environment on the Performance of a Biological Control Agent, Emily Bick* 117

Planning Tools to Evaluate Salmonid Habitat Restoration in the Yolo Bypass, Chris Campbell 118

Modeling the Effects of Varying Disturbance Frequency and Magnitude on Population Persistence in Predator-Prey Systems, Christian Commander* 119

Advancing the Integration of Vegetation in Floodplain Modeling and Management to Achieve Multi-Objective Benefits for Flood Risk Reduction, Kevin Coulton 120

Interactions of Ending Overdraft and Delta Water Management, Mustafa Dogan* 121

Developing a High Resolution Bathymetric/Topographic DEM of the San Francisco Bay - Delta for use in CASCaDE II Models, Theresa Fregoso and Bruce Jaffe 122

Cost-Effective Shallow Water Bathymetric Modeling, Thomas Handley 123

Biogeochemical Modeling for Nutrient Management in San Francisco Bay, Rusty Holleman 124

Riparian Forest Dynamics along the Sacramento River, California (USA): Constructing Tree Age Models to Illustrate Successional Patterns, Andrea Irons* 125

A New Public Domain Hydrodynamic Model for the Yolo Bypass, Jeanette E. Newmiller..... 126

Downscaling Wind and Wave Fields for 21st Century Coastal Flood Hazard Projections in San Francisco Bay, Andrea O'Neill 127

A Large-Scale, Infrared Quantitative Imaging System for Measuring the Instantaneous Surface Velocity Field in Natural Flows, Seth A. Schweitzer..... 128

Climate Change Effects on Optimal Bypass Capacity, Alessia Siclari* 129

Central Valley Refuge Management under Non-stationary Climatic and Management Conditions, Karandev Singh 130

Yolo Bypass Model: Providing a Public Model to Evaluate Future Options, Lily Tomkovic* 131

Quantifying Spatio-temporal Inundation Patterns for Floodplain Restoration on the Lower Cosumnes River, California, Alison Whipple* 132

Natural Resource Management

The Central Valley Habitat Exchange: Quantifying Benefits for Multiple Species at Parcel and Landscape Scales, Amy Merrill and Daniel Kaiser..... 133

Desalination Cost Analysis for California, Ellie White..... 134

Natural Resource Management: Endangered Species

Adaptive Immunogenetic Variation in Endangered Salt Marsh Harvest Mouse Populations, Anastasia G. Ennis..... 135

Development and Use of an Environmental DNA (eDNA) Method for Determining Presence/Absence of Freshwater Mussels in the Tidally Influenced Delta, Ellen Preece 136

Salt Marsh Harvest Mice (*Reithrodontomys raviventris*) Distribution, Abundance, and Population Trends in the East Bay Regional Park District, David Riensche..... 137

Using DNA from Beetle Feces to Improve Cryptic Species Monitoring, Andrea Schreier 138

Predation of Salt Marsh Harvest Mice in the Suisun Marsh, Katie Smith..... 139

Attenuation of Unionid Mussel Environmental DNA in a River Environment, David Thomas 140

Analyses of Longterm Monitoring Data to Address Priority Data Gaps for Endangered Salt Marsh Harvest Mice, *Reithrodontomys raviventris*, Isa Woo..... 141

Outreach & Communication

Reducing Human Exposure to Mercury in the Sacramento-San Joaquin Delta,
Lauren Baehner and Brian Keegan 142

DTSC's Safer Consumer Products Program: Linking Data and Decisions,
Anne Cooper Doherty 143

Effective at Any Scale: Watershed-Based Decision Support Tools, Cristina Grosso 144

California EcoRestore, Erik Loboschefsky 145

Funding Science and Restoration in Bay-Delta Ecosystems: An Overview of New CDFW Grant Programs,
Hildie Spautz, Adam Ballard, and Erin Aquino-Carhart 146

Physical Processes

Seasonal Patterns in Sediment Deposition across Two San Francisco Bay Estuary Tidal Marshes,
Kevin Buffington* 147

Seasonal Variations Between Perimeter and Channel Dynamics in South San Francisco Bay,
Olivia Hoang* 148

Settling Velocities of Fine Sediments in San Francisco Estuary Margins, Jackie Ma 149

Wavy River Bed: The Sacramento River at Georgiana Slough – 2010 to 2016, Amy Zuber 150

Research Synthesis & Data Management

The Cache Creek Resources Management Plan: 20 Years of Applied, Integrated, Science for Adaptive
Management, Paul Frank 151

Text Mining of IEP Articles for Characterizing the Association of Native and Non-Native Fish Species and
Water Quality Parameters in the San Francisco Estuary, Tewdros Ghebremariam 152

Enhancing the Vision for Managing California's Environmental Information, George Isaac 153

Enhancing Regional Capacity for Habitat Project Tracking, Assessment and Reporting,
Kathryn Kynett 154

San Francisco Estuary and Watershed Science and The State of Bay-Delta Science Update, 2016,
Lauren Muscatine 155

The USGS Research Vessel Polaris Retires; We Reflect on What She Taught Us, Erica Nejad 156

Water and Sediment Quality

Reducing Dissolved Organic Carbon and Mercury Export from Subsided Delta Islands with Coagulant–
Wetland Treatment Systems, Sandra Bachand 157

Clues to Physiological Pathways in Diatoms from Stable Isotope Investigations - Influence of Irradiance and Nitrogen Source, Mine Berg 158

Sources and Transformations of Dissolved Organic Matter in the San Francisco Bay Estuary as Indicated by Biomarkers, Chia Ying Chuang 159

Predicting the Ecological Implications of Leachates from North Pacific Gyre Plastics from In Vitro and In Vivo Models, Scott Coffin* 160

Changes in DOC Concentration, Composition, and Reactivity During Passage Through Constructed Wetlands of the Central Delta: Implications for Drinking Water Quality, Angela Hansen 161

Elevated Se Concentrations in Biological Tissue Occur during Unprecedented Drought in the San Francisco Estuary, Ursula Jongebloed* 162

The Sensitivity of a Resident California Freshwater Mussel (*Anodonta oregonensis*) to Ammonia and Possible Regulatory Implications, Brant Jorgenson 163

Net Ecosystem Fluxes of Methyl Halides from a Coastal Salt Marsh with Invasive Pepperweed, Malte Julian 164

Drivers of Phytoplankton in the Sacramento River: Comparing Phytoplankton Abundance and Composition in the Presence and Absence of Treated Wastewater Effluent, Tamara Kraus 165

Spatial Patterns of Phytoplankton, Nutrients, and Cell Health From the Sacramento River to Suisun Bay: Are There Biological Hotspots?, Raphael Kudela 166

Using Multivariate Analysis to Understand the Yolo - Cache Slough Complex's Water Quality Variability, Otome Lindsey 167

South Bay Salt Ponds Restoration: Tracking Changes in Surface Water Mercury Contamination in Response to Reconnecting Tidal Flow to Historic Wetlands, Mark Marvin-DiPasquale 168

A Change in Character: Agricultural Sediments Release Compositionally Distinct Dissolved Organic Matter, Sandrine Matiasek 169

Optimizing Sampling Methods for Monitoring Pollutant Trends in San Francisco Bay Urban Stormwater, Aroon Melwani 170

Ammonium and Nitrate Sources and Patterns in the Bay Delta Using Stable Isotope Techniques, Rachel Mixon 171

Targeted and Non-Targeted Analysis of Aqueous Film Forming Foam (AFFF)-Related PFAS in a Wastewater Treatment Plant, June-Soo Park 172

Management Implications for Small Urban Reservoirs Based on a Multi-Year Study of Three East Bay Watershed-Reservoir Pairs, Laura Rademacher and Kristina Faul 173

Nutrient Budget Study of Nitrogen Related Constituents in the Sacramento River at Hood, Marcia Scavone-Tansey 174

Coagulant and Sorbent Efficacy in Removing Mercury from Surface Waters in Cache Creek, Erica Schmidt..... 175

Sediment Accretion in Constructed Wetlands of the Central Delta: Comparisons between Untreated Cells and Those Treated with Iron and Aluminum Based Coagulants, Elizabeth Stumpner..... 176

Non-targeted Analysis of Water-soluble Compounds in Ambient Bay Water and Wastewater to Identify Emerging Contaminants, Jennifer Sun 177

Record-High Observations of Water Temperature and Specific Conductance, San Francisco Bay, CA, Paul Work..... 178

Simple Mass Budget Model to Evaluate Long Term PCB Fate in the Emeryville Crescent Sub-embayment, Donald Yee 179

Marine Invasive Species in San Francisco Bay

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The Marine Invasive Species Program analyzes and inventories nonindigenous species (NIS) invasions in marine and estuarine waters of California. Through a multi-agency effort, we maintain an inventory of NIS in open coast, bays and estuaries, and monitor for new introductions and spread of existing NIS, and assess the effectiveness of ballast water controls. This poster will 1) describe the our monitoring program and results, 2) discuss NIS trends in the San Francisco Bay, and 3) highlight enhancements to our database.

Keywords: Marine, Invasive, Non-Indigenous, Species, California, San Francisco Bay, Spread

Poster Cluster: Aquatic Invasive Species Activities in California/Bay-Delta: Threats, Prevention, and New Invaders

Decreasing the Risk of Aquatic Species Invasion from Vessels Arriving at Bay-Delta Ports

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Nonindigenous species (NIS) are organisms that pose significant threats to human health, the economy, and the environment. NIS are intentionally or unintentionally transported through human activities to new habitats such as California's marine, estuarine, and freshwater environments. Once an NIS is moved, established in a new geographic location, and has impacts, it is considered an invasive species. The California State Lands Commission's Marine Invasive Species Program (MISP) strives to reduce the risk of aquatic nonindigenous species introduction into California's waters. This poster provides an overview of the structure and activities of the Marine Invasive Species Program, examines the risk vessels pose for introducing invasive species, and presents data on the MISP's efforts to reduce the risk of vessel-mediated introductions.

Keywords: Invasive, Species, Marine, Aquatic, Nonindigenous, California, prevention, risk, introductions, organism

Poster Cluster: Aquatic Invasive Species Activities in California/Bay-Delta: Threats, Prevention, and New Invaders

Invasive Watersnake Poses Threat to California Native Species

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Watersnakes of the genus *Nerodia* are native to North America east of the Rocky Mountains. Two species of watersnakes, *N. sipedon* and *N. fasciata*, have established populations in California including the Sacramento River watershed south of Sacramento, a constructed marsh in Folsom, and near Lake Natoma, a reservoir along the American River. A study identifying areas climatically suitable for *N. sipedon* and *N. fasciata* showed that large parts of western North America have habitat capable of supporting the two watersnake species and identified several species of fish, amphibians, and gartersnakes that could be at risk from their presents. For these reasons, it is important to understand the distribution, ecology, and potential for controlling populations of *N. sipedon* and *N. fasciata*. A coalition of biologists is working together to foster partnerships and build capacity to address issues surrounding the management, eradication, or control of *Nerodia* populations in western states. Group efforts included research to assess the status and ecology of *N. fasciata* and the feasibility of eradication. Results provided a better understanding of the potential impacts of *N. fasciata* in an urban habitat and sampling methods to detect incipient populations before high population densities are achieved. Environmental DNA (eDNA) provides a promising new method for the detection and monitoring of invasive species. Molecular tools may provide a cost-effective tool for detecting watersnake populations at low densities. If incipient populations are detected, intensive rapid-response efforts might allow local eradication. Research to integrate Nerodia eDNA sampling with occupancy modeling, a statistical framework that quantifies the probability of detection for a given sampling method using a repeated survey design, is near completion. This poster summarizes the current status of populations, reasons for concern, and details accomplishments and current efforts to develop future management strategies.

Keywords: Watersnakes, invasive, *Nerodia*, *sipedon*, *fasciata*, eDNA, eradication

Poster Cluster: Aquatic Invasive Species Activities in California/Bay-Delta: Threats, Prevention, and New Invaders

Invasive Watersnakes (*Nerodia spp.)* in California: Monitoring, Detections, and Eradication

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Watersnakes of the genus *Nerodia* are native to the eastern U.S., but through the pet trade and subsequent owner releases have been introduced to and established in environments far beyond their native range. *Nerodia* are highly aquatic, non-venomous snakes that primarily prey upon amphibians and fishes. In 1992, a population of *N. fasciata pictiventris* was discovered within a constructed marsh and adjacent watershed in Folsom (Sacramento County). In 2007, a population of *N. sipedon* was discovered in a freshwater wetland in Roseville (Placer County). A 2014 observation of *N. sipedon* 3.5 km north of the known *N. sipedon* population suggests the progressing drought and diminishing habitat may be driving dispersal of individuals in search of aquatic habitat and resources. The establishment and spread of *Nerodia* in California is of particular concern given their proximity to a number of special status prey species, and inherent ecological overlap with the state/federally threatened giant gartersnake (*Thamnophis gigas*). For the conservation of native species and their habitats, in 2015 the California Department of Fish and Wildlife, in collaboration with UC-Davis and the Nerodia Working Group, initiated a project to eradicate the *N. sipedon* population from Roseville. In 2016, the on-going eradication efforts were broadened to the *N. f. pictiventris* population in Folsom and survey efforts will commence at reported detection sites within the Sacramento-San Joaquin Delta. Up-to-date results and implications will be reported.

Keywords: Invasive, watersnake, gartersnake, predator, competition, pet release, conservation, amphibians, fish

Poster Cluster: Aquatic Invasive Species Activities in California/Bay-Delta: Threats, Prevention, and New Invaders

Assessing Invasiveness of Aquatic Plants to Facilitate Management in the Sacramento-San Joaquin Delta

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The California State Parks' Division of Boating and Waterways (Division) is the lead agency of the state for the purpose of cooperating with other state, local, and federal agencies in identifying, detecting, controlling, and administering programs to manage, control, and when feasible, eradicate invasive aquatic plants in the Sacramento-San Joaquin Delta (Delta), its tributaries, and the Suisun Marsh. However, until 2015, the Division was authorized to treat only 3 aquatic plant species, *Egeria densa*, *Eichhornia crassipes*, and *Limnobium laevigatum*, and each required individual legislation to do so. Recent legislative action (AB763; 2013) reformed the approach for granting the Division the authority to treat additional invasive aquatic plant species, now requiring that the California Department of Fish and Wildlife (CDFW), in consultation with partner agencies, conduct a risk assessment determining whether the aquatic plant is to be considered invasive. CDFW utilizes the U.S. Aquatic Weed Risk Assessment tool to assess the species' ecology, reproductive potential, dispersal mechanisms, competitive ability, actual and potential impacts (including impacts to navigation and recreation, the environment, economy, and human health as specified in Harbors and Navigation Code (HNC) §64.5), and resistance to management. To date, CDFW has conducted assessments of five aquatic plant species: *Potamogeton crispus*, *Myriophyllum spicatum*, *Ludwigia* spp., *Ceratophyllum demersum*, and *Cabomba caroliniana*. Each species was determined to be an invasive aquatic plant, per the definition provided in HNC, and authorized for treatment within the Delta. Assessment accuracy, questions, scores, and findings will be incorporated.

Keywords: weed risk assessment, invasive plants, aquatic weeds, herbicides

Poster Cluster: Aquatic Invasive Species Activities in California/Bay-Delta: Threats, Prevention, and New Invaders

An Overview of the Creation of Mercury Models for the Delta and Yolo Bypass: Linking Modeling and Delta Regulatory Decisions

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This poster provides an overview of the effort underway to develop a biogeochemical model of mercury (Hg) and methylmercury (MeHg) cycling for the Delta and Yolo Bypass with input from field and laboratory studies. This effort fulfills the Phase 1 Delta Mercury Control Program requirements for open waters. Regulated entities (collectively known as the open water group, led by the Department of Water Resources) must evaluate whether operational changes or other strategies could be implemented to reduce open water MeHg production. Because the hydrodynamic and environmental settings are so complex, scenario modeling of trends provides a mechanism to understand how operational activities might impact MeHg production throughout the open water channels of the Delta and the Bypass when flooded.

For the Delta, DWR's DSM2 hydrodynamic model is being updated and expanded to include Hg biogeochemistry and sediment transport modules (bed and suspended). DSM2 is a widely used model of Delta flows and water quality. In the Bypass, the Dynamic Mercury Cycling Model (D-MCM) is being used. D-MCM models Hg biogeochemical processes; hydrodynamics are being provided from TUFLOW

Field and laboratory experiments focus on filling data gaps in the Bypass needed by the D-MCM. Erosion microcosm measurements are providing estimates of sediment erodibility associated with common land uses in the Bypass. Flux experiments will provide calibration data of advective and diffusive fluxes of Hg/MeHg between sediment and overlying water. Water samples collected during flood events from the major inlets and outlets of the Bypass will provide loading and mass balance estimates. A vegetation senescence experiment is examining the role of decaying vegetation, overlain by floodwaters, on MeHg production. The loading flux of tidal wetlands is being provided by measurements of Hg/MeHg flux from several tidal wetlands. Preliminary results of modeling and data efforts are shown in posters associated with this cluster.

Keywords: Overview, Mercury, Modeling, Delta, Yolo Bypass

Poster Cluster: Creation of Mercury Models for the Delta and Yolo Bypass: Linking Modeling and Delta Regulatory Decisions

Modeling Mercury in the Yolo Bypass, a Mercury-Contaminated Floodplain

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The California Bay-Delta region is impacted by ongoing mercury contamination from historical mining. Microbial activity in downstream aquatic environments can convert the inorganic mercury supplied by legacy mining to methylmercury, the most toxic and readily bioaccumulated form of mercury. To protect human and wildlife health, the Delta Mercury Control Program was adopted for methylmercury in 2011. A mechanistic model of mercury cycling (D-MCM) is being applied to the Yolo Bypass, California to identify options to reduce methylmercury supply and meet regulatory requirements. The Yolo Bypass is a 24,000 ha floodplain used for flood control for the Sacramento River, and is a source of water to the Bay-Delta region. The Yolo Bypass is used for a variety of farming and wetland management purposes, and experiences seasonal wetting and drying cycles. These features present unique challenges for modeling rates of methylmercury supply. Model inputs are constructed from a combination of field data, site experiments, and literature. Additional posters in this section describe ongoing studies providing data for the model. Flow depths, velocities and discharges were provided by TUFLOW, a 1D/2D hydrodynamic model. Soil/sediment resuspension rates are estimated by combining hydrodynamic predictions with USGS erosion microcosm measurements of resuspension rates for a range of flow and land use conditions. Mercury loading estimates are being provided by the California Department of Water Resources (DWR). Water column and sediment/soil concentrations of total and methylmercury are being measured by DWR and the Moss Landing Marine Laboratory (MLML). Pore water mercury fluxes and the effects of vegetation senescence on methylmercury production are also being studied experimentally by MLML to provide information for modeling. Model calibration to existing conditions is ongoing. Results will be presented in the poster.

Keywords: Modeling, Methylmercury, Yolo Bypass

Poster Cluster: Creation of Mercury Models for the Delta and Yolo Bypass: Linking Modeling and Delta Regulatory Decisions

Progress on Extending a Delta Model to Include Mercury and Sediment

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A Delta mercury and sediment transport model is being developed to support decision making related to recent Delta methylmercury Total Maximum Daily Load (TMDL) requirements. Methylmercury is the form of mercury that bioaccumulates in the food web. Since mercury is a neurotoxin, eating mercury-laden fish can cause developmental and other health issues. Mercury enters the Sacramento-San Joaquin Delta from both natural sources and legacy sources from historical mining. The Department of Water Resources and consultants from Reed Harris Environmental have teamed up to extend an existing flow and water quality model, the Delta Simulation Model 2 (DSM2), to include suspended sediment, bed sediment and mercury cycling. In order to extend DSM2, the water quality module was replaced with a new General Transport Model (GTM) that is designed to include all of the current water quality parameters simulated in DSM2 and also to allow expansion for additional water quality constituents such as mercury and sediment. Available field data are being evaluated for use in model calibration, validation and application. The goal of the Delta mercury and sediment model is to examine how changes in operation and configuration of the Delta might impact the potential to methylate mercury. This poster will highlight model development and calibration, challenges, and future directions.

Keywords: Mercury, Suspended Sediment, Bed Sediment, Modeling, Delta

Poster Cluster: Creation of Mercury Models for the Delta and Yolo Bypass: Linking Modeling and Delta Regulatory Decisions

Erodibility of Yolo Bypass Sediments as a Mercury Vector

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The Yolo Bypass serves as a floodway to help protect the city of Sacramento from flooding. When not utilized for this purpose, it serves as a heavily utilized agricultural area, particularly for rice cultivation. Mercury methylation during flooding is a management concern.

Floods can yield velocities sufficient to mobilize sediments. Efforts underway to simulate the fate of mercury within the Yolo Bypass include the key process of sediment transport. Estimates of erodibility are required as input to this model.

The work shown here involved the extraction of sediment cores at 9 locations within the Yolo Bypass, spanning a variety of land uses and crops, and immediately placing the cores within an erosion microcosm. A spinning disk applies shear stress to the water above the core, and this stress is transferred to the sediment column below. With sufficiently high stresses, the sediment is eroded. The turbidity of flow through the microcosm increases and is recorded and later converted to suspended sediment concentration (SSC). The end result is a time series of shear stress and SSC as functions of time. Critical shear stress can be determined, as well as relationships between shear stress and erosion rate, and erosion rate vs. depth into the soil column. Land maintained as disked and undisked wetland was found to have slightly higher erodibility than land used for wild and white rice cultivation. Erosion functions are provided to a numerical model of mercury (Amos et al. 2016 DSC abstract).

Keywords: Sediment transport, Yolo Bypass, Mercury

Poster Cluster: Creation of Mercury Models for the Delta and Yolo Bypass: Linking Modeling and Delta Regulatory Decisions

Sediment – Water Exchange of Inorganic and Methyl Mercury in the Yolo Bypass

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Production of MeHg is generally accepted to be mediated by sulfate-reducing bacteria, hence, there are a number of environmental variables (organic carbon, sulfate, oxygen) and conditions (temperature, porosity, soil type) that could influence the net production of MeHg and its ultimate release into the water column. This study investigated sediment-water exchange of mercury species from a wide range of habitat types on the Yolo Bypass. Two methods were used to determine sediment-water exchange; first a direct assessment using incubated cores and second, modeling the sediment-water exchange from measurements of interstitial pore water concentration gradients. Results indicate habitat type and land use influence mercury fluxes from sediment in the Yolo Bypass. These results provide calibration data to the Dynamic Mercury Cycling Model (D-MCM) which will be used to improve our understanding of factors controlling production and transport of Hg and MeHg in the Yolo Bypass.

Keywords: mercury, methylmercury, wetlands, modeling, flux, Yolo Bypass, sediment

Poster Cluster: Creation of Mercury Models for the Delta and Yolo Bypass: Linking Modeling and Delta Regulatory Decisions

Methyl Mercury Production from Senescence Vegetation During Flooding in the Yolo Bypass

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To provide needed data for the Yolo Bypass Dynamic Mercury Cycling Model, a series of inter-related studies are being conducted. The objective of this study is to evaluate the flux of MeHg from plants, when inundated by floodwaters, to assess their importance to the overall mass balance of MeHg in the Yolo Bypass (YB)B.

We estimate that plant biomass associated with non-irrigated pasture in the YB could be several hundred million kgs. If inundated, this is the largest land-use in the YB that could be covered by floodwaters. However, the impacts of senescing vegetation to MeHg production is unknown. Previous field and laboratory studies by Moss Landing Marine Laboratories have documented high concentrations of MeHg (over 10 ng/L in some cases) are released when dried plant material is inundated with water. To test whether MeHg from pasture lands have the potential to contribute to the overall MeHg mass balance in the YB, a pilot study was conducted in the Yolo Bypass to determine the mass of MeHg released. Replicate, 4 inch cores were collected from dryland pasture. In the laboratory, vegetation was dried and the cores were overlain with Sacramento River water. Three of the cores were gently aerated, while 3 were not. All cores were incubated for 2 weeks. Non-aerated cores with sediment and vegetation released the most MeHg. Aerated cores with sediment and vegetation produced less MeHg than the non-aerated cores. The sediment only cores produced the lowest MeHg by far whether aerated or not. A continuous record of oxygen measurements was also taken in pasture lands in the YB during a flood in February. Depressions of oxygen occurred during the flooding events.

These results suggest that senescent vegetation may be an overlooked contributor to MeHg loads associated with flooding of the YB.

Keywords: Methyl Mercury, Vegetation, Flooding, Yolo Bypass

Poster Cluster: Creation of Mercury Models for the Delta and Yolo Bypass: Linking Modeling and Delta Regulatory Decisions

Mercury and Methylmercury Mass Balance Estimates of the Yolo Bypass during Flooding Events

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In response to regulatory requirements, consultants for the Department of Water Resources (DWR) are developing the Dynamic Mercury Cycling Model (D-MCM) to simulate methylmercury (MeHg) cycling and transport within the Yolo Bypass floodplain. Reliable total mercury (THg) and MeHg loads at the inputs and outputs of the Yolo Bypass are necessary to calibrate the D-MCM model. Foe and others (2008) quantified input and output loads for the Bypass, but they only collected whole-water samples for THg and MeHg. Understanding the amount of mercury in the particulate phase versus the amount in the dissolved phase provides greater insights into the sources of MeHg production. To fill this data gap for the D-MCM model, DWR is collecting data to quantify particulate and dissolved THg and MeHg loads at the inputs and outputs of the Yolo Bypass during times when the Bypass floods.

During the study period of 2013-2016, California has been in a historic drought, and the Yolo Bypass has flooded twice: a small flood in December 2014 and a large-scale flood in March 2016. DWR conducted one water sampling event during each of these two floods. Water samples were analyzed for filtered and total THg and MeHg, as well as for various ancillary parameters. During the December 2014 sampling event, the Bypass was a net source of THg (44.6 g/day) and MeHg (2.7 g/day). The greatest increase in total MeHg loads occurred between I-80 and Lisbon. The Bypass was a net source of THg entirely due to its particulate fraction, while it was a source of MeHg due to relatively equal contributions from the particulate and filtered phases. This suggests that the observed MeHg production was likely the result of a combination of processes, including sediment resuspension and diffusion from sediments, with some being more important than others.

Keywords: Mercury, Methylmercury, Loads, Yolo Bypass, Modeling, Water Quality, Flooding, Delta

Poster Cluster: Creation of Mercury Models for the Delta and Yolo Bypass: Linking Modeling and Delta Regulatory Decisions

Methylmercury Imports and Exports of a Freshwater Tidal Wetland in the Yolo Bypass

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Mercury and methylmercury (MeHg) are contaminants of concern in the Sacramento-San Joaquin Delta (Delta). The Department of Water Resources (DWR) is currently doing a study of four freshwater and brackish water tidal wetlands to determine total mercury (THg) and MeHg loads, in addition to loads of other relevant constituents such as total suspended solids and organic carbon. These loads will be used for two main purposes for compliance with the Delta Mercury Control Program, promulgated by the Central Valley Regional Water Quality Board; first, the loads will be used as a boundary condition for the DWR Mercury Model for the Delta and Yolo Bypass; and second the loads will be used to characterize imports and exports of THg and MeHg of tidal wetlands in the Delta and Yolo Bypass.

DWR began the study in May 2014, and completed a one-year load study of a freshwater tidal wetland in the Yolo Bypass. Staff collected samples for flood and ebb tides of 10 tidal cycles, monthly during the warm months and bimonthly during the cold months. DWR is continuing to study additional wetlands and will through 2018.

The preliminary data at the tidal wetland in the Yolo Bypass indicate that the tidal wetland was always a sink for water, and generally a sink for THg and MeHg. THg and MeHg flood and ebb concentrations were not significantly different ($p > 0.05$ for both). Filtered MeHg and dissolved organic carbon were not correlated, although total suspended solids were correlated with both particulate THg and MeHg. The dissolved THg was usually a small portion of the total THg, whereas the dissolved MeHg was a more variable fraction of the total MeHg concentration.

Keywords: Mercury, Methylmercury, Yolo Bypass, Tidal Wetlands, Sacramento San-Joaquin Delta, Loads

Poster Cluster: Creation of Mercury Models for the Delta and Yolo Bypass: Linking Modeling and Delta Regulatory Decisions

The 2015 Emergency Drought Barrier: Huge Management Action, Huge Science Opportunity

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The Emergency Drought Barrier was installed across west False River May-November of 2015 to slow the intrusion of salt into the central Delta in the face of extreme drought conditions. The placement of the barrier provided a chance to advance fundamental understanding of hydrodynamics, water quality, and ecosystem processes throughout the central Delta. In the spring of 2015, the Delta Science Program organized discussions between agency and academic scientists regarding opportunities to augment planned compliance monitoring of the barrier with targeted scientific studies. Our approach emphasizes the relationship between the proposed research and particular scientific questions, predictions, and hypotheses.

A suite of research projects spanning hydrodynamics and bathymetry, aquatic vegetation, and benthic and pelagic productivity reveal patterns of response to this large scale manipulation. Water quality targets were met while the barrier was in, so in that way the barrier functioned as intended. However the research studies revealed some surprises. Circulation within Frank's Tract did not occur as modeled, blooms of the toxic algae *Microcystis* were less intense than projected, and hydrologic changes pushed the overbite clam Potamocorbula further up the Sacramento River channel. Here we provide an overview of the suite of studies, along with a few highlights about what was learned. More details from select studies are presented in our oral session and the rest of the poster cluster, "Evaluating an Emergency Response: False River Drought Barrier Efficacy and Effects." Synthesis efforts are still underway for these projects and we welcome feedback and discussion from the larger Bay-Delta science community.

Keywords: Emergency drought barrier, intrusion of salt, Central Delta

Poster Cluster: Evaluating an Emergency Response: False River Drought Barrier Efficacy and Effects

Setting the Stage for the Science: Planning and Implementing the 2015 West False River Emergency Drought Barrier Project

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Faced with severe drought conditions not seen since the 1970s, California took extreme actions to protect the water-reliant beneficial uses of the interior Sacramento-San Joaquin River Delta. In January 2014 dry conditions and projections that 2014 would be the driest year on record prompted Governor Edmund G. Brown Jr. to declare a State of Emergency. The Department of Water Resources (DWR) evaluated barriers to limit the quantity of reservoir releases needed to control salinity intrusion into the Delta. DWR determined from modeling an optimal barrier configuration to increase Sacramento River flow into the central Delta (Sutter/Steamboat Slough barriers) and to reduce tidal excursion into the central Delta (west False River barrier). Rapid planning, permitting, stakeholder coordination, design, and petitions for modifications to water rights were necessary. Locations and designs were modified to benefit local stakeholders and listed fishes. Spring rains alleviated the need for a 2014 barrier, but conditions remained dry and reservoir storage continued to decline, prompting greater need for barrier planning in 2015. Listed fish and local landowner concerns led to numerous project reformulations and the eventual proposal to build just one barrier across west False River. Under an emergency US Army Corps of Engineers authorization, DWR began constructing the 2015 barrier on May 4, and after placing 147,300 tons of rock and driving 35,500 square feet of sheet piles the 800-foot-wide channel was closed on May 28. The barrier performed well and slowed the intrusion of salt into the central Delta with the reduced outflows allowed under the temporary urgency change to water rights conditions, yet challenges, including effects of hydrodynamic changes, continued. After over 3 months of intensive work the barrier was fully removed on November 15, the permitted removal deadline. New monitoring stations are online, study results are in, lessons were learned, and planning continues.

Keywords: drought, salinity, barrier, emergency, fishes, levees, water rights, planning

Poster Cluster: Evaluating an Emergency Response: False River Drought Barrier Efficacy and Effects

Water Quality Effects of the 2015 False River Barrier

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In 2015, the Department of Water Resources' Bay-Delta Office installed an emergency drought barrier across False River west of Franks Tract. The purpose of the False River Barrier (barrier) was to reduce the intrusion of saltwater into the central Delta during drought conditions when water storage in upstream reservoirs was insufficient to meet Delta salinity and net outflow requirements. Left unabated, continued salinity intrusion from San Francisco Bay could (1) render Delta water undrinkable, affecting roughly 25 million Californians; (2) render Delta water unusable for agriculture; and (3) decrease freshwater habitat in the Delta for sensitive aquatic species.

DWR and USGS worked collaboratively to create and maintain a monitoring network that evaluated the water quality effects of the barrier. The monitoring network used in-situ water quality sondes to record Temperature, Specific Conductance, Turbidity, and Dissolved Oxygen measurements every 15 minutes. Discrete samples were collected for laboratory analyses of chlorophyll, TSS, Cl^-/Br^-, and for total and dissolved nutrients. The data were analyzed to address several questions: (1) Did the barrier succeed at limiting salinity intrusion? (2) How did the barrier change the spatial distribution of salinity within the Delta? (3) Did the barrier have an effect on other water quality parameters?

The analysis proved the barrier was successful at limiting salt-water intrusion into the interior Delta, while allowing the flows of the San Joaquin and Sacramento Rivers to limit upstream intrusion. Other water quality parameters were not significantly affected by the barrier. The water quality monitoring network designed to evaluate the effects of the drought has allowed DWR to refine future drought mitigation efforts that conserve limited water supplies needed to provide for human health and safety, ecosystem processes, and agricultural purposes.

Keywords: Drought Barrier Salinity Monitoring chlorophyll DWR USGS

Poster Cluster: Evaluating an Emergency Response: False River Drought Barrier Efficacy and Effects

Effects on Listed Fishes from the 2015 West False River Emergency Drought Barrier Project

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The need to limit salinity intrusion into the Sacramento-San Joaquin River Delta led California's Department of Water Resources to install the West False River (WFR) Emergency Drought Barrier (EDB) from spring to fall, 2015. Fish monitoring data indicate that migrating juvenile Winter-Run Chinook Salmon had left the Delta prior to EDB construction, whereas small proportions of Spring-Run Chinook (<20%) and Steelhead (<10%) were in the Delta (juvenile Green Sturgeon are potentially present year-round). Assessment of the proportion of Delta Smelt near the EDB is challenging because of the species' current low abundance, with the greatest density apparently in the north Delta and a small proportion likely to have been blocked from exiting the south Delta by the EDB. Vibratory pile driving for abutment sheet/king piles limited noise effects. Sediment disturbance during rock placement increased turbidity, but only near the EDB; following barrier closure, turbidity greatly increased in nearby channels in which velocity increased, whereas low flow decreased turbidity in WFR. These differences in turbidity could have affected Delta Smelt habitat suitability. SCHISM hydrodynamic modeling suggested very high flows occurred through the notch in the middle of the EDB before full closure and formed a number of eddies in WFR which could have increased short-term predation susceptibility. High-resolution measurements indicate that over 95% of tidal flow in WFR was blocked by the EDB which, although creating an impingement risk on EDB barrier rocks for larval/juvenile Delta Smelt already in the channel, would have limited additional entrainment into WFR. Leaving the abutments in place for future EDB installations could have created additional low-velocity, eddy habitat (data from SCHISM modeling), but subsequent investigations found that the abutments are no longer necessary. The assessment of EDB effects provides valuable data to aid decisions made regarding future implementations of Delta barriers, should these be necessary.

Keywords: drought; emergency; salinity; False River; barrier; Chinook; Delta Smelt; turbidity

Poster Cluster: Evaluating an Emergency Response: False River Drought Barrier Efficacy and Effects

Headwater Mercury Source Reduction Strategy in the Sierra Nevada

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The State of California's longest neglected environmental problem is mercury contamination from the Gold Rush. The largest contributor to the Bay Delta mercury load is the tributaries in the Sierra Nevada and in the Coast range. Mercury contaminated sediment from legacy gold mines in the Sierra continues to be a source of inorganic mercury (Hg) to the environment. Watershed-wide management decisions need to be informed by an understanding of mercury fate and transport that begins with accurate data for headwater legacy mine sources. Remediation strategies for hydraulic mines often includes the retention of contaminated sediment on site, creating or enlarging a pond, and the extent to which these ponds become areas where mercury can methylate is largely unknown. Mining and mercury use was extensive in the Yuba, Bear and American River watersheds and mercury contamination in these watersheds is pervasive. Fish mercury concentrations in the reservoirs of these watersheds reflect the long-lasting effects of mercury pollution as well as the imminent threat to public health through sport fish consumption. Remediation of contaminated sediment accumulated behind reservoirs using innovative technology may reduce the fish mercury levels in sport fish. Baseline data of fish mercury concentrations in reservoirs before and after remediation of contaminated sediment is critical to measuring success. The Headwater Mercury Source Reduction Strategy is informed by data from these efforts. Future work includes the inventory of the mercury sources in the Yuba and Bear River Watersheds on the Tahoe and Plumas National Forests, the evaluation of these sources in order to prioritize them for remediation, and standardizing methods for their assessment and remediation. The Strategy will be incorporated into the updated Forest Plan, institutionalizing this project into future land management decisions that address legacy mercury contamination in the State of California.

Keywords: Mercury, Headwaters, Source, Fish, Sediment, Mines, Risk, Baseline, Strategy, Remediation

Poster Cluster: Headwater Mercury Source Reduction Strategies

Sediment and Mercury Loads to Humbug Creek: A Sierra Nevada Tributary Impacted by the Malakoff Diggins Hydraulic Mine

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The largest contributor to the Bay-Delta mercury load is the tributaries in the Sierra Nevada and in the Coast range. Mercury contaminated sediment from legacy gold mines in the Sierra continues to be a source of inorganic mercury (Hg) to the environment. The discharge from Malakoff Diggins, once one of the largest hydraulic mines in California, is a source of Hg and sediment to Humbug Creek. The purpose of this study was to estimate the load of particulate bound Hg and suspended sediment in Humbug Creek for Water Years 2012 and 2013. Grab samples were taken from baseflow and multiple storm events and analyzed for nonfiltered Hg (total), filtered Hg (dissolved) and total suspended sediment (TSS). A stage discharge relationship was developed for the Humbug Creek gage station over a range of flow conditions. Samples were collected from Humbug Creek upstream of the Malakoff Diggins discharge point, from the discharge point and downstream of the discharge and Humbug Creek confluence at a stream gage. The annual load in Humbug Creek for suspended sediment and particulate bound Hg was calculated at the gage using relationships established with continuously monitored turbidity (15 min data) and grab samples of total suspended sediment ($n = 25$, $R^2 = 0.82$) and particulate bound Hg ($n = 15$, $R^2 = 0.80$). The annual load was 100-120 grams of particulate bound Hg and 475,000-575,000 kg of suspended sediment. For both water years, as much as half of the annual sediment load was from a single storm event during which 3-4g of particulate bound mercury was released per day. The contribution of mercury loads from legacy hydraulic gold mines should be quantified as it is a critical source control strategy to the Bay-Delta Mercury TMDL.

Keywords: Mercury, Headwaters, Source, Sediment, Mines, Load, Discharge, Baseline, Strategy, Particulate, Turbidity

Poster Cluster: Headwater Mercury Source Reduction Strategies

Mercury in Fish of the American and Bear Watershed Reservoirs: Baseline Conditions and Exposure Risk at Lake Clementine and Rollins Reservoir, CA

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The largest contributor to the Bay-Delta mercury load is the tributaries in the Sierra Nevada and in the Coast range. The primary pathway of human exposure to mercury is the consumption of contaminated fish. Identification of patterns of fish tissue mercury levels are a key mechanism for understanding risk drivers and human exposure potential. Site-specific fish tissue data aid the Office of Environmental Health Hazard Assessment (OEHHA) in the development of consumption advisories and establish baseline conditions to evaluate headwater mercury source reduction strategies at legacy gold mines. This research consists of Year 1 of a three year project to collect fish data from six reservoirs downstream of historic hydraulic mines in the Cosumnes, American, Bear, Yuba watershed region. Angler survey data informed sampling to ensure that commonly caught and consumed species were harvested from Lake Clementine and Rollins Reservoir. A total of 72 samples from four species groups were collected in 2015. Geometric mean THg (ppm, wet weight) were highest for black bass at both Lake Clementine (n = 8, THg = 0.41) and Rollins Reservoir (n = 26, THg = 0.60), with a significant positive relationship between fish total length and THg at both water bodies (rho = 0.85, $p<0.05$; rho = 0.85, $p<0.01$). Sunfish data for both reservoirs were lower in THg than black bass (n = 29, THg= 0.16; n = 24; THg = 0.20), with a significant positive relationship between fish total length and THg at Lake Clementine (rho = 0.83, $p<0.01$). These data allow OEHHA to develop warranted site-specific fish consumption advice at both locations and can be used as a metric to determine if actions to address inorganic mercury (Hg) sources at legacy gold mines result in reduced human exposure risk at downstream waterbodies.

Keywords: Mercury, Headwaters, Source, Fish, Exposure, Mines, Risk, Health, Baseline, Strategy

Poster Cluster: Headwater Mercury Source Reduction Strategies

Metal-Based Coagulant Effect on Dredged Sediment Slurry for Lake Combie Reservoir Sediment and Mercury Removal Project, Grass Valley CA

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The largest contributor to the Bay-Delta mercury load is the tributaries in the Sierra Nevada and in the Coast range. Removal and treatment of mercury contaminated sediment from behind reservoirs may be an effective control strategy to limit the downstream transport of mercury. This study was conducted to assist the Nevada Irrigation District (NID) with the analysis of the sediment and mercury removal and treatment process at Lake Combie Reservoir. Sediment removal from the reservoir creates a turbid slurry that was tested and treated before water was returned to the reservoir. Bench scale jar tests were conducted using varying concentrations of coagulants to determine an effective dose for field scale tests. Field scale tests were conducted using batch material from the reservoir and monitored at multiple treatment steps until the treated water was adequate for release. Treated slurry water was tested for turbidity and metals concentrations, including Mercury (Hg), Chromium (Cr), Iron (Fe), Molybdenum (Mo), Nickel (Ni), and Zinc (Zn). This study presents a method for continuous in-situ prediction of total mercury (THg) and dissolved mercury (DHg) concentrations using in-situ measureable parameters as proxies for mercury in the treatment process. These parameters (TSS, TDS, and UV_{254}) were selected using a step wise multivariate regression model with p-values <0.0001 and R^2 values equal to 0.85 and 0.97 for the prediction of DHg and THg, respectively. Removal and treatment of sediment from contaminated reservoirs will remove an environmental toxin, mercury, from the aquatic environment and improve reservoir trapping efficiency and water storage space, creating a multiple benefits solution to a legacy contamination problem that has both local and regional effects.

Keywords: Mercury, Source, Headwaters, Reservoirs, Mines, Coagulant, Treatment, Storage, Removal, Transport

Poster Cluster: Headwater Mercury Source Reduction Strategies

Shallow Subsurface Groundwater Quality and Flow Paths in the Malakoff Diggins Hydraulic Pit

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Remediation of hydraulic mines with contaminated discharge often involves creating or enlarging a pit pond. Characterization of the shallow groundwater environment is critical baseline data prior to remediation because methylation of mercury is more efficient in environments with low dissolved oxygen, high organic matter and sulfate and iron reducing bacteria. This study aims to characterize the shallow groundwater environment in the Pit at Malakoff Diggins, once the State's largest hydraulic mine site, and to determine its contribution to Hiller Tunnel, a point source of contaminated surface water discharge. Constituents including dissolved oxygen (DO), pH, temperature, electrical conductivity (EC), and oxidation reduction potential (ORP) were measured in eight piezometers bi-weekly starting in November 2015. Water quality in Hiller Tunnel was measured bi-weekly starting in April 2016. Preliminary data indicates that DO varied spatially and temporally while EC varied spatially. Groundwater in piezometers at the edge of the pit near where surface water enters the Pit had higher concentrations of DO (1.82 – 3.81 mg/L) and EC (0.893 – 1.667 mS/cm) compared to groundwater distal to the surface water sources. pH was neutral to slightly acidic on average at all locations (6.18 – 7.15). High DO may be attributed to freshly mixed runoff percolating into the subsurface. ORP may be related to the proximity to surface water inflow. Piezometers further from the surface water inflow had reducing conditions (0 – -141.5 ORP), which is consistent with lower DO (0.13 – 1.43 mg/L) at these locations. Future work will include determination of dissolved organic carbon and metals concentrations (mercury, methylmercury, copper, lead, nickel, and zinc) in the shallow groundwater of the Pit. This information is pertinent to Bay- Delta management because Malakoff Diggins is a known source of sediment and mercury contamination to the South Yuba River, a tributary to the Bay-Delta system.

Keywords: Mercury, Headwaters, Source, Sediment, Mines, Methylation, Groundwater, Remediation, Water Quality

Poster Cluster: Headwater Mercury Source Reduction Strategies

Assessing the Role of Sediment Supply in Mudflat Width at Decadal and Seasonal Time Scales

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Mudflats provide valuable habitat for unique ecosystems such as benthic algae and critical feeding area for migratory bird species. Together with adjacent salt marshes they form a natural defense against wave attack by attenuating waves. In this study, we explore the relationship between sediment supply and mudflat width for the mudflat just south of Dumbarton Bridge in South San Francisco Bay. The width of the mudflat has changed at decadal and seasonal time scales, as documented by repetitive bathymetry surveys. From 1858 to 1931, the mudflat narrowed approximately 200 m. From 1931 to 2005 it widened to a point where it was wider than it was in 1858. The decadal change in mudflat width is correlated with overall sediment losses and gains in the South Bay. Mudflat width appears to respond to suspended sediment load on seasonal time scales as well. In 2010, the cross-sectional averaged suspended sediment concentrations (SSC) at Dumbarton Bridge were two times greater in spring-summer than in the winter (Shellenbarger et al., 2013). The mudflat widened in the spring-summer when SSC was higher and was relatively stable in winter when SSC was lower.

These observations suggest that sediment supply is a controlling factor in mudflat width. We explore this hypothesis using a simple 1D model (Delft3D) forced by tides, waves, and suspended sediment concentration. We report model predictions of mudflat width for simulations with varying suspended sediment concentrations while holding tide and wave forcing constant. In the face of rising sea levels and overall trends of decreasing sediment supply in the San Francisco Estuary, understanding the role of sediment supply on mudflat width may aid in resource management decisions.

Shellenbarger, Wright, and Schoellhamer, 2013, 10.1016/j.margeo.2013.05.007

Keywords: mudflats, sediment transport, interferometric swath bathymetry surveys, sediment exchange

Poster Cluster: Linking Sediment Dynamics to Long-Term Management Decisions

Climatology of Salinity and Suspended Particulate Matter in San Francisco Bay

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Salinity and suspended particulate matter (SPM) data are documented in a unique 48-year US Geological Survey program monitoring environmental variables in San Francisco Bay. This program started in 1968 and continues to the present. This monitoring program comprises longitudinal surveys of the bay, conducted about once per month. Vertical profiles of salinity and SPM are collected at 36 sampling locations, from the Sacramento River Delta to the southern limit of South Bay. This data set is a valuable source of information, unparalleled in any other estuarine system, and can provide the climatology of spatial variability of salinity and SPM throughout the bay. However, the sampling methodology aimed to provide mainly a spatial distribution of the variables and did not account for tidal variability, which is important in tidal systems like the bay. The longitudinal profile extends for 170 km and a complete survey can take at least 2 days. Additionally, not all stations were sampled in every survey, and many surveys were only carried out in the South Bay. We will discuss the potential bias introduced through tidal variability, along with a method to minimize such biases. With the tidal-bias minimized, the long-term and monthly climatology will be investigated. In particular, we will search for correlations between salinity and SPM with river discharge at the Delta and wind, which are the main forcings of non-tidal variability in the bay.

Keywords: data analysis, hydrology, transport processes

Poster Cluster: Linking Sediment Dynamics to Long-Term Management Decisions

Sediment Flux Measurements at the Golden Gate: Progress toward Closing the Sediment Budget for San Francisco Bay

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Sediment is an important resource for San Francisco Bay (SFB), in the context of restoration projects, dredging operations, ecosystem health, and contaminant transport and fate. One way to help manage sediment (and sediment-associated contaminants) in SFB is by developing a sediment budget to account for sources, sinks, and storage of sediment. Previously developed sediment budgets have shown sediment exchange at the oceanic boundary of SFB (Golden Gate) is the most poorly understood element of the SFB sediment budget, owing to logistical challenges that inhibit routine field observations. In this study, field observations of suspended-sediment flux at the Golden Gate were conducted on outgoing (ebb) and incoming (flood) waters during two distinct periods of the WY2016 hydrograph: peak (4000 m^3/s) and low (200 m^3/s) rates of freshwater inflow to SFB. Suspended-sediment flux was estimated from a boat-mounted acoustic Doppler current profiler which provided measurements of discharge and acoustic backscatter (ABS) at a cross-section near the oceanic boundary. Discrete water samples collected *in situ* were analyzed for suspended-sediment concentration (SSC) and related to ABS. During the period of peak freshwater inflow, maximum discharge observed at Golden Gate reached 130,000 m^3/s during ebb tide; observed SSC (20-40 mg/L) were lower than expected compared to upstream conditions. A network of five SSC monitoring stations extending 5-80 km upstream demonstrated a watershed-sourced sediment pulse (SSC reaching 200 mg/L) moved downstream to San Pablo Bay, an observation corroborated by concurrent satellite imagery. This observation, combined with lower SSC toward the Golden Gate, suggests the sediment pulse was trapped within SFB, indicating a freshwater inflow threshold exceeding 4000 m^3/s for sediment export at the oceanic boundary. Previous research proposed a lower threshold (3000 m^3/s); one explanation for this discrepancy is the decreased sediment yield from the watershed since the 19th century, requiring greater flows to export sediment.

Keywords: sediment, SSC, dynamics, flux, sediment budget, supply,

Poster Cluster: Linking Sediment Dynamics to Long-Term Management Decisions

Primary Sediment Supply, Pathways and Transport Mechanisms to the Central Sacramento-San Joaquin Delta

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Changes to the Sacramento-San Joaquin Delta began in the late 1800s and numerous changes have occurred including aquatic species population declines and changes to water management. One species of concern is the endangered Delta smelt which requires a turbid environment for feeding, migratory cues, and to avoid predation. When turbid water enters the Central Delta it is a favorable environment for Delta Smelt. These conditions coincide with increased smelt observations at the pump facilities in the South Delta which results in mortality. Furthermore, efforts to restore significant aquatic habitat throughout the Delta are in progress, but water management and landscape-scale restoration activities require an understanding of the hydrology, sediment quantity, and transport mechanisms. Cooperatively, the USGS and DWR have an extensive network of flow stations throughout the Delta where we also monitor turbidity. Turbidity is used as a surrogate to compute suspended-sediment concentrations and sediment fluxes are computed from the product of cross-sectionally averaged suspended-sediment concentrations and flow. The primary source of sediment to the Delta is the Sacramento River which delivers pulses of sediment during the winter and early spring. From our network of stations, we analyze the primary pathway of sediment from the Sacramento River to the Central Delta and describe travel times and mechanisms that lead to increased turbidity in the south Central Delta. We found the sediment concentrations in Georgiana Slough to be correlated to concentrations from Sacramento River at Freeport. Approximately 96% of the sediment transport down Georgiana Slough is advected into the interior Delta towards the large pump facilities. This has important implications for native fish and water management alike. We detail transport times of peak sediment concentrations during the first flush, present sediment flux analysis, and describe the sediment transport mechanisms once this sediment source reaches the Central Delta.

Keywords: sediment, turbidity, Central Delta, Georgiana Slough,

Poster Cluster: Linking Sediment Dynamics to Long-Term Management Decisions

Wave Attenuation across China Camp Tidal Marsh

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As the potential for nature-based coastal protection becomes more widely recognized, it is critical to understand how and to what extent tidal marshes attenuate wave action. Here we study wave attenuation across the edge of the salt marsh at China Camp State Park in San Pablo Bay. A field campaign was carried out during seasonally high ("king") tides in December 2014 and January 2015 and was then repeated during high tides in June 2016. High-frequency pressure sensors and optical turbidity sensors were deployed at eight stations along a 150 m cross-shore transect; the transect started on the mudflat 50 m outside the edge of vegetation, ran through the cordgrass-dominated zone (*Spartina foliosa*), and ended in the pickleweed-dominated zone (*Salicornia pacifica*). Using the winter and spring deployments, we compare the seasonal variation driven by the differing weather regimes, wave climates, and vegetation characteristics. Wave statistics were calculated from high-frequency pressure data, and wave attenuation was modeled as an exponential decay. Under winter conditions, the decay coefficients were an order of magnitude greater in the vegetated marsh than over the mudflat. Waves were completely attenuated 78 m into the vegetation. The reduction in wave energy also allows sediments to drop out of suspension and settle onto the marsh platform, where they contribute to vertical accretion and marsh sustainability. By quantifying wave attenuation under a range of conditions, the results from this study will inform designs for coastal hazard mitigation and efforts to restore and protect this vital habitat.

Keywords: wave attenuation, tidal marsh, sediment transport, nature-based coastal protection

Poster Cluster: Linking Sediment Dynamics to Long-Term Management Decisions

Invasive Plant *Arundo donax*: Mapping and Prioritizing Its Eradication in the Sacramento-San Joaquin Delta Region of Northern California

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It is generally accepted by the invasive plant control community that there is not enough funding to eradicate all problem weeds, and the work of invasive species control must be strategically focused. For many years Team Arundo del Norte and the Sonoma Ecology Center have been working on the control of riparian invader *Arundo donax* (giant reed). With funding from the Sacramento-San Joaquin Delta Conservancy, the Sonoma Ecology Center has mapped the distribution of *Arundo* within the boundary of the Legal Delta and developed eradication priorities based on the value of the threatened habitat. To determine eradication priorities, habitat suitability data for a suite of representative riparian species were assigned threat indices to derive a multi-species conservation value index. At a given location, this index suggests the eradication priority for known occurrences of *Arundo*. The resulting *Arundo* eradication priority map will be used by the Delta Conservancy to guide eradication efforts and the riparian habitat valuation map could be used with occurrence data for other riparian weed species.

Funded by - Sacramento-San Joaquin Delta Conservancy Arundo Control and Restoration Program

Keywords: *Arundo*, eradication priorities, riparian

Poster Cluster: Mapping the Invasive Plant *Arundo donax* and Prioritizing It for Eradication in the Legal Delta

Index-Based Multispecies Conservation Value (IMCV) Model for Prioritizing Invasive Weed Eradication

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The IMCV metric is a measure of habitat value and can suggest a priority for eradicating invasive species threats to that habitat. It is derived from habitat suitability rankings for a suite of selected species. These rankings are weighted by threatened or endangered listing status to give greater weight to listed species. For this project, the weighting is derived by merging federal and state listings. Species were chosen to represent the range of biota and habitat important for protection. Delta specific as well as threatened and endangered species were selected with the help of biologists at CDFW, CDWR, Delta Conservancy and Sonoma Ecology Center. 23 species from 7 taxa were considered for the IMCV. This poster shows the combined species input layers for 7 taxa and the final combined IMCV habitat ranking map for the Sacramento – San Joaquin Delta region.

Funded by - Sacramento-San Joaquin Delta Conservancy Arundo Control and Restoration Program

Keywords: IMCV, habitat value, invasive species

Poster Cluster: Mapping the Invasive Plant *Arundo donax* and Prioritizing It for Eradication in the Legal Delta

Microcystis Drought Response Program Collaborative Research Summary

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Cyanobacteria blooms are often toxic and affect the health and survival of aquatic species in the San Francisco Estuary and are expected to increase with the increased frequency and intensity of droughts associated with climate change in California. The 2014 and 2015 droughts provided an opportunity to test the hypothesis that the amplitude and toxicity of *Microcystis* blooms will increase with successive years of drought. As a part of the California Drought Response Program, a suite of studies were conducted in 2014 and 2015 to characterize the blooms, determine causal factors and identify biological community impacts. This poster summarizes the collaborative field and laboratory research conducted by researchers at the California Department of Water Resources, University of California at Davis, San Francisco State University, California Maritime Academy and the University of Georgia. Research included quantifying the magnitude, toxin concentration, growth rate, nitrogen sources, fish toxicity, and biological community impacts of the *Microcystis* blooms in 2014 and 2015.

Keywords: Cyanobacteria, *Microcystis*, toxin concentration, nitrogen sources, biological community impacts

Poster Cluster: *Microcystis* Drought Response Program Collaborative Research

Sampling and Analyses Conducted for the 2014 and 2015 *Microcystis* Drought Response Program

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The severe drought in 2014 and 2015 provided favorable conditions for blooms of the toxic cyanobacteria harmful algal bloom (CHAB) species, *Microcystis aeruginosa*. As part of the *Microcystis* Drought Response Program, a study was conducted semi-monthly from July to December in 2014 and August to November in 2015 at ten stations located in the central and south delta of the San Francisco Estuary. The objective of the study was to measure the impact of drought conditions on the toxin production and abundance of *Microcystis,* as well as physical, chemical and biological conditions in the Delta ecosystem. *Microcystis* and zooplankton mass were collected with net tows, and the samples were identified and enumerated using a Flowcam, a digital imaging flow cytometer. Physical and chemical properties of the surface water were measured at each station using a YSI water quality sonde, and subsurface irradiance was measured with a LiCOR quantum sensor. Surface water samples were also collected for nutrient and suspended solids concentration, cyanobacteria toxins, DNA, and isotope analyses. The study is significant as water quality conditions and the phytoplankton communities in the Delta are likely to be impacted by more frequent and severe drought conditions.

Keywords: *microcystis*, drought, toxin, cyanobacteria bloom

Poster Cluster: *Microcystis* Drought Response Program Collaborative Research

The Impact of Successive Drought Years on *Microcystis* Blooms in San Francisco Estuary

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Future climate change is expected to increase the frequency and intensity of drought in California and associated toxic cyanobacteria blooms in San Francisco Estuary. The droughts in 2014 and 2015 were the third and fourth most severe drought years in the history of San Francisco Estuary, and provided the opportunity to test the hypothesis that successive drought years create environmental conditions that promote larger and more toxic *Microcystis* blooms in the estuary, than a single drought year alone. Field samples were collected at 10 stations every other week during the bloom season in 2014 and 2015. Physical, chemical and biological factors were measured using a combination of YSI sonde and laboratory analyses of water samples for toxin, chlorophyll *a*, nutrient, phytoplankton taxa and suspended sediment concentration. *Microcystis* colony biomass on the surface of the water column was measured by surface net tow and their growth rate was measured by carbon uptake. Nitrogen sources were determined using stable isotope concentration and diffusion studies. Contrary to expectations, the more severe drought in 2015 was not associated with a larger *Microcystis* bloom than in 2014. Median chlorophyll *a* concentration for all stations was three times greater in August and September in 2014 than 2015. Most physical and chemical conditions and processes in the water column were similar in 2014 and 2015, including the presence of excess nutrients and use of ammonium as the primary nitrogen source. The difference in bloom magnitude between years was most closely associated with changes in the seasonal variation in streamflow and water temperature. Elevated water temperature extended the duration of the bloom into December in 2014, but only into October in 2015. Relatively high primary producer growth rate, in combination with low inflow and agricultural export, also enhanced the accumulation of bloom biomass more in 2014 than 2015.

Keywords: cyanobacteria, *Microcystis,* drought, climate change, blooms

Poster Cluster: *Microcystis* Drought Response Program Collaborative Research

Rates of Primary Production for the 2015 *Microcystis* Bloom in the San Francisco Estuary

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The goal of the 2015 *Microcystis* Drought Response Program was to assess the amplitude, duration and toxicity of Delta *Microcystis* blooms as well as gain insight into potential impacts of *Microcystis* on water quality associated with multi-year drought conditions. As part of this study, we measured primary production twice monthly from August to November at 10 stations throughout the Delta, where *Microcystis* has historically been abundant. Water quality parameters including light attenuation were measured at all stations. Near-surface water samples were inoculated with ^{14}C labeled bicarbonate and incubated for 24 hours at four light levels (50, 25, 10 or 5% of surface irradiance). Primary production (PP) rates were calculated as 1) light saturated (i.e., PP at 50% of surface irradiance), 2) biomass-specific (i.e., normalized to chlorophyll-a) and 3) depth–integrated through the photic zone. Depth-integrated PP was highest at stations located in the southeastern Delta (Rough and Ready Island, Old River, Mildred Island, San Joaquin River, Victoria Canal) compared to stations in the western Delta (Antioch, Browns Island, Collinsville, Franks Tract and Jersey Point). The difference likely reflects more favorable irradiance conditions that were found in the southeastern Delta. Light-saturated and biomass-specific PP were also generally higher in the southeastern stations and may too reflect adaptations to higher light conditions or differences in species composition. Taken together, these results suggest that differences in algal carbon physiology influence patterns in algal biomass during drought conditions. The rates presented will help inform future drought management.

Keywords: *Microcystis*, Primary Production, Drought, Water Quality,

Poster Cluster: *Microcystis* Drought Response Program Collaborative Research

Abundance of Key Cyanobacteria Species and Cyanotoxin Concentrations during Severe Drought Years, 2014 and 2015

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Cyanobacteria, also known as blue-green algae, are photosynthetic aquatic microorganisms of major public health concern due to the deterioration of water quality through the production of toxic and odorous chemicals. Various cyanobacterial species flourish in warm water, therefore elevated water temperature due to drought could provide favorable conditions for *Microcystis* and other harmful cyanobacterial species to thrive. Despite the deleterious effects of cyanobacterial harmful algal blooms (CyanoHABs) on human and aquatic environments, field data are still limited and little is known about how drought conditions may alter cyanobacterial species assemblages and their abundances in the Sacramento-San Joaquin Delta. To better understand the effect of drought conditions to CyanoHABs in the Delta, we measured the abundance of three cyanobacterial species (*Microcystis*, *Aphanizomenon* and *Anabaena*) by qPCR and their associated cyanotoxin concentrations using enzymatic and immunological assays in the summers of 2014 and 2015, record severe drought years. Our results indicate that the abundance of cyanobacteria, particularly *Microcystis aeruginosa*, was extremely high in the summer of 2014. Interestingly, the abundance of total cyanobacteria, including *M. aeruginosa,* was significantly lower in 2015 compared to 2014 even though the basic water quality parameters, including water temperature, were generally similar in both years. Other potential cause(s) contributing to the differences in the cyanobacteria species abundance between 2014 and 2015 will be discussed.

Keywords: Drought, Cyanobacteria, Abundance, qPCR, Cyanotoxin

Poster Cluster: *Microcystis* Drought Response Program Collaborative Research

2014 and 2015 Critical Drought Effects on Zooplankton Composition during *Microcystis* Blooms

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In 2014 and 2015 California experienced two of the driest years on record, resulting in increased residence times and water temperatures in the San Francisco Estuary. Such conditions are favorable for cyanobacterial harmful algal blooms (CHAB), including *Microcystis aeruginosa*, a known toxic cyanobacteria. A drought response study investigated the distribution, abundance, genetic composition, toxin production and food web impact of *Microcystis* spp. in the San Francisco Estuary. The goal of this study was to compare the abundance and distribution of key zooplankton taxa as it relates to *Microcystis* spp. blooms during the critical drought years of 2014 and 2015. *Microcystis* spp., zooplankton, water quality, and ambient water samples were collected biweekly from ten stations in the San Francisco Estuary from July to December in 2014 and August through November in 2015. Zooplankton samples were preserved in 70% ethanol and were identified by taxa and enumerated for biomass using a FlowCAM digital imaging flow cytometer. For both drought years, copepod and cladoceran species were the most abundant zooplankton during the CHAB. Sites along the inner delta yielded the highest biomass and diversity of zooplankton. As an effect of global climate change, the frequency and intensity of drought is expected to increase in California. The findings are significant because prolonged droughts are likely to change water quality conditions, increase CHABs, and ultimately cause adverse impacts on the Sacramento-San Joaquin aquatic food web.

Keywords: Drought, Zooplankton, *Microcystis*, Harmful Algal Blooms, Food Web

Poster Cluster: *Microcystis* Drought Response Program Collaborative Research

Characterizing Biodiversity and Relative Abundance of Cyanobacteria by Shotgun Metagenomic Sequencing Analysis

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Harmful cyanobacteria blooms are ubiquitous around the world and are of global concern due to their ability to produce toxins, which are known to cause cancers in wildlife and humans. Drought conditions and overall global temperature increases provide favorable growing conditions for toxic cyanobacteria, causing these blooms to become more frequent and intense. However, little is known about the biodiversity of cyanobacteria assemblages and their toxicity in drought conditions in aquatic ecosystems. To address this gap in knowledge, we evaluated the biodiversity of cyanobacteria as well as other microscopic organisms in the Sacramento-San Joaquin Delta by shotgun metagenomic sequencing analysis. Data from this analysis detected over 30 genera of cyanobacteria, *Microcystis* spp. being the most dominant genus. This data also demonstrated the first appearance of *Anabaena circinalis*, a possible neurotoxin producer, in the San Joaquin River in 2014 a year of serious drought. A characteristic geographical pattern was observed amongst the sampling sites; *Microcystis* and other cyanobacteria were dominant at the three sampling stations in the confluence (Antioch and Collinsville) and Franks Tract while bacteria accounted for over 50% at Mildred Island and San Joaquin River. Interestingly, the highest percentage of phytoplankton and zooplankton was observed at Rough 'n Ready, suggesting the site is more productive than the other locations. Our results indicate that shotgun metagenomic sequencing analysis is a powerful tool to understand biodiversity and relative abundances of wide range of aquatic organisms.

Keywords: Cyanobacteria, Bacteria, Biodiversity, Abundance, Functional Analysis, Metagenomics

Poster Cluster: *Microcystis* Drought Response Program Collaborative Research

Water Quality in the Delta and Chinook Salmon: A Hot Issue with Murky Consequences

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Understanding for relationships between water quality and Pacific salmon smolt predation is limited. In our study, we addressed the hypothesis that poor water quality will decrease a salmon smolt's swimming performance, and presumably its predator evasion capabilities. Predation is a major factor affecting salmon smolt survival throughout California's San Joaquin River and Delta. Acoustic telemetry, predator stomach content analysis, and baited predation event recorder studies have quantified predation rates, but the effect of water quality on predator evasion capability has not previously been evaluated. We quantified the swimming performance of juvenile Chinook salmon, *Oncorhynchus tshawytscha,* in relation to water quality parameters. We measured maximum swim speed (U_{max}) for hatchery-reared Chinook salmon smolts in both a controlled and field environment using a mobile swim tunnel respirometer. U_{max} was measured for fish before and after a two-day exposure within the lower San Joaquin River (California, USA) while being held in flow-through cages. In order to sample across a diversity of environmental conditions, we conducted trials during a six-week period that coincided with the peak smolt outmigration. We constructed regression models to evaluate relationships between swimming performance and several water quality metrics. We found a negative relationship between maximum swim speed and temperature and turbidity, respectively, and described these relationships graphically. Our findings suggest that opportunities for water quality management that may improve salmon smolt survival include managing temperatures and suspended sediment concentrations to optimize the swimming capacity of migrating smolts. These management actions may also improve a migrating smolt's ability to evade predators.

Keywords: Chinook salmon, water quality, temperature, swim performance, aerobic scope

Poster Cluster: Non-Native Predator Fish Research in the Sacramento-San Joaquin Delta

Seasonal Movements and Distribution of Central Valley Striped Bass (*Morone saxatilis*)

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Striped bass (*Morone saxatilis*) are highly mobile and thus have the potential to both be impacted by various environmental and human stressors, and impact widespread native prey fish populations via predation. Unfortunately, very little is known about the movement or migration patterns of one major population on the west coast, except that they are also highly mobile and widely distributed. However, abundant research on east coast populations indicates striped bass movements can be deliberate and dynamic, leading to distinct life history strategies. The goal of this project is to quantitatively summarize Central Valley striped bass seasonal movements and look within general patterns for groups exhibiting unique behaviors. In spring 2011-2013, we acoustically tagged 81 striped bass (220-625 mm fork length) on the Sacramento River at Freeport and downtown Sacramento. Acoustic receivers span from San Francisco Bay to China Rapids near Red Bluff, CA. We quantified residence times within regions (San Francisco Bay, Suisun Bay, Delta, and Sacramento River), number of movements between regions, and maximum distance traveled for individual striped bass. To examine general movement patterns, these data were summarized by season, year, and size/maturity. To investigate potential distinct life history strategies, we used a cluster analysis on these metrics. Preliminary results found seasonal differences in striped bass distribution: spring showed the most upstream distribution into the Sacramento River, while summer and fall had widespread distribution from the bays to the delta, and winter showed a restricted distribution primarily in the delta. Understanding movement patterns of this important Bay-Delta species will likely have implications on life history, adaptability, and food-web effects. Furthermore, evidence of diversity in behaviors within a population may provide substance for resilience in the face of changing environmental conditions (e.g. drought, climate change, human habitat alteration), or conversely, lack thereof may explain recent declines in the population.

Keywords: striped bass, movement, telemetry, Sacramento

Poster Cluster: Non-Native Predator Fish Research in the Sacramento-San Joaquin Delta

Examining the Spatial and Temporal Distribution of Striped Bass within the Delta in Wet vs. Dry Years

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Understanding the distribution of mobile predators is critical for recognizing the potential impact of predation on threatened and endangered species. According to foraging theory, mobile fish such as striped bass select habitat that will maximize their fitness through overlap with prey and optimal temperature. Habitat is heterogeneously distributed throughout space and time, and drought can significantly alter fish habitat distribution through increases in temperature and shifting salinity gradients. Some research suggests that striped bass spend more time in freshwater during low-flow, which may also interact with temperature to influence distribution. To investigate how the distribution of striped bass may be influenced by drought conditions we are synthesizing existing datasets and incorporating new microchemistry analyses of striped bass otoliths as part of a Delta Science Fellowship awarded in the spring of 2016. This project is currently underway and the preliminary results will be presented. To synthesize what is known regarding the spatiotemporal distribution of striped bass in relation to annual water runoff within the Sacramento-San Joaquin Delta three different types of striped bass distribution data will be evaluated: 1) several years (2011-2015) of sonic telemetry data that reveal the movement and distribution of tagged individuals, 2) a long-term (1969-2015) database provided by CDFW that has capture and recapture locations of disk-tagged striped bass, and 3) striped bass otolith microchemistry analyses using Sr:Ca elemental ratios to determine the proportion of time an individual striped bass spent in fresh vs. saltwater for each year of life. The distribution information will be summarized per year by sex and life stage (sub-adult vs. adult). Continuous and categorical statistical approaches will be used to examine the relationship between annual water runoff and striped bass distributions. Preliminary analysis indicates yearly variation in freshwater use by individual striped bass.

Keywords: striped bass, predator, telemetry

Poster Cluster: Non-Native Predator Fish Research in the Sacramento-San Joaquin Delta

Phoning It In:
A New Approach to Tracking Movement Patterns and Habitat Nuances of Diving Ducks

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Methods to evaluate habitat use and localized movements of diving ducks is complicated by concerns over adverse effects of externally-mounted tracking devices, thus limiting the spatial resolution of inference for these species. However, regional and sub-bay connectivity within the Bay-Delta system is presently undocumented, but represents a region of species-specific ecological needs occurring within a mosaic of habitats. The goal of this project was to test emerging technologies for evaluating wintering diving duck movements and habitat associations in the Bay-Delta region. During the winter 2015-2016, we deployed 14 solar-powered GPS-GSM backpack transmitters using custom molded silicone harnesses developed to facilitate transmitter attachment to diving ducks. Three species were marked in this pilot year: Canvasback (n=12), Greater Scaup (n=2), and Lesser Scaup (n=1). A total of 4,148 GPS-quality (<20m) locations were obtained from marked individuals between December 2015 and May 2016. Individuals utilized a full spectrum of habitats including shallow shoals, tidal marshes, managed marshes, and static deep-water ponds within the Bay sites and transitioned inland towards freshwater habitats during spring months. We describe general movement patterns and habitat nuances highlighted by this methodology, as well as study design considerations for broader applications of this marking scheme. Given looming threats of climate change and cyclical drought conditions the importance of describing key habitat features, spatio-temporal patterns of distribution, and landscape connectivity for these unique-niche species in this ecosystem is essential.

Keywords: Bay-Delta, distribution, diving ducks, GPS-GSM, estuary, tidal habitats, tracking

Poster Topic: Bird Biology, Ecology, & Protection

Factors Influencing the Abundance of Wintering Western Snowy Plovers at Crown Beach State Memorial Park

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Many shorebird populations are declining worldwide. Survival during the nonbreeding season, when mortality from food shortages and raptor predation is likely highest, influences shorebird population growth. These selection pressures, as well as anthropogenic influences, can shape wintering shorebird habitat use patterns. The Western Snowy Plover (*Charadrius alexandrinus nivosus*) is a small shorebird that uses sand-spits, dune-backed beaches, open areas around estuaries and river mouth beaches for nesting and roosting. The Pacific Coast population of Western Snowy Plovers is listed as a federally threatened species and as a California Species of Special Concern. Previous studies suggest humans, dogs, crows, and other birds are the main sources of annoyance to plovers on public beaches. We observed Western Snowy Plover behavior and examined these disturbance factors at Crown Beach State Memorial Park in Alameda, California. For over three years, the majority of disturbances to plovers, in decreasing order of abundance are as follows: gull species, beach using public, crows/ravens, and dogs. Roughly 10% of the time, plovers responded negatively to hunting gulls by either flying away and not returning, or by running away along the beach and returning when gulls departed. Plovers showed negative response to hunting corvids nearly 40% of the time, and the most severe reactions to dogs at 78% of the time. Beach using public resulted in disturbance and avoidance behaviors by the plovers during 35% of the observations. In 2014, the District displayed passive signage encouraging beach users to “share the beach” by avoiding roosting Western Snowy Plovers. The following season the plover protection zone was formalized, by installing symbolic fencing, signage, and establishing the “Plover Protection Patrol” volunteer program to monitor plovers and educate the public. From 2014 to 2016, the wintering population of Western Snowy Plovers at this site has increased from six to over thirty individuals.

Keywords: Western Snowy Plover, Bird Conservation

Poster Topic: Bird Biology, Ecology, & Protection

Estuary Monitoring Platform: Standardized Biological Sampling across Habitat Types

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Numerous techniques are used to monitor estuary fish status and population trends. Gear selectivity and efficiency and ability to track larvae are weaknesses in current techniques. Attempts to integrate multiple abundance indices has had limited success. Although considerable collaboration has occurred, coordinated monitoring and permitting have been difficult. Processing fish and invertebrate identification and enumeration data requires extended periods of sampling downtime and is time-consuming. Additionally, association of individual species lifestages and abundances with microhabitat features and food web components would strengthen analyses (IEP MAST 2014).

The Estuary Monitoring Platform (Platform) was developed to sample fish and invertebrates and reveal habitat associations while having minimal or no "take" of sensitive species. Platform deployment expands data collection to shallow water habitat, with the capability of transitioning to deeper-open water, providing reliable sampling efficiency and CPUE estimates. To validate performance, we compared Platform fish catch and capture efficiency against three traditional methods (beach seine; electrofishing; trawling) in two different habitat types (nearshore/littoral zone; open water) on a Central Valley reservoir.

The prototype Platform sampled depths to 5 ft and operated at speeds of 0.2 ~ 4 knots. Platform image acquisition and live-trapping recorded a variety of species and estimate catch per unit effort similar to other techniques. All species captured by each technique were observed by the Platform. The Platform was able to link biological data directly to simultaneously recorded water quality parameters and geographic location.

The Platform can collect streaming images of organisms passing through the system and associate them with environmental parameters in space and time, reducing take during Estuary studies. The Platform can compliment existing Interagency Ecological Program and other fish monitoring efforts and contribute to Estuary science program efforts to inform ecosystem restoration and native species recovery actions. Specific study results and future deployment applications will be discussed.

Keywords: Prototype, fish, invertebrate, sampling gear, non-invasive, video, San Francisco Estuary

Poster Topic: Fish Biology, Ecology, & Protection

Effects of Bifenthrin on the Estrogenic and Dopaminergic Pathways in Embryos and Juveniles of Zebrafish (*Danio rerio*)

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Bifenthrin (BF) is a pyrethroid pesticide widely used in urban and agricultural applications. Previous studies in fish have shown that environmentally relevant concentrations of BF can affect the endocrine system by leading to the over production of 17b-estradiol (E2) and altering the expression of dopaminergic pathway components in the central nervous system in fish. Dopaminergic neurons regulate luteinizing hormone (LH) and follicle stimulating hormone (FSH), which control E2 biosynthesis, suggesting that BF may disrupt the hypothalamic-pituitary-gonad (HPG) axis. The hypothesis that BF impairs this pathway was tested in embryonic and one-month old juvenile zebrafish (*Danio rerio*). At 3 hours post fertilization (hpf), and one month of development, fish were exposed to 0.15 and 1.5 ppb BF for 96 hours. The relative levels of transcripts related to the dopaminergic and the HPG axis (tyrosine hydroxylase (TH), dopamine receptor 2A (DR2A), dopamine active transporter (DAT), sodium/potassium ATPase (NA/K ATPase), LHb, FSHb, and vitellogenin (VTG)) were investigated by qRT-PCR. Levels of E2 were measured by ELISA. Dopamine and its metabolites (3, 4-dihydroxyphenylacetic acid and homovanillic acid) concentrations were evaluated by LC-MS/MS. Preliminary results show significant decreases of TH, NA/K ATPase, and VTG transcripts in zebrafish embryos, and a significant increase in the expression of TH and DAT in zebrafish juveniles. Estradiol levels were significantly decreased in embryos. These results show a possible anti-estrogenic effect of BF in embryos, and estrogenicity in juveniles. Studies on dopamine concentrations are ongoing. Further analysis of differentially expressed genes coupled with endocrine responses can help assess potential toxic and sub lethal effects of BF using zebrafish as an animal model.

Keywords: Pyrethroids, endocrine disruption, dopaminergic pathway, zebrafish

Poster Topic: Fish Biology, Ecology and Protection

Examining Effects of Wastewater Effluent upon Growth Rates of Inland Silversides in San Francisco Bay Tributaries

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Wastewater runoff and other forms of human-engineered hydrology can alter ecosystems for fish species in their respective habitats. This study used otolith aging to determine growth rates of inland silversides in Alviso and Artesian Sloughs (tributaries of South San Francisco Bay) and Napa River, Petaluma River, and Sonoma Creek (tributaries of San Pablo Bay). The study expected to see higher growth rates in individuals collected from Artesian Slough compared with individuals collected from the other tributaries due to warm, nutrient-rich wastewater flowing as effluent from San José-Santa Clara Regional Wastewater Facility into Artesian Slough. This effluent should create favorable environmental conditions for inland silversides and allow the individuals to grow at an accelerated rate. Otoliths are extracted from the individuals and sanded with fine grit sandpaper in the frontal plane. Because otolith growth is directly correlated with fish length and age, widths of daily bands in the otoliths can be used as a proxy for daily growth. While the study did not find an accelerated growth rate in silversides from Artesian Slough, there was a greater catch per unit effort in Artesian Slough relative to the other sampled tributaries of South San Francisco and San Pablo Bays. This implies that growth of the inland silversides at the sampled sites may be density-dependent. Because wastewater runoff is ultimately a matter of water management, the study results show that wastewater in the estuary may be contributing to the proliferation of an invasive fish in the estuary.

Keywords: Otolith, Wastewater, Inland Silversides, Microchemistry, Growth Rate, Invasiveness

Poster Topic: Fish Biology, Ecology and Protection

Hydraulic Conditions Near a Model Louver System in a Laboratory Flume

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The San Francisco Bay Delta is heavily modified by anthropogenic factors. Man-made activities and structures, such as agricultural water diversions, pumping plants, dams, reservoirs, canals and aqueducts have dramatically altered flows within the Bay-Delta system. The flows are altered with respect to both timing and magnitude. Both the changing of flow patterns, and the physical export of flow have negatively affected biological communities. Fish species native to California are more sensitive to the effects of flow alteration than non-native species. The Delta acts as a hub for both the Central Valley Project (CVP) and the State Water Project (SWP). Timed releases of freshwater from upstream reservoirs reach the Delta, where they are drawn into CVP or SWP pumps, and exported. Determining the impact of current operational parameters at large-scale water diversion facilities on affected fish species is critical to their continued survival. This study investigates the hydraulic conditions near a model louver system simulating conditions at the John E. Skinner Delta Fish Protective Facility of the State Water Project and the Tracy Fish Collection Facility of the Central Valley Project (South Delta Fish Protective Facilities). The model louver system was developed to conduct experiments quantifying the successful bypassing of juvenile green sturgeon at a variety of experimental conditions. The results presented correspond to the first of three hydraulic variations tested in this ongoing study. Analysis of these results could provide insight into the design and operation of louver facilities in order to enhance conservation goals.

Keywords: hydraulics, fish protection, louver system, laboratory, modeling

Poster Topic: Fish Biology, Ecology and Protection

Behavior of Green Sturgeon *Acipenser medirostris* Near a Model Louver System in a Laboratory Flume

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In California's heavily-altered Bay-Delta ecosystem, anthropogenic factors coupled with drought may drastically change available habitats for many native fishes. Large water projects alter flows, expose juvenile fish to unnatural levels of larger piscivorus fish, and can cause warmer overall river temperatures. Native California fishes have been disproportionately affected by these changes compared to non-native species, and precipitous population declines have been observed for several species, some of which are listed under the Endangered Species Act, including green sturgeon. Therefore, research aimed to determine the impact of current operational parameters at large-scale water diversion facilities on sturgeon is critical to their continued survival. A model louver system simulating conditions at the John E. Skinner Delta Fish Protective Facility of the State Water Project and the Tracy Fish Collection Facility of the Central Valley Project (South Delta Fish Protective Facilities), and experiments were initiated to quantify the successful bypassing of juvenile green sturgeon at different sizes (ages), water temperatures, river sweeping flow speeds, and photoperiod (day or night). Fish were observed as they moved downstream towards the louver array where they either successfully bypassed the louver, were entrained through it, or avoided louver interactions. Several underwater cameras placed within the flume recorded fish-louver interactions and fish movement through the bypass channel. Louver contacts, impingement upon the louver, entrainment through the louver, and the timing of bypass events were recorded. Due to the overall small population size and the limited number of annual spawning adults of green sturgeon in the Bay-Delta, it is critical to understand if the current design and operation of louver facilities are cooperative with conservation goals.

Keywords: Green sturgeon, louvers, fish protection, swimming performance

Poster Topic: Fish Biology, Ecology and Protection

Developmental Toxicity of 2- and 6-Hydroxychrysene in Zebrafish Embryos

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Oil spills are one of the primary sources of polycyclic aromatic hydrocarbons (PAHs) in marine environments and are subject to biotic and abiotic weathering. PAHs can undergo photochemical oxidation, forming oxygenated photoproducts that can cause adverse ecological effects. Chrysene is one of the most persistent PAHs and is susceptible to photo-oxidation, resulting in production of oxygenated derivatives such as 2- and 6-hydroxychrysene. However, little is known about the toxicity of hydroxylated PAHs. Previously, we showed that exposure to 2- and 6-hydroxychrysene can adversely affect development of zebrafish embryos. Therefore, the goal of this study was to identify a sensitive window of embryonic development for 2- and 6-hydroxychrysene-induced toxicity. Embryos were statically exposed starting from 2, 5, 10 or 24 hours post-fertilization (hpf) to 0.5 and 5 µM of 2- or 6-hydroxychrysene for 74hrs. At 76 hpf, there was a significant decrease in survival after initiation of treatment with 5 µM 6-hydroxychrysene at 2 hpf, whereas no difference was observed following initiation of 2-hydroxychrysene treatment at any tested stage. However, the prevalence of cardiac deformities was significantly higher after treatment with 2- and 6-hydroxychrysene. These findings suggest that there is a critical time during early development when embryos show heightened sensitivity, leading to decreased survival after exposure to specific PAHs. Moreover, there was an increase in the intensity of yolk sac-localized fluorescence after treatment with either 2- or 6-hydroxychrysene. However, 2-hydroxychrysene resulted in the highest fluorescence intensity, suggesting differential uptake and/or metabolism between these two compounds. Our findings raise the need to identify mechanisms involved in the toxicity of these compounds to assess the potential risks of oil spills on fish populations. This research was made possible in part by a grant from BP/The Gulf of Mexico Research Initiative to the RECOVER Consortium, and in part by CAPES/INCT-TA and CNPq.

Keywords: Development, PAH, hydroxylated chrysene

Poster Topic: Fish Biology, Ecology and Protection

Understanding Catch Patterns of Invasive Catfish Species in the Yolo Bypass

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The San Francisco Estuary's largest floodplain, the Yolo Bypass, has historically supported a diverse fish community comprised of both native and invasive species. The adult fish catch in the perennial Toe Drain channel of the Yolo Bypass in the past decade has consistently been dominated by two non-natives: White Catfish (*Ameiurus catus*) and Channel Catfish (*Ictalurus punctatus*). Here, we examined patterns of adult White and Channel Catfish catch via analysis of both temporal and abiotic changes. Most notably, these populations of Yolo Bypass catfish are increasing over time. In combination with the lack of observable increases within any of the other migratory adult fish species caught during the same sampling effort, this increase could be cause for management concern. Catfish in other systems have notoriously been known to completely alter ecosystems for a number of reasons, including the voracity of the adult catfish diet, and their ability to tolerate a wide range of water qualities. If the catfish increase in the Yolo Bypass continues, their impact on the ecological community in this important floodplain could become more significant. We present here an investigative summary for the potential causes for this increase, and implications for future management of the Yolo Bypass.

Keywords: invasive, Yolo Bypass, catfish, community, fish ecology, adult fish

Poster Topic: Fish Biology, Ecology and Protection

Effects of Temperature on the Endocrinology of Smoltification in Juvenile Rainbow/Steelhead Trout (*Oncorhynchus mykiss*)

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The San Francisco Bay Delta is experiencing seasonally warmer waters and salt water intrusion into historically freshwater ecosystems due to climate change. Juvenile endangered Steelhead Trout (*Oncorhynchus mykiss*) inhabit this system from juvenile development through the smoltification process. It is possible that juvenile fish experience premature hypersaline acclimation due to seawater intrusion (PHA), and the effects of increased temperature and PHA on pre-smolt Steelhead are unknown. Rainbow trout (*Oncorhynchus mykiss*) were used as a genetic model for Steelhead, since they are the same species. Juvenile fry were exposed to 11^0C, 16.4^0C and 19^0C temperatures (n=12) for two weeks and then challenged for 24 hours to 32ppt seawater. Estradiol-17b (E2), cortisol, triiodothyronine (T_3), thyroxine (T_4) levels were measured in blood/plasma or whole animal homogenates using Enzyme Linked Immunnosorbent Assays. Gill Na+/K+ ATPase mRNA levels were measured using qPCR. Preliminary results show 50% survival and a lower average hepatosomatic index (HSI) of 0.89% of fish exposed at the highest temperature compared to an average HSI of 1.24% in fish exposed to the optimal temperature. Ongoing studies will explore the impacts of PHA and pesticides on smoltification and osmotic stress in multiple life stages of salmonids. This material is based upon work supported by the Delta Stewardship Council Delta Science Program.

Keywords: Steelhead trout, smoltification, climate change, temperature

Poster Topic: Fish Biology, Ecology and Protection

Migratory Behavior of Acoustically-Tagged Adult White Sturgeon and Chinook Salmon in the Yolo Bypass, 2012-2016

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The overarching aim of this project is to investigate the movement behavior of different types of migrants in the Yolo Bypass, an intensely altered seasonal floodplain in the Sacramento-San Joaquin Delta of California. Both white sturgeon (*Acipenser transmontanus*) and Chinook salmon (*Oncorhyncus tshawytscha*) navigate the floodplain during their spawning migrations, but with very different reproductive strategies. White sturgeon are iteroparous: they undergo multiple reproductive cycles (and thus multiple spawning migrations) over the course of their lifetimes. Chinook salmon are semelparous, undergoing a single spawning migration and reproducing only once before death. Like native species everywhere, both are uniquely adapted to the historical conditions of their local environment, which has since undergone extreme modification by humans. The ecological success of a migratory species may vary with life stage, migratory route, and response to passage barriers. Understanding how these animals move through their environment is a fundamental part of determining how the migratory landscape is best conserved, managed, or reconciled. This presentation synthesizes four years of data from acoustically-tagged adult migrants, and provides answers to basic questions about the route(s) taken by adult migrants, the spatiotemporal patterns of system use (i.e., the spatial extent of migrant movements as well as the timing of entry, exit, and residence in the system), the behavior around passage barriers by different migrant types, and the environmental cues they may respond to on their migratory paths in different years.

Keywords: migration, floodplain, sturgeon, salmon, behavior

Poster Topic: Fish Biology, Ecology, and Protection

Inter-population Differences in Osmoregulation of Sacramento Splittail

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The Sacramento Splittail, a minnow native to the Delta, is currently listed as a Species of Special Concern by the California Department of Fish and Wildlife. Designing conservation and management plans for this fish can be difficult due to their semi-anadromous life history as well as the existence of genetically distinct populations. Two populations are categorized as the San Pablo (SP) and Central Valley (CV) populations, which differ in their exposure to relatively high and low salinities at the juvenile stage, respectively. During wetter years, the saltwater gradient between the two populations is reduced and the more homogeneous salinity regime may allow population intermixing; however during dry years the saltwater gradient is more distinct, creating a migration barrier and possibly driving adaptive divergence. The differences in salinity between primary spawning/rearing habitats may suggest population-specific differences in salinity tolerance. To test this, a common garden experiment was performed exposing juvenile Splittail from the CV and SP populations to 14ppt or 11ppt saltwater for 24, 72, 168, or 336 hours. Expression patterns of genes specific to osmoregulation and acclimation were then analyzed to evaluate intraspecific differences. Each population showed distinct patterns of gene expression consistent with local adaptation to osmotic regimes. This finding is relevant to the development of new conservation strategies that recognize population-specific concerns. Additionally, this information sheds light on the population effects changes in salinity have on delta species, specifically those susceptible to decline.

Keywords: Sacramento Splittail, osmoregulation, gene expression, adaptive divergence

Poster Topic: Fish Biology, Ecology and Protection

Temperature and Feeding Rate Interact to Impact Growth and Survival of Larval Green Sturgeon

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Temperature and food availability are two major determinants of successful growth and survival of fishes. This study was performed to assess how temperature and food availability may impact larval green sturgeon growth and development. Fish (initial age ca. 27 days post hatch) were reared at four different water temperatures (11, 14, 17, and 20°C) and fed daily at two different food rations (100% and 25% of a laboratory-derived optimal feed rates (OFR)). Each treatment group was held at rearing conditions for six weeks, and mass, fork length (FL; cm) specific growth rate (g/day; cm/day), and condition factor ([mass/$FL^{3]}$ x 100) were assessed at 0, 3 and 6 weeks. For treatment groups fed to 100% OFR, temperature was positively correlated with the growth of larval green sturgeon; for treatment groups fed at 25% of optimal, temperature did not significantly affect the growth of larval green sturgeon. Additionally, temperature had an overall negative correlation with condition factor of the fish in both feed treatment groups. These results can help develop criteria for early life history requirements of green sturgeon and to inform management actions seeking to increase larval and juvenile recruitment success of this species of conservational concern.

Keywords: larval green sturgeon, *Acipenser medirostris*, temperature, feeding rate, growth, survival,

Poster Topic: Fish Biology, Ecology and Protection

Efforts to Conserve Pacific Lamprey

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Historically widespread along the West Coast, Pacific Lamprey (*Entosphenus tridentatus)* abundance has declined and its distribution has become restricted throughout California, Oregon, Washington, and Idaho. To assess and conserve Pacific Lamprey, a conservation initiative composed of a risk assessment, a conservation agreement, and regional implementation plans was developed. The risk assessment found a relatively high risk of extirpation in the majority of watersheds, and these results were instrumental in gaining partners' support for the Pacific Lamprey Conservation Agreement (Agreement), a voluntary commitment by the parties to collaborate on efforts that reduce or eliminate threats to Pacific Lamprey. The goal of the Agreement is to accelerate implementation of priority Pacific Lamprey protections, restorations, monitoring and evaluations, and research actions. The Agreement seeks to advance conservation through the development of Regional Implementation Plans which will evaluate information gaps, prioritize and implement conservation actions, and evaluate their effectiveness to address these gaps. There are seven California Regional Implementation Plans (RIPS); however, the Sacramento, San Joaquin, and San Francisco Bay RIPs that are currently being developed are the most relevant to Bay-Delta management and for determining ecosystem sustainability for the future.

Keywords: lamprey, conservation, Regional Implementation Plan, information gaps, collaboration, risk assessment

Poster Topic: Fish Biology, Ecology and Protection

Lots of Data without the Fishy Smell: Application of Acoustic Imaging to Evaluate Fish Behavior near Tidal Wetlands

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Major tidal wetland habitat restoration efforts are planned to benefit Delta Smelt, juvenile salmonids, and other imperiled species in the Sacramento-San-Joaquin Delta. However, successful implementation of habitat restoration is constrained by a paucity of information on the function and services that tidal wetlands provide for fishes. Our current understanding of tidal wetland service and function is constrained for several reasons. First, the rapidly changing environmental conditions and complicated physical structure of these habitats make fish sampling difficult. Moreover, empirical studies of fish in tidal wetlands are often constrained by sample size, and frequency of data collection. To address these limitations, this study used an acoustic camera to collect high frequency continuous monitoring data at the entrance of a tidal wetland. More specifically, we evaluated fish abundance and behavior in response to rapidly changing environmental conditions. Here, we report on a study aimed at understanding responses of fishes to bi-directional tidal flows and environmental factors driving movements into and out of tidal wetland habitats. Results from this work will help understand the value or detriment of different habitat features and will assist with future habitat restoration efforts.

Keywords: acoustic camera, tidal marsh wetland, Aris

Poster Topic: Fish Biology, Ecology and Protection

Occurrence of Large-Scale Loach (*Paramisgurnus dabryanus*) in the Sacramento-San Joaquin basin, CA

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Exotic species have been implicated as a major threat to native freshwater fish communities throughout the world. The San Francisco Estuary and its watershed have been recognized as the most invaded system in the world where exotics often dominate the fish community. Unfortunately, the U.S. Fish and Wildlife Service verified the occurrence of a new exotic fish species known as Large-scale Loach *Paramisgurnus dabryanus* on November 12, 2014 within the San Joaquin River in Madera County, California. A total of seven specimens were collected in isolated pool habitats using backpack electrofishing and beach seining techniques. In collaboration with the University California at Davis and Museum of Natural History of Los Angeles County, we verified that each specimen was a Large-scale Loach using DNA bar-coding and meristics (e.g., examined radiographs). We determined that this is the first known occurrence of Large-scale Loach in the United States following a review of literature and the United States Geological Survey Nonindigenous Aquatic Species Database. To elucidate the likelihood of establishment in and ecological risk to the San Joaquin River, we conducted a U.S. Fish and Wildlife Service Ecological Risk Screening Summary (ERSS). The ERSS results suggested that the likelihood of Large-scale Loach becoming established and impacting the aquatic community in the San Joaquin River is moderate based on the prevalence of degraded aquatic habitats in the river coupled with the flexible life history and habitat requirements of the Large-scale Loach. However, our ERSS results were highly uncertain because of limited peer-reviewed literature on the biology, ecology, and distribution of Large-scale Loach. Therefore, we recommend that public and private natural resource entities evaluate the ecology, distribution, and abundance of Large-scale Loach to determine their potential impact to the fish communities and related restoration projects occurring in San Francisco Estuary and watershed.

Keywords: Exotic, San Joaquin River, Large-scale Loach, Ecological Risk

Poster Topic: Fish Biology, Ecology and Protection

Reconstructing Fish Life History using Strontium Isotope Laser Ablation MC-ICP-MS Analysis of Scales, Spines, and Fin Rays as a Non-Lethal Alternative to Otolith

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Strontium isotope ratios (^{87}Sr:^{86}Sr) in otoliths are a well-established tool to determine origins and movement patterns of fish. Alternative sample tissues (scales, spines, fin rays) may also provide valuable geochemical information and are particularly useful as a non-lethal alternative for endangered fish species. Unlike otoliths that are predominantly aragonite, these tissues are comprised of biological apatite. Analyses of biological apatite using in situ laser ablation multi-collector inductively coupled plasma mass spectrometry (LA-MC-ICP-MS) is complicated by polyatomic interferences on mass 87, which can cause inaccurate ^{87}Sr:^{86}Sr measurements. To quantify this interference, we applied LA-MC-ICP-MS to three marine samples including a white seabass (*Atroctoscion nobilis)* otolith, green sturgeon (*Acipenser medirostris)* pectoral fin ray, and salmon shark (*Lamna distropis)* tooth, as well as freshwater walleye (*Sander vitreus*) otoliths, scales, and spines from Boysen Reservoir, Wyoming. These samples were selected because they originate from homogenous ^{87}Sr:^{86}Sr isotope reservoirs, allowing us to decouple potential analytical interferences from actual mobility and habitat change of the fish. Instrument conditions that maximize signal intensity resulted in elevated ^{87}Sr:^{86}Sr isotope ratios in the bioapatite samples, related to the polyatomic interference ($^{40}Ca^{31}P^{16}O$,$^{40}Ar^{31}P^{16}O$). Instrument conditions that reduce oxide levels successfully removed the effect of the polyatomic interference and resulted in consistent values across all tissue types. This provides fish ecologists with a powerful new tool to reconstruct life histories for threatened or endangered fish species where otolith extraction is not a viable option.

Keywords: Strontium isotopes, Otolith, Bioapatite, Migration

Poster Topic: Fish Biology, Ecology and Protection

The Effect of Chlorpyrifos on Salinity Acclimation of Steelhead Trout: Changes of Serum Hormone and Gene Expression in Liver, Gill and Rosette

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As a part of their unique life cycle, most salmonids undergo transition from freshwater to saltwater, requiring various adjustments in metabolism, osmotic and ion regulation. The hypersaline acclimation of salmonids can be affected by environmental pollutants such as pesticides during their downstream migration to the estuary. The present study aims to determine how toxicity of chlorpyrifos (CPF) impacts hypersaline acclimation of steelhead trout (*Oncorhynchus mikiss*). We exposed fish (52±5 g, 4 fish in each 4 replicate 20L glass tank) to 0, 20, 40, 80, 160 µg/L of CPF for 7 days, and then to hypersalinity (12ppt) for another 7 days. After 7 days of exposure, sampling was done either on serum or tissues (liver, gill and rosette). Mortality, levels of cortisol, T3 and T4 in serum, and expression of genes involved in detoxification, ion transportation and neural signal transduction were measured at the 7th day (CPF exposure) and 14th day (salinity) exposure. CPF exposure did not significantly alter cortisol levels, but fish exposed to CPF then exposed to hypersaline conditions showed higher cortisol levels than freshwater control groups. Serum thyroid hormones T3 and T4 were increased in a dose-dependent manner after CPF exposure as well as during the salinity acclimation. Hepatic mRNA of Glutathione-S-Transferse pi (GST) increased up to two folds following exposure to CPF and a similar trend was observed after hypersaline exposure. CPF downregulated around 0.5 fold the Na+/K+ATPase α1 in the gills. Transcriptional responses in neuronal signal transduction will be assessed in rosette samples. The current results indicate that chlorpyrifos could impact on the salinity acclimation of steelhead trout through inhibiting ion transportation and increasing serum thyroid hormones.

Keywords: chlorpyrifos, salinity acclimation, steelhead trout, serum hormone, gene expression

Poster Topic: Fish Biology, Ecology and Protection

Time- and Oil-Dependent Genomic and Physiological Responses to Deepwater Horizon Oil in Mahi-Mahi (*Coryphaena hippurus*) Embryos

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The Deepwater Horizon (DWH) oil spill contaminated the spawning habitats for numerous commercially and ecologically important fishes. Exposure to the water accommodated fraction (WAF) of oil from the spill has been shown to cause cardiac toxicity during early developmental stages across fishes. To better understand the molecular initiation events and explore new pathways responsible for toxicity, RNA sequencing was performed in conjunction with physiological and morphological assessments to analyze the time-course (24, 48 and 96 hour post fertilization (hpf)) of transcriptional and developmental responses in embryos/larvae of mahi-mahi exposed to WAF of weathered (slick) and source DWH oils. Slick oil exposure induced more pronounced changes in gene expression over time than did source oil exposure. Predominant transcriptomic responses included alteration of EIF2 signaling, steroid biosynthesis, ribosome biogenesis and activation of the cytochrome P450 pathway. At 96 hpf, slick oil exposure resulted in significant perturbations in in eye development and peripheral nervous system, suggesting novel targets in addition to the heart may be involved in the developmental toxicity of *DHW* oil. Comparisons of changes of cardiac genes with phenotypic responses were consistent with reduced heart rate and increased pericardial edema in larvae exposed to slick oil but not source oil.

Keywords: DWH oil spill, transcriptome, developmental toxicity, phenotypic anchoring, Mahi-mahi

Poster Topic: Fish Biology, Ecology and Protection

Aerobic Scope Reveals High Thermal Performance in Juvenile Chinook Salmon, *Oncorhynchus tshawytscha*

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Defining suitable thermal habitat for fishes is of fundamental importance to ensure population persistence, but translating laboratory measures of thermal performance into regulatory numeric criteria remains difficult. The mechanisms driving population declines due to changes in environmental temperature are poorly understood, yet they are essential for effective management of California native fishes. In an effort to provide valuable physiological temperature data that can be used by conservation managers, we tested the thermal performance of juvenile Chinook salmon (*Oncorhynchus tshawytscha*) across a range of environmentally relevant temperatures. Fish (initial size ca. 8.8 cm FL, 9 g) were acclimated to 14 or 20°C, and swim tunnel respirometers were used to measure routine metabolic rate (RMR) and maximum metabolic rate (MMR) at test temperatures ranging from 12 to 26°C. Absolute aerobic scope (AAS=MMR-RMR) and factorial aerobic scope (FAS=MMR/RMR) were calculated to determine the capacity of each fish to supply oxygen to tissues above and beyond the basic routine need. MMR, AAS, and FAS did not differ significantly between the two thermal acclimation groups, while RMR was lower in fish acclimated to 20°C. Overall, RMR, MMR, and AAS increased as test temperatures increased, and AAS was maintained until mortality rates abruptly increased at 25°C. These data are critical for managers seeking to link the survival of fishes with environmental temperature regimes, to identify temperature ranges optimal for survival, and to help determine future restoration sites that will be important for the recovery of native fish populations.

Keywords: salmon, metabolic rate, climate change, oxygen consumption

Poster Topic: Fish Biology, Ecology and Protection: Salmon

2016 South Delta Chinook Salmon Survival Tag Retention Study: Increased Tag Burden Results in Increased Tag Expulsion

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The 2016 South Delta Chinook Salmon Survival Study was part of an ongoing telemetry study that was conducted to better understand the survival and route selection of emigrating Chinook Salmon *Oncorhynchus tshawytscha* smolts through the south Delta. In order to better interpret the artificial impact of survival introduced through the surgical tagging procedure, we also conducted a companion study to assess tag retention and fish survival after tagging. This consisted of surgically implanting a dummy acoustic transmitter into the abdominal cavities of 50 juvenile Chinook Salmon, and assessing the condition of each fish after a 30-day holding period. The 2016 survival and tagging effects studies contrasted previous years in that the tag burden (i.e., the ratio of the transmitter weight to body weight) was higher than the 5% maximum limit adhered to in past years for both released study fish (average tag burden in 2016 Week 1 = 6.3%; Week 2 = 5.2%) and tagging effects fish (average tag burden = 7.6%). Despite the increased tag burden, we observed 100% survival and an average of 85.8% increase in weight of tagged fish after the 30-day holding period. However, we also observed a decrease in tag retention compared to previous years of the study that remained below the maximum 5% tag burden limit (tag retention in 2016 = 88.0%; 2015 = 98.6%; 2014 = 100%). The tag expulsion observed in 2016 occurred only within the smallest 31.3% of held fish (average size of all 2016 held fish at Day 0 = 4.8 g, range = 4.5–6.9 g). These results generate insight regarding possible limitations in using smaller fish in future telemetry studies and help correct survival estimates for potential bias associated with tag expulsion rates.

Keywords: Chinook Salmon, acoustic telemetry, survival

Poster Topic: Fish Biology, Ecology and Protection: Salmon

Calculating Potential Fish Benefits from NMFS Delta Actions

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Calculating the benefits from the NMFS RPA Delta Actions is difficult because the available fish sampling data is limited; there are several conceptual models for fish behavior at Delta channel junctions or diversions; and there are limited measurements of survival in each major Delta channel. The calculation of fish benefits requires the following information: Delta inflows and channel flows; daily fish migration pattern; flow fractions and corresponding fish fractions for each Delta junction; and survival in each Delta channel.

Calculations are shown for estimating two benefits from closing the DCC; the fraction of migrating fish that enter the SJR pathway with reduced survival to Chipps Island and the fraction of fish that are salvaged and lost at the CVP and SWP exports. Calculations are shown for installing a fish screen or a fish exclusion device in Georgians Slough. Calculations are shown for shifting exports from SWP (20% salvaged, 80% lost) to CVP (60% salvages, 40% lost). Calculations are shown for reducing reverse OMR flow to -5,000 cfs, and for further reducing OMR flows to -2,500 cfs based on salvage loss triggers. Calculations are shown for reducing the April and May exports to a fraction of the SJR inflow, and for installing the Head of Old River barrier. Calculations are shown for increasing the SJR inflow in April and May, and for separating the SJR inflow from the CVP and SWP exports by routing the SJR down Old River while routing the export flows in Middle River and Victoria Canal. The calculation framework is based on the historical Delta flows (DAYFLOW) and the changes in Delta flows that would result from each RPA action. An expanded DAYFLOW, which includes daily estimates of each D-1641 objective and each RPA action should be created with a cooperative project between the WOMT agencies.

Keywords: Delta Fish Benefits, Salvage Loss Calculations, Flows and Diversions

Poster Topic: Fish Biology, Ecology and Protection: Salmon

Dynamic Visualization of Tethered Salmon Smolt and their Predators in San Joaquin River Habitats

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Many non-native predatory fishes (e.g. striped bass, largemouth bass, white catfish, and channel catfish) are known to prey upon salmon smolt in the San Joaquin River (SJR) system. The locations, densities, and dynamics of these predators and quantitative impact on smolt are unknown. During 2014 and 2015 a study was conducted to examine effects of manipulated predator densities and prey transit time on juvenile salmon survival. In support of this, repeated active acoustic surveys were conducted to detect and estimate predator densities throughout the SJR from Port of Stockton to Lathrop. Additionally in 2015 parts of Clifton Court Forebay and the Stockton Deepwater Channel of the SJR were surveyed. This electronic-poster presents dynamic three-dimensional visualizations of results from these surveys and experiments, including: maps of riverbed bathymetry, backscatter, and SAV; sonar-detections of fish as they were encountered during the surveys; tethered smolt tracks and predation events; and estimated densities and abundances of predatory fish over time (March through May, 2014 and 2015).

Keywords: 3D animated visualization, non-native fish, salmon-smolt predation, novel methods

Poster Topic: Fish Biology, Ecology and Protection: Salmon

Monitoring for Pathogens and their Effects on Out-Migrating Chinook Salmon in the Delta

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Water temperatures in the Sacramento-San Joaquin River Delta are postulated to rise over the next decades as a result of global climate change. A side effect of elevated water temperatures is the facilitation of disease spread and infection in fish. Recently observed elevated water temperatures coincided with juvenile Chinook salmon migration timings, potentially enhancing susceptibility to disease. We conducted multiple-endpoint assessments to evaluate the health status of out-migrating Chinook salmon juveniles throughout the Delta. First we exposed caged hatchery-origin to ambient waters to assess the types of pathogens present in the San Joaquin River that may potentially impact migration success and rearing survival. Second, we evaluated field caught wild juvenile fish and hatchery origin (released) juvenile fish to assess potential differences in disease status. We examined gill, brain, and kidney to determine pathogen presence and abundance, as well as the expression of immune-response genes to assess the relative impact of infection on the fish. In the caged fish, *Ichthyophthirius multifiliis,* Rickettsia-like Organism, and *Flavobacterium psychrophilum* were identified as pathogens of potential concern for Chinook salmon. *Ichthyophthirius multifiliis* was the most commonly detected pathogen and the pathogen with the highest loads. Gill tissue had the highest levels of detection for the pathogens, highlighting the utility of the gill for pathogen detections in wild fish. We will present comparative data for hatchery origin (caged), hatchery origin (released), and wild out-migrating Chinook salmon, and discuss how this data, and developed tools can be incorporated into monitoring programs in order to provide comprehensive health status assessments of out-migrating salmon. Understanding the dynamics of pathogens in Pacific salmon systems will improve resource manager`s ability to predict successful smolt migration and rearing survival during periods of high water temperatures or extreme drought.

Keywords: Elevated water temperatures, Drought, Disease, Pathogens, Out-migrating Chinook salmon, Monitoring

Poster Topic: Fish Biology, Ecology and Protection: Salmon

Emigration Rate and Survival of Winter-run Chinook Salmon

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Sacramento River Winter-Run Chinook salmon are locally adapted to escape summer heat in the Central Valley by navigating farther than other runs earlier in the year to cold, refugial tributaries above Shasta Reservoir, where they spawned and reared throughout the summer. This unique life history strategy of extended instream residence is found nowhere else on the West Coast. The decline of Winter-Run Chinook Salmon is largely attributed restricted spawning and juvenile rearing to the mainstem of the Sacramento River, with early life stages reliant on controlled flows released from Shasta Reservoir. We evaluated the response of juveniles to managed flow conditions by tracking movement patterns and emigration survival of hatchery Winter Chinook. Fish were tracked from the spawning area below Keswick dam to the ocean from 2013-2016, all of which were drought years. An array of 120 receivers was deployed throughout the Sacramento River and San Francisco Estuary, terminating at the Golden Gate Bridge. Up to 570 fish per year were surgically implanted with Juvenile Salmon Acoustic Telemetry System (JSATS) transmitters and released. Despite drought conditions and generally low flows, fish movement and survival varied with the magnitude of flows. Low flows corresponded with long in-river residence and low survival whereas strong peak flows corresponded to rapid emigration and high survival. Extended periods of Winter-Run Chinook Salmon holding under low flow conditions have not been observed in other runs and thus may reflect a residual life history behavior. Overall, this study highlights the importance of pulsed flow conditions for promoting higher survival of juvenile Winter-Run Chinook Salmon emigrating to the ocean, which will inform future management of the species.

Keywords: Winter-run Chinook Salmon Central Valley Sacramento River Acoustic telemetry juvenile

Poster Topic: Fish Biology, Ecology and Protection: Salmon

Differential Impacts of Outmigration, Survival, and Biocomplexity for the Central Valley Chinook Salmon Population

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Traditionally, conservation management has focused on maximizing species abundance, while more recent discussions have focused on biocomplexity and resilience. Which is more important for salmon in the California Central Valley? Here, we modeled expected adult return abundance to the Stanislaus River under different scenarios of juvenile migration strategies and survival based on empirical data. We estimated survival probability by size (selection functions) by comparing juvenile outmigrant size distributions from rotary screw trap sampling with those reconstructed in the surviving adults using otolith chemistry. We then separated the data into four dimensions (total number of outmigrants, total survival probability, outmigrant size distributions, survival size distribution) and ran all possible combinations to identify the factors having the largest effect on the number of adult returns. Our results suggest that the total number of outmigrants and total survival probability were the most important factors explaining the number of returns (explaining 50% and 30% of the variance, respectively). Diversity in life history traits (i.e. the size distribution of outmigrants and survival rates) explained most of the remaining variability (about 10% each). Our results suggest that maximizing the total number of outmigrants is the best strategy to maximize population size, but that variable migration strategies should be maintained for population stability and resilience.

Keywords: biocomplexity, portfolio effect, size-specific survival

Poster Topic: Fish Biology, Ecology and Protection: Salmon

Central Valley Passive Integrated Transponder (PIT) Tag Array Feasibility Study

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NOAA led a collaborative pilot study in 2015-16 to develop and test a variety of Passive Integrated Transponder (PIT) tag detection systems to assess the potential for using PIT tags to monitor the movement and survival of listed salmonids in the Central Valley and Sacramento-San Joaquin Delta. Detection array approaches were developed for 4 sites that represent the range of channel sizes and structures present in the Delta, in increasing level of challenge: (1) shielded circular antenna array on a pipe in a high RF noise environment; (2) prototype pontoon-mounted vertical fin array with 6-ft long hydrofoil fins on the upper Mokelumne River, representing tributary rivers; (3) larger pontoon-mounted vertical fin array with 12-ft long fins on the mainstem San Joaquin River, representing large, tidally-fluctuating channels; and (4) towed arrays for trawl-type surveys in the largest channels where the lower Delta meets San Francisco Bay. Arrays at sites 1-3 were installed and operated March through May 2016 and detection rates were estimated by releasing PIT-tagged hatchery Chinook salmon smolts. Evaluation of the towed array consisted of fabricating and field testing a prototype array in the Northwest and then combining the performance results with environmental data (bathymetry, salinity, flow, etc.) from the lower Delta to estimate various scenarios for sampling effort and potential detection rates. Results from this initial feasibility study will help inform deliberations about how PIT tags might provide an additional tool to complement existing approaches, such as acoustic tagging, to advance research and monitoring of listed fish in the Central Valley and Delta. Partners in the project include California Department of Fish and Wildlife, California Department of Water Resources, East Bay Municipal Utility District, US Bureau of Reclamation, US Fish and Wildlife Service, and Biomark.

Keywords: PIT tags, antennas, salmon, San Joaquin River, Mokelumne River

Poster Topic: Fish Biology, Ecology and Protection: Salmon

Migratory Behavior and Survival of Reintroduced Spring-Run Chinook Salmon Smolts in the San Joaquin River and Delta

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Along with actions to reconnect and restore habitat in the San Joaquin River, there is a concurrent spring-run Chinook salmon reintroduction effort underway. Chinook salmon smolts have been released in the spring near the confluence of the Merced River with the San Joaquin. However, there is little information available on the migratory behavior and survival of these fish as they exit the river and traverse the San Francisco Estuary before entering the Pacific Ocean. We are planning to release two groups of salmon smolts outfitted with injectable-sized JSATS (juvenile salmon acoustic telemetry system) transmitters to assess movement rates, behavior, and reach-specific survival in relation to environmental parameters. One group will be released upstream of where the Merced River flows into the San Joaquin, in a similar manner as the hatchery produced spring-run smolts used in the reintroduction effort. A second group of tagged fish will be released at the entrance to the Sacramento-San Joaquin Delta, near Durham Ferry.

An array of acoustic receivers in the San Joaquin River and San Francisco Estuary will permit us to reconstruct encounter histories of individual fish and subsequently derive survival estimates, detection probabilities, and movement rates of the salmon smolts, as well as relate these estimates to changing environmental conditions. The results of this study will inform us survival rates of these reintroduced fish as they emigrate the river, how survival is affected by changing environmental conditions, how water operations may affect the survival, and will allow us to focus future studies on reaches of river that have consistently low survival. The survival estimates will also be incorporated in life cycle models to forecast future abundance of spawners returning to the San Joaquin River. Information learned throughout the course of this study will also be useful in gauging the effectiveness of the reintroduction effort.

Keywords: Telemetry, Spring-run, Chinook salmon, Survival, San Joaquin River, Delta, JSATS

Poster Topic: Fish Biology, Ecology and Protection: Salmon

A Brief History of Central Valley Hatchery Releases in Time and Space

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Salmon hatcheries play a complex role in the California Central Valley. Originally established to mitigate upstream habitat loss, they now dominate Chinook salmon fall run production and have a significant impact on the dynamics and genetic diversity of the entire stock complex. Here, we follow on from the study of Huber & Carlson (2015) by geolocating the release locations of all fall-run Chinook salmon releases in the Central Valley since 1946. We examine how management practices have evolved over the past 70 years, focusing on the timing and location of hatchery releases. We also explore the relationship between straying index and trucking distance for each of the five main hatcheries. Over the past 70 years, hatchery salmon have been trucked increasing distances from the hatchery-of-origin, while variation in date at ocean entry has been truncated. The major implication of increased trucking distances lies in the increased probability of these individuals straying to other rivers to spawn, reducing genetic diversity and opportunities for local adaptation. Reduced diversity in ocean entry timing increases the chances of a mismatch with optimal ocean conditions. This simplification of the Central Valley "portfolio" has the potential to reduce the resiliency of both wild and hatchery populations, and should be considered in future management decisions.

Keywords: Hatchery practices, salmon, straying, life history diversity, portfolio effect, trucking

Poster Topic: Fish Biology, Ecology and Protection: Salmon

Fall Run Chinook (*Oncorhynchus tshawytscha*) Salmon Upstream Migration Behavior in San Joaquin River Basin

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Acoustic telemetry has evolved and improved over several decades enabling researchers and agencies to more accurately study the movements of a variety of fish species. These improvements allow researchers to explore important aspects of anadromous fish behavior relating to streamflow management, stressors and restoration actions. In California's Central Valley, researchers have deployed an array of acoustic hydrophones in conjunction with acoustic tags to study anadromous fishes such as sturgeon (*Acipenser spp.*), Chinook salmon (*Oncorhynchus tshawytscha*) and steelhead (*Oncorhynchus mykiss*). These acoustic arrays of receivers cover the entire length of freshwater rivers in the Central Valley to the Golden Gate Bridge and in the Pacific Ocean. California Department of Fish and Wildlife (CDFW) conducted an adult Chinook salmon tracking study in San Joaquin River from 2012 to 2015. Sixty-eight Chinook salmon were implanted with acoustic tags and released in the San Joaquin River upstream of Mossdale County Park. Using the detection data that is shared by researchers and agencies, we were able to construct migration timing, pattern, and speed of each tagged Chinook salmon.

Adult Chinook salmon spawning migration is poorly understood in California's Central Valley despite working beginning as far back as the 1960s (Hallock et al, 1970). Limited data has been collected about adult salmon spawning migration, timing, movement behavior, and travel speed. Scientists hypothesize adult fall-run Chinook salmon hold in the Delta or river, migrating to spawning grounds when river conditions improve as a result of increasing river flow and decreasing river temperature. Results indicate adult Chinook salmon are capable of traveling between Sacramento and San Joaquin River Basins before they arrive at their final spawning ground. Detection data shows migration behavior related to river flow changes. Salmon exhibit complex searching patterns during their upstream migration and similar patterns have been demonstrated in studies within the Columbia River Basin.

Keywords: San Joaquin River, Fall run Chinook salmon, telemetry study

Poster Topic: Fish Biology, Ecology and Protection: Salmon

Growth Rate Comparison of Longfin Smelt (*Spirinchus thaleichthys*) Between Wet and Dry Years Through Otolith Analysis

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The San Francisco Bay-Delta is host to the southernmost population of longfin smelt (*Spirinchus thaleichthys*), which is listed as a threatened species in California. Fall Midwater Trawl (FMWT) catch show the abundance of age-0 longfin smelt is correlated with freshwater flow, however, the mechanism behind the pattern is unknown. We hypothesized that growth rates would be higher during high freshwater flow years. As in many estuaries, high freshwater outflow is associated with increased primary production and zooplankton prey availability thus potentially fueling increased growth of longfin smelt. We tested this hypothesis using otolith aging techniques to back-calculate size at age-1 for adults, otolith increment widths for juveniles, and estimated growth rates from age-length keys. We found that longfin smelt were larger at age-1, however, growth for juveniles was slower during dry years. Furthermore, we found a persistent reduction in mean length from the September survey of the FMWT over the years suggesting long-term climate patterns and shorter-term hydrology may be interacting to influence growth and survival of longfin smelt. Consistent dry years, lack of freshwater flows, and the threat of increased extremes due to climate change will put the longfin smelt in a more precarious position then they are currently. If freshwater flows are important to longfin smelt abundance and growth, management options that provide adequate freshwater flows will provide a necessary component for longfin smelt population recovery.

Keywords: Longfin Smelt, *Spirinchus thaleichthys*, drought study, growth rate, otolith analysis

Poster Topic: Fish Biology, Ecology and Protection: Smelt

Temperature Tolerance and Metabolism of Threatened Smelt

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Increases in water temperature due to climate change and drought are of great concern for managers of the San Francisco Estuary. Several native fishes are in decline; however, it remains unclear how further temperature stress may contribute to these declines. The threatened Longfin Smelt (*Spirinchus thaleichthys*) and the critically endangered Delta Smelt (*Hypomesus transpacificus*) are of particular concern in California. In efforts to forecast how increased temperatures may impact these fishes, we measured upper temperature tolerance (CTMax) and whole-fish oxygen consumption rates (MO_2) at 14ºC and 20ºC, in both species, at 50 days post hatch (dph). Delta Smelt had a higher CTMax (27.6ºC) compared to Longfin Smelt (24.8ºC). MO_2 was greater in Delta Smelt exposed to 20ºC compared to 14ºC, reflecting an increased energetic cost at warmer temperatures. In contrast, Longfin Smelt MO_2 was similar at 20ºC and 14ºC, suggesting that these fish may have limited capacity to adjust their physiology to elevated temperatures and there may be a mismatch between oxygen demand and supply at this early larval stage. Understanding the thermal limits and physiological responses to increases in temperature can help identify species-specific sensitivities and vulnerabilities of native, ecologically important California fishes to projected increases in water temperature.

Keywords: Delta Smelt, Longfin Smelt, temperature, tolerance, metabolism, endangered fishes

Poster Topic: Fish Biology, Ecology and Protection: Smelt

Putting Extreme Drought into a Long-Term Context: Growth Rate Variability and Recruitment Success in Response to Environmental Conditions

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The Delta Smelt (*Hypomesus transpacificus*) was once abundant among the pelagic fish assemblage inhabiting the upper SFE and Delta until the 1980's when the population began to decline. Recruitment theory suggests growth in the early life is a strong predictor of year class abundance. We hypothesize that the recent drought conditions have reduced growth rates and survival in the early life. In this study we use otolith age-length relationships from Delta Smelt collected during the Summer Townet Survey to develop an age-length model. The model was applied to fish collected during the 20-mm survey from 1995 to present to estimate growth and survival. Growth and survival varied considerably over the time series and tended to be lower and more variable during dry years when fish were less abundant. However, temperature and prey availability contributed to growth rate variability confounding trends between growth, survival and freshwater outflow. This study highlights the importance of incorporating multiple environmental drivers over long timescales to understand recruitment success for Delta Smelt. The recent, unprecedented drought represents a period where environmental conditions are converging to significantly limit recruitment success.

Keywords: Delta Smelt, growth rates, survival, otoliths

Poster Topic: Fish Biology, Ecology and Protection: Smelt

Growth and Life History of Delta Smelt Utilizing the Yolo Bypass

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Problem Statement: Our research aims to examine the differences in growth rates and life history strategies observed between Delta Smelt captured in the Yolo Bypass versus those captured throughout the Delta.

The Yolo Bypass, located adjacent to the Sacramento River near the city of Sacramento, is one of the largest managed flood plains in California and has been documented to provide beneficial habitat for many native fishes. Since 2009, the abundance of Delta Smelt, an endangered species endemic to the Sacramento-San Joaquin Delta, has increased dramatically in the Yolo Bypass. Concomitantly, the abundance of zooplankton prey for the Delta Smelt in the Yolo Bypass has also increased. We hypothesize that the growth rate of Delta Smelt utilizing the Yolo Bypass will be greater than individuals occupying other freshwater and low-salinity habitats. We tested this hypothesis using otolith growth increments from Delta Smelt collected by rotary screw trap in the Yolo Bypass Toe Drain from 2010-2014 and compared their growth to individuals collected throughout the rest of the estuary from the same time period. Growth rates of juvenile fish utilizing the Yolo Bypass were elevated compared to the rest of the estuary, suggesting that this managed floodplain habitat provides better feeding conditions for the species and that the region may be a freshwater refuge for the endangered Delta Smelt.

Relevance: This research helps refine our understanding of how an endangered native species can exhibit unique life history strategies and make use of new habitat in response to changing conditions in the Sacramento-San Joaquin Delta.

Keywords: Delta Smelt, Yolo Bypass

Poster Topic: Fish Biology, Ecology and Protection: Smelt

Development and Evaluation of Using Environmental DNA Sampling to Detect and Monitor Wild Delta Smelt

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The Delta Smelt is a threatened species endemic to the Sacramento/San Joaquin Delta (Delta) and other parts of the upper SF Estuary whose population has collapsed within the past few decades. Surveys in recent years found very few remaining fish, a sharp and alarming decline for an annual species. Even when the Delta Smelt populations are healthy, traditional surveys (e.g. Spring Kodiak Trawl (SKT)) have several limitations in their ability to monitor Delta Smelt over the large area that comprises their native range. Unsurprisingly, as the population has declined, effective monitoring of Delta Smelt has become even more difficult. Environmental DNA (eDNA) sampling is a technique where the presence/potential absence of organisms is detected in environmental samples, such as water. Two major benefits of using eDNA is 1) eDNA sampling does not require visual identification, and 2) eDNA sampling has little to no risk of sampling-related mortality that is typical with traditional surveys. Therefore eDNA is a promising potential complement to traditional surveys for detecting the increasingly rare Delta Smelt. We are currently in Phase I of a pilot project designed to develop an eDNA sampling technique specifically designed to detect Delta Smelt in the Delta using a targeted qPCR assay. We present initial results of a pilot study designed to develop and test the feasibility of an environmental DNA protocol for detecting Delta Smelt in the San Francisco Estuary. Initial results include filtration and extraction protocols, Delta Smelt DNA shed rate, assay sensitivity, and an analysis of presence of PCR inhibition. We will also present information on the pros and cons of eDNA sampling in general, as well as future work plans for this project.

Keywords: eDNA, Delta Smelt, sampling, protocol development

Poster Topic: Fish Biology, Ecology and Protection: Smelt

Phenotypic Effects of Domestication on Captive-Bred Cultured Delta Smelt

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The Fish Conservation and Culture Lab (FCCL) is currently culturing the 9th generation of endangered Delta Smelt (*Hypomesus transpacificus*). These fish have been removed from the wild since 2007. In order to understand the effect of domestication on the captive-bred cultured Delta Smelt, the growth and survival of larvae with both parents from the wild were compared to the larvae of parents from the 8th generation of the refuge population (control group) under two different turbidity environments (5.5 and 9 NTU). The results show the larvae with wild parents were slightly smaller than the control group till they were 80 days post hatch (dph), and the survival of the ones with wild parents was lower at 40 dph than the control groups, especially for the group with low turbidity (84% vs 92% at 9 NTU; 53% vs 80% at 5.5 NTU). In addition, phenotypic parameters including fork length, body weight, and fecundity from both refuge and wild-born populations (they were brought in the lab from the wild at the sub-adult stage) were compared when they were sexually mature for spawning. The results show in the past six years, the wild-born populations were getting smaller, especially in the past two years, while the refuge population have maintained a similar size. The fecundity of wild-born population also decreased with the fish size.

Keywords: Delta Smelt, domestication, phenotype, refuge population

Poster Topic: Fish Biology, Ecology and Protection: Smelt

The Search for the Spawning Habitat of Delta Smelt

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The Delta Smelt (*Hypomesus transpacificus*) is a federal and state ESA-listed fish that is endemic to the San Francisco Bay–Delta. Delta Smelt population abundance has been in decline for decades, yet some aspects of their life history are still a mystery to the scientific community. This study aims to gain an improved understanding of their preferred spawning habitat. We address this question by comparing the distribution of newly-hatched larval (5-6 mm FL) Delta Smelt and ready-to-spawn adult Delta Smelt, and subsequently analyzing habitat attributes of areas where both life stages occur. Our study draws on data from three long-term monitoring surveys: the Smelt Larval Survey, the20-mm Survey, and the Spring Kodiak Trawl. We focus on years 2009 to 2015 to capture a variety of environmental conditions in our dynamic and ever changing Delta ecosystem.

We found 'hot spots' where both ready-to-spawn adult and newly-hatched larval Delta Smelt were present in spatial and temporal proximity to each other, indicating spawning habitat. Using those areas, we explore where spawning is likely occurring, where spawning is not likely occurring, and identify habitat attributes common to those areas. With this information we can start to pin-point the specific spawning substrate that Delta Smelt are using, and in the future could conduct egg surveys in those locations. At the management level, gaining a better understanding of suitable Delta Smelt spawning habitat would better guide habitat restoration efforts and could eventually lead to more favorable Delta Smelt habitat.

Keywords: Delta Smelt, Habitat Spawning, Mature Juvenile

Poster Topic: Fish Biology, Ecology and Protection: Smelt

Maternal effects on egg quality in Delta Smelt (*Hypomesus transpacificus*)

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Maternal effects have the potential to influence important early life-history traits of offspring, such as egg and larval quality and survival. In this study, the relationship between maternal traits (i.e body weight, fork length, and condition factor) and indicators of egg quality (i.e. egg size, and quantity of fatty acids) and larval quality (i.e. larval total length at hatch, oil globule size, and yolk size) were investigated in the endangered estuarine fish Delta Smelt (*Hypomesus transpacificus*). Results show a trend for larger females to produce larger eggs in the first clutch, but this relationship diminishes in the second clutch of eggs, which were generally smaller than the first clutch. Using mixed effect linear models to analyze relationships between maternal traits and indicators of offspring quality revealed that the condition factor of the female, egg size, and clutch (first or second) were predicting variables of the quantity of important fatty acids (Omega-3's) required for larval growth and survival. This study highlights that factors affecting adult female size and condition may have transgenerational effects, as offspring from larger females may have an advantage in growth potential (e.g. via more nutritional resources in the egg) and thus a higher survivorship. These findings have long-term implications at the population level for the Delta Smelt, as sub-optimal environmental conditions (e.g. reduced food availability) in the San Francisco Estuary Bay-Delta may impact the growth of adult fish and in turn indirectly affect the offspring fitness leading to negative consequences for the population after multiple generations.

Keywords: Delta Smelt, maternal effects, egg quality, larval survival

Poster Topic: Fish Biology, Ecology and Protection: Smelt

Longfin Smelt Distribution, Abundance and Evidence of Spawning in San Francisco Bay Tributaries

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The Longfin Smelt Project Work Team has identified various studies that would expand our current understanding of Longfin Smelt distribution, abundance, abundance trends, spawning location(s), and the relationship between Delta outflow and longfin smelt abundance (e.g., Kimmerer 2002). The UCD Fisheries Research Team launched a field survey in 2015 to document the geographic extent of longfin smelt adult distribution and larval rearing in San Francisco Bay tributaries. In four tributaries, (Napa River, Sonoma Creek, Petaluma River, and Coyote Creek) adults were sampled using an otter trawl while larvae were sampled using CDFW's Smelt Larval Survey sled biweekly from January-March. In the pilot study year 2015, adult longfin smelt were found at the upstream extent of each bay tributary, with Coyote Creek having the highest catch. Larval longfin smelt were found at various areas along Napa River, Sonoma Creek, and Petaluma River. No larval longfin smelt were found in Coyote Creek. In the second year of the study the team was able to expand with extended fresh water areas into San Pablo bay as well as extending the sampling time frame through use of the 20mm net from March to June. In 2016 longfin smelt were caught in all three gear types at various life stages. Through expanded sampling locations and gear types, UCD is gaining additional information on water quality features coinciding with larval longfin smelt presence.

Keywords: Longfin Smelt Project Work Team, San Francisco Bay Tributaries

Poster Topic: Fish Biology, Ecology and Protection: Smelt

Field Calibration of the SmeltCam

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The SmeltCam functions as an open-ended codend that automatically collects information on the number and species of fishes that pass freely through a trawled net without human handling. The SmeltCam captures high speed images of object passing through it and a computer algorithm attempts to differentiate fish from other objects and to identify the species of fish. Recent research has indicated that the SmeltCam is an effective tool for field studies of Delta Smelt and other fishes. Here, we report on a field calibration study of the SmeltCam. The study involved placing a closed codend on the back of the SmeltCam during day and night sampling and comparing the species and numbers of fishes cpatured in the codend with those observed by the SmeltCam. This field calibration compliments previous laboratory flume studies and provides information that improves the functionality of the SmeltCam. Continued development of the SmeltCam will provide an effective tool to study rare and sensitive species in the Bay-Delta.

Keywords: smeltcam, delta smelt, sampling methods

Poster Topic: Fish Biology, Ecology and Protection: Smelt

Identification of Individual Cultured Delta Smelt Using Visual and Automated Analysis of Natural Marks

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Given the limited availability of tagging methods for individual small fishes, we evaluated the feasibility of external natural marks to identify subadult-adult Delta Smelt (*Hypomesus transpacificus)* produced at the Fish Conservation and Culture Lab (FCCL). As potential natural marks we selected the dorsal head area (DHA) where external pigmentation is particularly abundant. To verify the effectiveness of natural marks, fish were individually tagged using Visible Implant Alpha tags. Three photo sessions were conducted beginning 230 and 244 days post-hatch in two fish groups over two periods, respectively (January-May 2013 and October-April 2014-15), with the latter group including low and high light treatments to evaluate the influence of light on natural marks. We used a digital camera to acquire DHA and evaluated their effectiveness as natural mark using visual (naked eye) and automated image recognition (TinEye's Match Engine API). Shorter intervals between photo sessions (nearly 56 days in 2013 and 90 days in 2014-15) resulted in higher correct matching for both visual recognition (100% in 2013 and 70-100% in 2014-15) and automated recognition (59-89% in 2013 and 19-33% in 2014-15). Pigmentation generally became less apparent under the high light treatment, leading to a marginally lower percent of automated recognition relative to fish under low light. Unlike visual recognition for the 2014-15 sessions, the percent of correct visual matching in the 2013 sessions remained constant (100%) as a function of the number of days between sessions, suggesting a smaller change in pigmentation during the maturation and spawning periods (winter-spring) than before maturation (fall-winter). These results suggest natural marks may be more reliable to track cultured Delta Smelt at the adult stage than from the sub-adult to adult stage. Application of natural marks in wild fish requires further testing as preliminary observations revealed significantly lower DHA pigmentation in field-caught adult Delta Smelt.

Keywords: Delta Smelt, tagging, pigmentation, image recognition, natural marks

Poster Topic: Fish Biology, Ecology and Protection: Smelt

Can We Tag Delta Smelt? Feasibility of PIT and Acoustic Tagging of Cultured Adults

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Delta Smelt abundance has declined to a record low, resulting in major resource management issues and increased demand for better information. To date, information on the movement, survival, and behavior of Delta Smelt has been principally inferred from collection of fish during trawling and salvage monitoring. Recent advances in miniaturization of passive integrated transponder (PIT) tags and Juvenile Salmon Acoustic Telemetry System (JSATS) transmitters now allow these technologies to be considered for smaller fishes such as Delta Smelt. The ability to track individual Delta Smelt would substantially improve knowledge of the species' habitat use, migration routes, and entrainment vulnerability. Building on a growing body of juvenile salmonid telemetry research, this study investigated 28-day survival and tag retention of cultured Delta Smelt (>70 mm) intracoelomically fitted with PIT tags (8.4 mm, 33 mg) and prototype JSATS transmitters (15.0 mm, 220 mg). Survival of PIT-tagged individuals was high (95%). Survival of individuals with injected and surgically inserted dummy acoustic tags was lower (50-60%). Tag retention was high in all tag treatments (95-100%). These results indicate that Delta Smelt fitted with PIT tags can be used to examine management actions, subject to additional behavioral and physiological studies, but acoustic tags must be made smaller. Logistic regression suggests that survival of >90% would require a maximum tag mass/body mass ratio near 0.02.

Keywords: Acoustic telemetry, Passive integrated transponder, Delta Smelt, JSATS, Tagging techniques

Poster Topic: Fish Biology, Ecology and Protection: Smelt

Trophic Ecology of Zooplankton and Larval Fish the Cache Slough Complex

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The San Francisco Bay-Delta food web production and linkages appear to be declining. Much of that decline is thought to be related to a large phytoplankton decline that occurred after the 1987 introduction of the Asian clam, *Potamocorbula amurensis.* However, the role of the Delta's detrital food web may also be compromised because areas of emergent wetlands in the Bay-Delta are now extremely limited. Detritus-based food webs, however, have received relatively little attention in the region. Given the historical Bay-Delta landscape, non-phytoplankton detrital material could play an important role in supporting planktivores such as delta smelt and other analogous pelagic fishes.

For this project, we tracked food web relationships among primary producers, zooplankton, and larval fish in the Cache Slough Complex- a tidal freshwater region in the north delta exhibiting high numbers of larval delta smelt, as well as emergent marsh ecosystems. We characterized variation in primary prey taxa of planktivorous larval fish (delta smelt, threadfin shad, Mississippi silversides, gobies, and prickly sculpin). We compared larval fish diets across species, as well as across time (April-June 2015), and among six locations representing vegetated and open water habitats. We found minimal differences in diet across space, time, and species. Diets of the larval fish species examined were dominated by the non-indigenous calanoid copepod *Pseudodiaptomus forbesi* (59-100% numerically), followed by rotifers and other unidentifiable copepods. This reflected the assemblage structure of mesozooplankton sampled concurrently with the larval fish, which was also dominated by *P. forbesi*.

Another goal of our study was to determine the respective contributions of phytoplankton and detrital organic matter as food web sources supporting larval fish and zooplankton. Stable isotope (MSI) signatures of larval fish and zooplankton indicate that a mixture of detritus from within the Liberty Island/Cache Slough Complex, phytoplankton and filamentous green algae.

Keywords: food web, larval fish, zooplankton

Poster Topic: Food Webs

Are there Non-Target Impacts of *Eichhornia crassipes* Management on Aquatic Invertebrate Communities?

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We investigated the impacts of *Eichhornia crassipes* management on aquatic invertebrate communities of the Sacramento-San Joaquin River Delta. Using a Before, After, Control, Intervention (BACI) experimental design, we sampled aquatic invertebrate communities per plant biomass before and four weeks after herbicide application in *Eichhornia crassipes* mats. We selected five herbicide treatment locations paired with five control locations. For each sampling event, we collected four random samples of plants and associated invertebrates per site using a custom-built ¼ m^2 quadrat with a 250µm mesh pouch. Invertebrates were preserved in 70% ethanol and sorted to genus level in the laboratory. Plant material was dried and weighed to obtain dry biomass measures. Our assessment of treatment versus control locations before and after the time of treatment indicates that seasonality has a stronger influence on invertebrate abundance and diversity measures than weed management activities. The abundance of invertebrates per plant biomass collected four weeks after the time of treatment was approximately 8% greater at control locations and approximately 10% greater at treatment locations – neither constituting a significant difference. Neither species richness nor evenness are significantly different before and after treatment. The primary community-level difference noted before and after treatment is a significant rise in the number of predators present after treatment. For example, spiders and damselflies are significantly more abundant after treatment and may eventually contribute to increased top-down controls of primary consumer populations. This research is important for informing management decisions surrounding aquatic vegetation and the ways in which management may impact littoral food webs. Overall the impacts of current treatment activities appear to be minimal for invertebrate communities associated with water hyacinth. These findings are useful given the urgency for aggressive water hyacinth management in the Delta and indicate that current management practices are not strongly influencing Delta invertebrate food webs.

Keywords: *Eichhornia crassipes* management, aquatic invertebrate communities, non-target impacts, food webs

Poster Topic: Food Webs

Response of the Yolo Bypass Floodplain to a Spring Flow Pulse

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The Yolo Bypass is the largest floodplain to the Central Valley, with complex hydrology that includes Sacramento River floodwaters and flows from a series of west-side tributaries. This complex network of tributaries all flow into the Toe Drain channel on the east side of the Bypass, which maintains year-round connectivity to the Sacramento-San Joaquin Delta. Much like other seasonal floodplains, late-winter and spring inundation of the Yolo Bypass has shown to enhance both local and downstream phytoplankton productivity. Previous Yolo Bypass floodplain studies have supported the flood-pulse concept (Junk et al 1986), providing evidence that variability in river-floodplain connectivity benefited in-channel phytoplankton biomass. In March 2016, the Yolo Bypass experienced a two week period of floodwaters from the Fremont Weir that inundated the floodplain for approximately three weeks. As a result of continuous data collected in the Toe Drain below Lisbon Weir by a multi-parameter water-quality instrument, we were able to capture a high resolution time-series of estimated chlorophyll-*a* (chl *a*) trends as they varied before, during, and after the inundation period. We further analyzed how the chl *a* concentrations related to key physical variables such as flow, stage, water temperature, turbidity, and specific conductance. Initial analyses show that there are significant differences before, during, and after floodplain inundation for all physical variables (ANOVA $p < 0.001$), with a notable increase in mean water temperature and a decrease in turbidity as the floodplain drained into the Toe Drain. In addition, water temperature and specific conductance were strongly correlated to changing chl *a* concentrations (Pearson Correlation $p<0.001$), throughout the flooding event. Our analyses provide further insight for managers seeking to learn more about the Yolo Bypass floodplain as it functions in local and downstream food web production and export.

Keywords: Yolo Bypass, floodplains, flow, chlorophyll a

Poster Topic: Food Webs

What's For Dinner? A Compositional Study of Particulate Organic Carbon in the San Francisco Bay-Delta

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The San Francisco Bay-Delta boasts an expansive historical data record ranging from fish population surveys to real-time water quality monitoring, but surprisingly little is known about the variability in particulate organic carbon (POC) across time and space and its effect on the lower food web. POC is a major source of energy for zooplankton, which lie at the base of the aquatic food chain. The sources of POC are diverse, especially in dynamic tidal systems such as the San Francisco Bay-Delta. Autochthonous POC may be attributed to phytoplankton, submersed or floating aquatic vegetation, or non-phytoplankton microalgae. Riverine detritus, agricultural drainage, and urban runoff may also contribute to an allochthonous pool of POC that can be processed by the lower food web. As part of a larger study linking POC sources with zooplankton growth, we collected POC samples seasonally along a transect from San Pablo Bay to the Sacramento-San Joaquin Delta, where sampling sites were selected to take advantage of the rich historical survey and monitoring data. Samples were analyzed for lignin, chlorophyll a, $\delta^{13}C$, and $\delta^{15}N$. Feeding experiments with the calanoid copepod *Eurytemora affinis* were conducted in order to assess the relative bioavailability of collected POC. This work sheds light on the spatial and temporal heterogeneity in POC composition, and, linked with water quality monitoring data, may help to predict shifts in carbon sources to the San Francisco Bay-Delta food web with changes in land-use and climate.

Keywords: particulate organic carbon, food web, source

Poster Topic: Food Webs

Is the Cache Slough Complex a Source Region for Zooplankton in the Upper San Francisco Estuary?

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The Cache Slough Complex (CSC) is a highly productive area that supports a resident population of delta smelt. Our project is part of a collaboration among several research groups to determine what makes the CSC good fish habitat and its importance as a source of zooplankton prey for fishes. Our specific focus was on estimating the flux of zooplankton between the shallow flooded islands and channels that connect the CSC to the broader estuary. The southern entrance of Liberty Island was chosen for initial field work because an Acoustic Doppler Current Profiler had been installed there and calibrated to provide high-frequency measurements of discharge needed to calculate the flux of zooplankton. We sampled semi-continuously over a complete tidal cycle during 3 discrete events in June, July and October of 2015. Zooplankton were collected with a submersible pump deployed at 1 m depth and discharging into a 150 um net. Samples were collected for 20 minutes every half hour for 26 hours. The target species, the calanoid copepod *Pseudodiaptomus forbesi*, was identified to gross life stage and counted. The flux of copepods was calculated as the summed product of volumetric discharge and zooplankton abundance. Copepodites were patchy and their highly variable abundance was uncorrelated with flow. Preliminary results with adult abundance suggest no net flux in June, a landward flux into Liberty Island in July, and a possible weak seaward flux out of Liberty Island in October.

Relevance: It is commonly thought that zooplankton produced in shallow habitats are exported to provide a source for the larger estuary. Our results so far do not support this theory; however, similar flux measurements should be made in other locations in the CSC and elsewhere to broaden our understanding of the magnitude and conditions leading to export fluxes.

Keywords: copepods, flux, Liberty Island

Poster Topic: Food Webs

Carbon Uptake by Single Celled Microalgae in the Benthic and Pelagic Zones of Historical Wetlands

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Wetlands of the San Francisco Estuary (SFE) comprise many different hydrological and morphological environments. These diverse habitats provide a variety of ecosystem services, such as carbon sequestration and food web support through organic matter production and export. Due to this provision, former wetlands- both of the SFE and globally- that were historically diked off for agriculture or development are now being converted back to prior condition in order to restore ecosystem processes. At present comprehensive functioning of SFE aquatic wetlands and the ecosystem services they provide are not well defined to enable evaluation of such restoration. This study determined rates of primary production by benthic and pelagic microalgae in historic wetlands to evaluate their relative impacts on carbon cycling and provide a potential framework to evaluate future wetland restoration efforts. Microalgal biomass (chlorophyll concentrations) and productivity ($H^{13}CO_3^-$ uptake) were measured monthly along with nutrients and dissolved inorganic carbon from February to October at two historic wetlands, China Camp State Park (San Rafael, CA) and Rush Ranch Open Space Preserve (Suisun City, CA). Chlorophyll concentrations and areal primary production by benthic microalgae frequently exceeded that of the pelagic microalgae, despite the benthic algae having lower physiological carbon uptake. These results yield insight into the carbon cycling of single celled algae in historic wetlands and provide baseline knowledge for the potential of restored SFE habitats to provide valuable ecosystem services.

Keywords: Carbon cycling, microalgae, benthic, wetlands, restoration, organic subsidies

Poster Topic: Food Webs

Phytoplankton Community Structure in the Lower South Bay Margins

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There has been growing concern over eutrophication in the San Francisco Estuary. Historically this system has shown a strong resilience to the effects of eutrophication, however, over the past decade that resilience appears to be weakening in the form of increased phytoplankton blooms. In particular, the Lower South Bay (LSB) sub-embayment has relatively high nutrient levels because it receives discharge from three wastewater treatment plants. The nutrient inputs combined with a long hydraulic residence time of the shallow LSB raises additional concern for phytoplankton blooms and harmful algal blooms (HABs). There is also concern that restored and managed salt ponds in the LSB may promote growth for HAB species.

The San Jose- Santa Clara Regional Wastewater Facility (Facility), the largest wastewater treatment plant in the LSB, has been monitoring the water quality of LSB for decades. To address the growing concern of potential for eutrophication, we began phytoplankton monitoring in 2013 to track any changes in phytoplankton community structure and to gather baseline information on lower trophic level community composition. Our phytoplankton data show an overall dominance of diatoms in the bayward stations and an increase dinoflagellates in the margin areas (Alviso-Coyote Creek) where there are numerous restored and managed salt ponds. Also within this area is Artesian Slough, which showed the highest phytoplankton densities of our data set. This fresh to brackish slough receives discharge from the Facility as well as two managed salt ponds.

Currently, this is the only monitoring for phytoplankton species in the margins of the Lower South Bay. The tidal exchange between the Lower South Bay and its margins is extensive so it is imperative to characterize phytoplankton in this area to gain a better understanding of how it may vary between ponds and sloughs and during bloom periods.

Keywords: Phytoplankton, salt ponds, Lower South Bay, Harmful Algal Blooms

Poster Topic: Food Webs

Sacramento River Phytoplankton Growth: Relative Importance of River-Water Sources, Light, Nutrients, and Clam and Zooplankton Grazing

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Phytoplankton in the Sacramento River can be an important food source for other aquatic organisms, but phytoplankton biomass has been observed to decline along the river between the City of Sacramento and the confluence with Cache Slough. Recent studies suggest that phytoplankton decline in the river does not appear to be driven by effluent-derived nutrient concentrations. The goal of the project is to evaluate mechanistic factors that potentially limit phytoplankton growth within the Sacramento River. Our approach is to conduct a controlled mesocosm experiment to determine the relative importance of river-water sources, light availability, clam grazing, nutrient concentrations, and zooplankton grazing on phytoplankton growth. In June 2016 we will conduct a phytoplankton growth experiment in a series of 10-L cubitainers. Phytoplankton will be collected from two locations along the Sacramento River, <1 mile and 24 miles upstream of the Sacramento Regional Wastewater Treatment Plant (SRWTP). Phytoplankton will be held in a sheltered location within the river to determine population growth rates under different experimental treatments, including low and high light levels, presence and absence of bivalve grazing, and presence and absence of wastewater effluent, with three replicates each. Each cubitainer will be sampled at 24 and 48 hours for nutrient concentrations, dissolved silica, chlorophyll-a, picoplankton, and phytoplankton enumeration. Following final sampling, the remaining contents of each cubitainer will be used to conduct nutrient uptake experiments. The effect of microzooplankton grazing on phytoplankton biomass (chlorophyll-a) will be assessed in a separate set of 2-L cubitainers filled with varying dilution ratios of unfiltered river water and river water filtered to remove zooplankton, then held in the river for 24 hours. The results of the project will be of value in assessing phytoplankton productivity before the SRWTP upgrades (the EchoWater Project) and may be used to inform future management of the river ecosystem.

Keywords: Sacramento River, phytoplankton growth, mesocosm, light, clams, wastewater effluent, zooplankton

Poster Topic: Food Webs

The Molecular Ecology of SF Delta *Microcystis*

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Problem Statement: *Microcystis* blooms are a growing concern within the SF Delta food web due to their ability to produce harmful metabolites and because of their poor nutritional value. We hypothesized that these blooms may directly influence zooplankton fitness via the production of secondary metabolites (e.g., microcystin) or indirectly due to nutritional stress stemming from their ability to outcompete other beneficial algae (e.g., diatoms and cryptophytes).

Approach: We used a suite of genetic tools, including: quantitative PCR, amplicon and shotgun metagenomics in order to characterize the molecular ecology of SF Delta *Microcystis* blooms. Samples were collected from six sites during the summers of 2011-2012 (*n*=72). Physicochemical data were related to strain composition in order to assess whether certain habitat conditions selected for toxigenic strains of *Microcystis*.

Results: On the basis of 16S-23S rRNA ITS sequencing, we identified the presence of at least 10 strains of *Microcystis* within the freshwater region of the SF Delta, even though only two colony morphologies were observed. We estimate that at least six of these strains are capable of producing the hepatotoxin microcystin. We also identified *Microcystis* genes involved in the production of a number of other secondary metabolites that may negatively influence zooplankton fitness. A comparison of microbial community structure before, during and after a *Microcystis* bloom revealed a significant reduction in microbial diversity during the bloom.

Conclusions/Relevance: In this study, we identified the presence of several strains of *Microcystis* occurring within the Delta, each with the ability to produce a range of bioactive metabolites that may directly or indirectly influence the health and nutrition of key zooplankton species important to the food web. We speculate that trophic upgrading by bacterivorus microzooplankton may be an important link in the Delta food web worthy of future study.

Keywords: *Microcystis*, toxins, genetics, pelagic organism decline, food web

Poster Topic: Food Webs

Are Current Sampling Programs Accurately Describing Zooplankton Distributions on Scales Relevant to Feeding by Fish?

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We conducted a study of zooplankton distributions in the upper San Francisco Estuary at small scales (tens to hundreds of meters). The present study 1) assessed how representative the Interagency Ecological Program (IEP) zooplankton monitoring program is and 2) investigated the variability of plankton on scales similar to those of foraging by fish. Samples were taken near Brown's Island, West Island, and Big Break along the lower San Joaquin River. Sets of 6 samples were taken with a plankton net along transects from near shore to center channel, and sets of 10 samples were taken in the vicinity of a drifter. Sampling took place during June-July 2014 during neap and spring tides, ebb and flood, day and night. Analysis focused on three common copepod species. Transect samples showed little consistent variation along transects except that *Pseudodiaptomus forbesi* at Big Break was less abundant near shore than offshore by day. The ratio of adults to adults+copepodites was strongly related to turbidity by day but not by night, indicating demersal behavior. Drifter samples showed a minimum standard deviation of $\log_{10}$ sample counts of about 0.1, indicating that about 2/3 of replicate samples with adequate counts were within 80-125% of the mean. A measure of difference between plankton samples at pairs of stations was weakly related to distance between sample points but only at scales over ~300 m. These results show that the IEP sampling program is representative of plankton abundance considering small-scale and cross-channel variability, but not for demersal organisms which can be 10-fold more abundant by night than by day. Both sets of samples showed that small planktivorous fish could forage in patches of ~25% higher abundance of the mean.

Keywords: Copepod, Sacramento-San Joaquin Delta, patchiness, fish, demersal behavior, turbidity, salinity

Poster Topic: Food Webs

Delta Boundary Conditions: Plankton Communities and Water Quality in the Sacramento River and its Tributaries

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Phytoplankton in the Sacramento River can be an important food source for other aquatic organisms, but phytoplankton biomass has been observed to decline along the river between the city of Sacramento and the Cache Slough confluence. Recent studies by USGS and others investigating the effects of nutrients from Sacramento Regional Wastewater Treatment Plant (SRWTP) effluent on phytoplankton in the Sacramento River suggested that phytoplankton decline in the river does not appear to be primarily driven by effluent-derived nutrient concentrations. The goal of this project is to evaluate the importance of multiple factors that potentially limit phytoplankton growth within the Sacramento River. Our approach includes coupling a river survey with modeling of water sources and post-survey mapping of phytoplankton growth potential along the river. In May 2016 we conducted a 1-week survey of the river between Knights Landing and Isleton, sampling 11 sites on the mainstem river, and five tributaries along this reach. At each site we collected samples to assess water quality and to estimate the abundance of picoplankton, phytoplankton, microzooplankton, macrozooplankton, and to determine changes in phytoplankton growth rates. At the mainstem sites we also collected clams in five standardized trawls per site. Results will be presented for the variables noted above. River flow is being modeled to identify, for each survey location, the proportion of flow arising from different upstream sources. This research gives a snapshot of conditions along the Sacramento River to inform future management of the river ecosystem, and will provide critical data on Delta boundary conditions for coupled hydrological and ecological models of the river and Delta. The dataset will be of value in assessing river conditions before the SRWTP upgrades (the EchoWater Project), and will encourage the development of hypotheses for future studies to increase our understanding of how river management influences Delta conditions.

Keywords: Sacramento River, tributaries, management, water quality, nutrients, phytoplankton, zooplankton, clams

Poster Topic: Food Webs

Comparative Restoration Attributes in the Cache Slough Complex

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The northern Sacramento-San Joaquin Delta is recognized as home to a notably higher abundance of native fishes than the rest of the Delta region. Little is known, however, as to how different locations throughout the north Delta foster this native fish community. We used otter trawls, minnow traps, beach seines, electrofishing, and zooplankton tows, along with water quality monitoring and habitat assessment, to evaluate the ecological functioning of Cache and Lindsey Sloughs. During the drought conditions of the past three years, sites along Cache Slough displayed sparse submersed aquatic vegetation (SAV), high turbidity, high zooplankton densities, and high concentrations of chlorophyll a. Cache Slough's higher turbidity and zooplankton abundance offered shelter and food resources for planktivorous fishes and the slough displayed a higher abundance and diversity of native fishes than the Lindsey complex. Sites in Lindsey slough contrasted Cache with greater quantities of SAV, low turbidity, and low pelagic productivity. Lindsey's SAV dominated network contributed to more favorable conditions for SAV-associated sunfishes and other non-natives which likely prefer the lower turbidity in the slough for visual predation. In addition to inter-slough differences, we found considerable intra-slough differences in fish assembly and density. Chlorophyll a concentration, zooplankton density and fish density increased toward the terminal ends of the Cache Slough complex. We examine how these differences in slough function can be applied to design and implementation of new restoration projects in the Delta, by considering a few proposed and existing examples.

Keywords: native fishes, drought, restoration, north Delta, ecology

Poster Topic: Habitat & Ecosystem Function Restoration

Beyond the Levee: Strategies for Ecologically Functional High Tide Refugia in San Francisco Bay Tidal Marshes

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In the 1970s, researchers from the U.S. Army Corps of Engineers pioneered revegetation techniques that utilized tidal wetland vegetation to stabilize eroding shorelines in San Francisco Bay and other estuaries throughout the United States. This work emphasized the critical role that vegetation plays in damping wave energy and increasing the shear strength of wetland soils. Since then, the consideration of vegetation in Bay tidal salt marsh restoration has shifted: modern projects tend to prioritize vegetation structure to provide high tide/flood escape cover for listed wildlife species, especially along flood control levees at the landward limit of project sites. Insufficient vegetative stabilization of habitat-priority levees, especially in early tidal restoration stages, may expose levees to episodes of intensive wave erosion from winter storms. This can lead to proposals for rock armoring as pre-emptive or "emergency" levee stabilization. Rock armoring of salt marsh shorelines eliminates high tide refugia, increases high tide predation risk, and conflicts with shoreline transgression upslope as sea level rises. In broad salt marsh plains dissected by tidal channels, listed wildlife are able to find flood refuge within their relatively small home ranges by utilizing high marsh with tall vegetation along the channel banks. In contrast, modern tidal salt marsh restoration projects tend to leave marsh plains with sparse internal high tide cover, instead emphasizing landward-edge high tide cover. This configuration can leave wildlife with no cover within their home ranges, increase wildlife flood movements (and predation risk) during extreme high tides, and set up potential conflicts between wildlife with public trail use of levees. We discuss alternate approaches that balance vegetation and topography for high tide cover and vegetative shoreline stabilization across the entire marsh profile, increase shoreline resilience to accelerated sea level rise, and focus on plant functional traits as well as species composition in vegetation communities.

Keywords: tidal, marsh, restoration, refugia, ecotone, levee, mouse, rail, erosion, vegetation

Poster Topic: Habitat & Ecosystem Function Restoration

Testing a Novel Adaptation Strategy in a California Salt Marsh

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Coastal wetlands around the world are threatened by sea-level rise (SLR). While current research demonstrates that many, but not all, wetlands in California are keeping pace with SLR via sediment accretion, this resiliency is expected to only resist SLR projections for 2030 and likely 2050. To ensure wetland resilience for 2100 and beyond, wetland management must incorporate a range of tools at various scales. The Seal Beach National Wildlife Refuge (Refuge) encompasses 911 acres of remnant saltwater marsh in the Anaheim Bay estuary and is a perfect location to test a new SLR adaptation strategy, sediment augmentation, where a thin-layer of sediment is placed on a marsh plain to raise elevations. The Refuge is currently experiencing elevated rates of SLR (~3Xs higher than other California wetlands; 6.23 mm/yr) due to subsidence and with Orange County's imminent plans to dredge the adjacent harbor; this is the perfect opportunity to test sediment augmentation. This project placed 8-10 inches of clean, dredge material on approximately 8-acres of low-elevation (*Spartina*-dominated) marsh. Sediment was transported by floating pipe and placed on the marsh plain using a rainbow sprayer. One year of pre-construction monitoring, started in April 2015, and five years of post-construction monitoring will determine the effectiveness of sediment augmentation at the Refuge. The monitoring program will assess augmentation effects on elevation and sediment dynamics, creek morphology, carbon sequestration including greenhouse gas flux, invertebrates, emergent and submerged vegetation, and avian communities. The results of this project will be shared via trainings hosted by the USFWS for potential utilization throughout California's salt marsh systems.

Keywords: salt marsh, sea level rise, spartina, tidal wetland, adaptation, resilience

Poster Topic: Habitat & Ecosystem Function Restoration

Facilitating Salt Marsh Formation through Vegetative and Physical Barriers to Erosion

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The predicted acceleration of sea level rise in the mid-21st century has increased the need for salt marshes to build elevation capital in order to adapt to rising seas. Salt marsh restoration projects face an additional challenge of building large quantities of sediment on often-subsided lands in addition to building capital for resilience. A novel restoration technique has been used at the Sears Point restoration site within San Pablo Bay National Wildlife Refuge. Marsh mounds, which were created to buffer wave action, decrease erosion and serve as nuclei for colonizing marsh vegetation, are eroding. This study seeks to determine whether protecting the mounds through vegetation and physical barriers can decrease erosion and facilitate accretion to accelerate marsh formation. We protected mounds using a vegetative treatment of *Spartina foliosa* and a physical barrier treatment consisting of a coir erosion log oriented to intercept either wind-waves or tidal action. We hypothesize that *S. foliosa* will stabilize sediments, eliminating erosion and potentially leading to sediment accretion on the tops of mounds. We further expect that physical barriers to wind-waves or tidal action will reduce erosion, and in conjunction with *S. foliosa* treatments will enhance erosion protection and sediment accretion. In addition, we expect that changes to soil elicited by *S. foliosa* presence will foster development of soil invertebrates associated with tidal marshes and valuable to marsh functions including food web support. Early results show that the tops of unprotected mounds are eroding, while significant sediment accretion is occurring at low elevations on the mounds. We discuss the implications of our results for salt marsh restoration sites in the San Francisco Bay and other estuaries. These findings can be used to evaluate the efficacy of protecting marsh mounds to develop mature marsh, and to inform management decisions at sites replicating the marsh mound design.

Keywords: salt marsh; restoration; *Spartina foliosa*; sediment; erosion

Poster Topic: Habitat & Ecosystem Function Restoration

Decker Island Restoration Project

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Although Bay-Delta managers are likely interested in the final product of restoration actions, the process by which a restoration project becomes reality is just as important in achieving restoration goals and successful management of the ecosystem. Tidal habitat restoration in the Bay-Delta has a varying degree of difficulty based on size, location, existing conditions, permitting requirements, and expected outcomes. The Fish Restoration Program, a cooperative program between Department of Water Resources and Department of Fish and Wildlife, is tasked with restoring 8,000 acres of intertidal marsh and associated subtidal habitat in the Delta and Suisun Marsh as part of a restoration requirement in the federal biological opinions and state incidental take permit for the long-term operation of the State Water Project and Central Valley Project. The Decker Island Restoration Project, located on the Sacramento River in southern Solano County, partially fulfills that goal by providing 140 acres of tidal freshwater marsh. The Project site was once farmed and grazed, but is now partially underwater due to an abandoned rock weir/culvert structure. Existing habitats include a muted tidal wetland with emergent vegetation, riparian trees and shrubs, and ruderal grassland. The restoration team employed multiple phases of modeling, utilized best available science and adaptive management, and held a professional review panel to develop the most beneficial restoration possible while minimizing impacts to the existing wetland and riparian habitats. Permits and environmental documentation are now being pursued, and a monitoring plan is being developed to demonstrate Project effectiveness. Restoration construction is slated for summer/fall of 2017.

Keywords: Decker Island, restoration, tidal wetland

Poster Topic: Habitat & Ecosystem Function Restoration

Giving Land to Water, Placemaking of An Experimental Flooded Polder in the Sacramento-San Joaquin Delta

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Land subsidence, aging levee infrastructure, and predicted sea level rise are creating unique flooded polders in the Sacramento-San Joaquin Delta. Those flooded polders are considered novel ecosystems because it is not economically and ecologically feasible to return them back to historical states. With the continuous climate change and sea level rise, more and more flooded polders are expected to arise. Therefore, this study seeks to discover the design opportunities of flooded polders in order to optimize their future uses and place values in the Sacramento-San Joaquin Delta.

This study is conducted in two phases. The first phase includes case studies on the existing flooded polders in the Delta, interviews towards different groups of stakeholders in the Delta, and fieldwork on the Delta flooded polders. Through this process, the study discovers that that the potential users of the Delta flooded polders are the scientists who study and work at the Delta and the recreationists who enjoy a waterfront lifestyle. During the second phase, this study uses design research to uncover design opportunities of Delta flooded polders by testing out design at an experimental flooded polder: Bacon Island in South Delta. Working with the UC Davis Watershed Center scientists, an ecological planning framework is proposed to intentionally breach the island at three locations, and the design research is built around this ecological framework. Considering the feral nature of the Delta and the fact that minimum investment and maintenance will be allocated to flooded polders, the proposed design is capitalizing around the existing infrastructure with subtle interventions. Through design research, the study discovers that the Delta flooded polders have the chance to become a vivid place where scientists can study ecologies, recreationists can develop friendships, and all users can start a conversation about the Delta future.

Keywords: Flooded Polders, Adaptive Management, Landscape Architecture, Novel Ecosystem Design

Poster Topic: Habitat & Ecosystem Function Restoration

Comprehensive Ecology of *Schoenoplectus californicus*: Recommendations for Restoration of Tule Marsh

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Historically, the Sacramento-San Joaquin Bay Delta has lost more than 95% of its wetlands due to anthropogenic activity. Marsh restoration is a pivotal focus for the state of California. To maximize success of these restoration efforts and enhance decision making tools for effective planning of future restoration projects, it is essential to understand plant colonization and expansion dynamics, as well as constraints on plant species desired in planting efforts. We conducted a seed-bank assay, a field transplant study, a multi-year field sampling effort at Liberty Island, CA, as well as a series of controlled greenhouse experiments to characterize conditions for optimal growth of *Schoenoplectus californicus*. Results from these studies indicate that *S. californicus* expands primarily via vegetative rhizomatous expansion, as seed germination is inhibited by seasonal dormancy and hydrologic regime. *Schoenoplectus californicus* adults can survive extreme flooding conditions (>100% exceedence) as long as a portion of the aboveground biomass remains emergent. However, longer durations of flooding may retard lateral expansion. Lateral expansion may also be impeded by compacted soils; however, results from a soil core collection study indicates that *S. californicus* acts as an ecosystem engineer over time, reducing soil bulk density, adding soil organic matter and ameliorating densely compacted soils at restoration sites. Finally, results from a nutrient study suggest that *S. californicus* stem strength and resistance to lodging can be maximized with silica, particularly in the presence of high concentration of nitrogen. In summary, *S. californicus* is a stress-tolerant species with characteristics ideal for rapid Tule marsh establishment, levee protection and habitat provision. We recommend including *S. californicus* in restoration efforts in fresh to oligohaline tidal marshes, particularly in environments where flooding stress or high energy shorelines may limit the use of other emergent plant species.

Keywords: restoration; tule marsh; *Schoenoplectus californicus*

Poster Topic: Habitat & Ecosystem Function Restoration

Restoration approaches and planning for the Prospect Island Tidal Habitat Restoration Project

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In order to address long term declines of native fishes in Suisun Bay and Delta, the California DWR and DFW initiated planning of the 1,600-acre Prospect Island Tidal Habitat Restoration Project. The project is intended to restore tidal habitat connectivity and function in partial fulfillment of 8,000-ac tidal habitat restoration obligations of DWR, contained within biological opinions (BiOps) for long-term coordinated operations of the SWP and CVP. Physical, biological, and chemical processes were considered in developing screening metrics to relate ecosystem drivers (e.g., hydrodynamics, sediment supply, water quality, vegetation community composition) to species response for Delta Smelt, salmonids, and other native fishes. Hydrodynamic models were used to compare the potential benefits (e.g., phytoplankton production within the restoration site, tidal mixing of exported productivity, changes in intertidal extent) of various conceptual design alternatives, as well as any potential adverse impacts (e.g., promotion of invasive species, changes in flood conveyance, regional salinity). In order to address project uncertainties in addressing productivity and export, selected alternatives represented a range of intertidal connectivity and habitat mosaics. The proposed project is currently undergoing environmental permitting and when completed will enhance primary and secondary productivity and food availability for Delta Smelt and other native fishes, increase rearing habitat for salmonids and other listed species, and provide other ecosystem benefits associated with increased Delta freshwater tidal marsh habitat.

Keywords: restoration, modeling, tidal, habitat, wetland

Poster Topic: Habitat & Ecosystem Function Restoration

Advancing Transition Zone Restoration: Application of Soil Amendments to Increase Vegetation Establishment

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Transition zones between brackish marsh and upland areas of San Francisco Bay are critical habitat for hundreds of species, some of which are threatened or endangered. This habitat is integral for wildlife seeking high tide refugia as well as flood protection during storms. The Baylands Goals Update prioritizes the need to create, restore, and protect this habitat, particularly in anticipation of sea level rise. However, the restoration and creation of large transition zones (10-30 acres) is a relatively new endeavor and restoration practitioners are just beginning to consider how to implement these projects. There is an urgent need for pilot projects to develop methods to cost-effectively revegetate and restore these areas at a large scale.

This study focuses on the challenges of restoring transition zone vegetation on a levee adjacent to marshes in the Palo Alto Baylands. The site is comprised of heavily disturbed, low-nutrient soils from a variety of sources. Standard restoration practices of removing invasive species and planting native plants demonstrated low survivorship after planting in 2011. Subsequently, in 2012 a soil amendment experiment was conducted to explore alternative methods. This ongoing experiment assesses the efficacy of (1) soil tilling, (2) compost addition, and (3) a combination of both to in improve vegetation establishment at a site with low quality soils.

Our results show the highest native plant cover in the compost treatment plot (57.1%), followed by the till and compost treatment plot (34.1%). Both the tilled-only treatment and control showed lower percent cover (3.8% and 23.9%, respectively). While the experiment is ongoing, these results influence our work in adjacent transition zone restoration projects. Looking forward to the future of transition zone restoration in the San Francisco Bay, continued monitoring at this site and these results can inform similar projects to maximize restoration efforts.

Keywords: transition zone, soil amendment, levee, habitat restoration

Poster Topic: Habitat & Ecosystem Function Restoration

Climate Change Adaptations in a North Bay Centennial Marsh

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The Sonoma Creek Enhancement Project was completed in November of 2015, bringing tidal action to a 265 acre North Bay Centennial Marsh, and incorporating several experimental climate change adaptation elements. Audubon, CA, Marin/Sonoma Vector & Mosquito Control District and the San Pablo Bay National Wildlife Refuge partnered on this project and worked with ESA and Hanford, Arc to improve the ecological function of the Sonoma Creek Tidal Marsh Ecocsystem, and to prepare the system for Climate Change. The central component of the project was a 5,460 ft. long, 7 ft deep, 5 acre drainage channel, which was excavated from Sonoma Creek, through the 100 acre depressed central marsh basin of Sonoma Creek Marsh. The channel allows daily tidal waters to innundate and flush the previously stagnant water which accumulated in the central basin, killing and degrading marsh vegetation and wildlife habitat, and providing mosquito breeding grounds. Along with the myriad benefits that daily tidal flushing and draining bring, the tidal waters deposit sediment and increase bio-accumulation through increasing plant health and biomass. These processes will allow the central basin and eventually the 265 acre Sonoma Creek Marsh to build vertically in to the future. Twenty 20 foot wide by 50 foot long, and approximately 2 foot above mid marsh plain, marsh mounds were constructed on either side of the central channel. These will provide high tide refugia for endangered species and other marsh dwelling wildlife as storms become more frequent and intense. A seven acre 40:1 gently sloping transition ramp, built against the marsh side of the Tubbs Island levee also provides high tide refugia, and will allow geomorphological space for active and passive re-colonization of native transition zone plant communities, which are now in decline and which are anticipated to be adversely affected by Climate Change without active management.

Keywords: Climate Change, Enhancement, Transition Zone, Adaptation, High Tide Refugia

Poster Topic: Habitat & Ecosystem Function Restoration

A Storm Water Basin with Growing Diversity

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Upper Sand Creek Basin (USCB) is located in East Contra Costa County. The site was designed to fill multiple needs of the community. Of primary importance, the retention basin serves to manage storm water runoff from the streets of Antioch and from Sand Creek. The retention basin was designed to protect the cites of Brentwood and Oakely during periods of high rain fall. Other goals of USCB were environment enhancement, habitat restoration and open space. To help achieve those goals, within USCB 10 acres of constructed wetland was established with a natural creek design. In the Spring of 2014 under the coordinated effort of a local community organization (Friends of the Marsh Creek Watershed), and Contra Costa Flood Control, over 150 volunteers came together to plant California native trees and bushes.

The result is that today, just two years later, USCB is host to hundreds of red wing black birds, swallows, and the occasional red tail hawk. A few Blue Oak have grown almost 2 meters tall, with cottonwood, buckeye growing nicely as well. Tule was not planned but now lines 100% of the bank. Upper Sand Creek Basin will only become more diverse with species as the oaks, cottonwood and willows mature. Since the initial planting the local community has been out to help weed around the young saplings and mulch, and clean up trash that flows in during high rain events. More ideas to involve the community with the site are; a quarterly bird census, insect community evaluation, a benthic macroinvertebrate survey and we plan on testing alternative methods of hebivory protection to maximize oak sapling survival. Thanks to the insight of the Contra Costa Flood Control to construct Upper Sand Creek Basin we will have the opportunity to learn how our management practices effect developed wetlands.

Keywords: Storm water retention basin, constructed wetland, community involvement

Poster Topic: Habitat & Ecosystem Function Restoration

The Oro Loma Horizontal Levee Demonstration Project - Scaling Up Native Species Propagation Methods to Accommodate Large Transition Zone/Ecotone Projects of the Future

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The Baylands Ecosystem Habitat Goals Report Update emphasizes the need to protect and restore 100,000 acres of tidal marsh habitat. Around the bay, project sites totaling approximately 35,000 acres of tidal marsh are currently awaiting restoration. Many of these projects include large transition zone/ecotone habitats, a habitat type fundamental in protecting against sea level rise, providing wildlife refugia, and increasing biodiversity. Pilot projects to test methods for restoring baylands processes are a high priority, particularly to identify the most effective techniques to restore significant acreage in the face of sea level rise.

The Oro Loma Horizontal Levee Demonstration Project constructed an ecotone slope, designed to provide transition zone functions, at the Oro Loma Sanitary District facilities in San Lorenzo, CA. The native species assemblage for the project was chosen to mimic historic moist grassland/bayland ecotone habitat that has been largely eradicated from San Francisco Bay.

The plant propagation methods for the project were designed to “scale-up” and to reduce the cost and time of growing large numbers of plants propagated in a nursery setting. Over 70,000 plants were grown to vegetate the ecotone slope. Propagules were sourced locally from remnant plant communities of the East Bay. The majority of plants were grown in a large scale and low-maintenance method at a division bed nursery constructed on the Sanitary District property adjacent to the project site. This approach reduced the amount of vegetative material initially collected by utilizing the species ability to propagate rhizomatously.

Within the compressed timeline of one year, the species chosen for the project thrived in the division bed nursery environment, producing healthy rooted stock and greatly surpassing the 70,000 plants requested. The demonstration project established a low-cost and low-intensity labor method for large-scale plant propagation and can inform propagation methods for future large-scale ecotone/transition zone restoration projects.

Keywords: Native plant propagation, Transition zone, Demonstration project, Sea level rise

Poster Topic: Habitat & Ecosystem Function Restoration

Restoration Design in the Sacramento-San Joaquin Delta: Lessons from Case Studies

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While the goals for tidal, floodplain, and riparian restoration projects in Delta may range from meeting habitat mitigation needs to providing other benefits such as flood attenuation or water quality improvements, the common goal of restoring self-sustaining native habitats and ecosystems means that most, if not all, restoration projects should be based upon a common set of principles and tools to ensure success. This requires awareness of tidal and riverine processes and disturbance regimes, vegetation, fisheries, and wildlife response to these processes as well as ecological interactions. The ultimate measure of our success will be the degree to which native species are able to use and thrive in the habitats we provide. We build upon experiences throughout the Delta using specific examples to illustrate a variety of methods for restoring ecosystems for a sustainable future. Case studies include projects aimed at enhancing the physical template to restore ecological processes such as restoring tidal action in the Cache Slough region to enhance primary and secondary productivity and food availability for Delta Smelt and other native fishes; increasing tidal access and tidal wetland habitat in the central Delta to support spawning and rearing of salmonids; and combining changes to the physical template with revegetation in the eastern Delta to benefit giant garter snake and native fishes. Another project in the central Delta involves no changes to physical site conditions but is focused on improving vegetation composition and structure to support wildlife diversity, including benefits to Swainson's hawk. For all these projects, the explicit integration of ecosystem processes operating at appropriate scales is a fundamental part of planning, implementation, and adaptive management. Practical but often critical matters of site selection, sequencing, funding, stakeholder interactions, and permitting are also recognized as equally important aspects of restoring or enhancing the Delta for native species.

Keywords: tidal, floodplain, restoration, self-sustaining, ecosystems, revegetation, productivity, Delta Smelt, salmonids

Poster Topic: Habitat & Ecosystem Function Restoration

Invertebrate Responses to Eelgrass and Oyster Restoration in a San Francisco Estuary Living Shorelines Project

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This research was conducted to monitor the response of aquatic macroinvertebrate populations to the restoration of intertidal habitat, including eelgrass (*Zostera marina*) and native oyster reefs (*Ostrea lurida*) in the San Francisco Estuary. Plots of each habitat-forming species, alone and interspersed, were established in 2012 and 2013 by the State Coastal Conservancy's Living Shorelines: Nearshore Linkages project (LSP). Living shorelines have been used throughout the world to reduce physical impacts on shorelines (e.g., increased wave action from storm surges and sea level rise), while simultaneously providing habitat to intertidal invertebrate and fish species. The LSP was the first project in the Estuary to implement restoration of eelgrass and oyster reef at a scale large enough (30m x 10m plots) to quantify both biological and physical results. Quarterly invertebrate monitoring was conducted in the restoration plots for one year prior to restoration (2011-12), and for two years post restoration (2012-15), using a series of traps, shoot collection, and vacuum sampling. The results from the trapping and suction sampling were intended to inform the degree to which restored eelgrass and oyster reef habitat, alone and together, promote colonization and use by invertebrates. The results from the shoot sampling were intended to determine if epiphytic invertebrate assemblages vary significantly between natural and restored eelgrass beds in the Estuary. Within two years, correspondence analysis revealed that eelgrass and oyster reef supported a unique invertebrate assemblage composition as compared to baseline and control plots, and that the composition was intermediate in combined eelgrass/oyster plots. Restored eelgrass has not established an assemblage equivalent to natural beds; several invertebrates beneficial to eelgrass growth are absent. We conclude that habitat structure provided through restoration will quickly support many invertebrate species, but some may require manual addition to provide the full range of natural functions.

Keywords: Living shorelines, eelgrass, oyster, restoration, San Francisco Estuary, invertebrate

Poster Topic: Habitat & Ecosystem Function Restoration

Coon Creek Watershed Assessment: An Interdisciplinary Approach for Evaluating Impacts and Developing a Restoration Strategy for a Foothill Watershed

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Many Sierra foothill watersheds suffer from a complex history of land use and flow management impacts that have caused impairment of physical processes and declines in anadromous salmonid populations. However, accurate assessment of the causal factors driving these problems and the subsequent development of watershed-appropriate rehabilitation and management strategies remains challenging. This presentation describes an interdisciplinary watershed assessment of Coon Creek, a foothill stream draining a 112-square mile catchment with its headwaters near Auburn. The watershed's numerous impacts include channel modification, flow manipulation, unscreened diversions, fish passage barriers, agricultural encroachment and urbanization. Nonetheless, the catchment remains one of the least developed foothill watersheds in the area and is prioritized by Placer County for protection and restoration actions. We adopt a 'spatially-nested' approach to generate a process-based understanding of the basin across multiple spatial scales and to identify causal mechanisms of watershed impairment. A fluvial audit assessment characterizes sediment supply and storage, vegetation influences and river engineering at the sub-reach scale to establish an understanding of the system's geomorphic processes and controls. Investigation of flow management, particularly base flows, at both the reach and basin scale characterizes impacts of water supply operations on various aspects of salmonid life cycle history. Combining this work with anadromous fish habitat assessments, targeted juvenile fish surveys, riparian habitat assessments, and water quality monitoring facilitates an integrated understanding of physical and ecological functions. This interdisciplinary methodology enables us to assess impacts of flow management and to identify controlling factors for anadromous fish decline. This approach also facilitates the development of cost-effective and appropriate process-based restoration and management strategies that include collaborative projects with water management agencies.

Keywords: Process-based restoration, flow management, salmonid, foothill

Poster Topic: Habitat & Ecosystem Function Restoration

What do Skaggs Island and Sagrada Familia have in Common?

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What could the 4,400-acre Skaggs Island in San Francisco Bay have in common with a famed Roman Catholic minor basilica in Barcelona, Spain? Skaggs Island was converted from tidal marsh into agricultural land in the 19-teens. In 1940, the U.S. Navy purchased 3,300 acres, leaving the remainder in farming. The primary goal of the restoration project is to restore the complex mosaic of estuarine tidal marsh habitats to support native plant and animal species. An overarching challenge is building sea level rise resiliency into the project design to ensure these habitats persist as sea level rises. Both parcels have subsided 6 feet below surrounding high marsh on average.

Beneficial reuse was considered, but sediment supply is limited. Roughly 1 million cubic yards is available annually, with far greater demand at this and other sites. With 40-70 million cubic yards of capacity, this would be a multi-decadal project with a completion horizon at least 50 years in the future. Similarly, the Sagrada Familia was conceived of and designed by Antonin Gaudi with his expectation that it would be completed by others decades after his death.

To accelerate this timeline, our current conceptual approach is a 3-pronged strategy that includes (1) subsidence reversal, (2) passive restoration of a portion of the site nearest the Bay, and (3) active restoration with dredged sediment import. Rainwater captured across the island would be pumped onto roughly 550 acres reduce salinity to favor growth of bulrush and other large rhizomatous plants to build root biomass and reverse subsidence. A portion of the site nearest the mouth of Sonoma Creek would be breached to passively capture available sediment. Beneficial reuse of dredged sediments would be used to raise the elevation of the majority of the site to some combination of marsh and upland elevations.

Keywords: resilience, marsh restoration planning & design, sediment reuse, subsidence reversal

Poster Topic: Habitat & Ecosystem Function Restoration

Long-Term Changes in Spatial Structure of Restored Wetlands within the Sacramento-San Joaquin Delta of California

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The Sacramento-San Joaquin Delta of California is a prime setting to study interactions between restored ecosystems, pristine habitats, and human-modified landscapes. Major land transformations have deteriorated ecological services historically provided by the Delta and hampered its resilience against global changes. In response, substantial work has been applied toward restoring degraded wetlands of the region. Yet post-restoration monitoring efforts have been lacking and few studies have analyzed the progress made to date at the regional scale. A thorough landscape perspective on wetland restoration is critical for understanding historical shortcomings and better equipping future restoration projects for increased ecological gains. We used 10 years of high resolution imagery from the National Agriculture Imagery Program to characterize changes in spatial structure of thirty wetlands restored between 1995 and 2015, then compared this set to co-occurring protected wetlands. An object-based image analysis was conducted to identify and classify patches of vegetation within each wetland and an overlay analysis was used to identify changes in the shape, size, connectivity, and rate of horizontal expansion of vegetated patches. We assessed how these structural characteristics varied with site design and landscape context. Preliminary results suggest that protected wetlands of the region are characterized by larger and more complex patches than co-occurring restored wetlands. Meanwhile, more recent projects show a greater level of habitat complexity and connectivity than older wetlands. This research highlights the influence of landscape dynamics on restored wetlands and enhances the current understanding of patch dynamics following restoration treatments. This knowledge is crucial for a better design and planning of future restoration projects.

Keywords: wetlands, restoration, landscape metrics, object-based image analysis, ecological trajectory

Poster Topic: Habitat & Ecosystem Function Restoration

Field-Based Monitoring of Restoration Progress in Wetlands of the Sacramento-San Joaquin Delta

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Ecological restoration is increasingly used to compensate for habitat loss and rehabilitate depleted ecosystem services, but has a highly variable level of success. Meeting restoration goals can be challenging in heterogeneous and dynamic landscapes. As such, a consistent monitoring effort is needed to identify factors constraining the recovery of ecosystems and to highlight site designs promoting restoration success. In the Sacramento-San Joaquin Delta, decades of agricultural and urban expansion have altered wetlands and the ecological functions they provided historically. In response, local organizations and governmental agencies are allocating considerable effort to restoring wetland ecosystems through the reestablishment of hydrological processes, improvement of tidal connectivity, and removal of invasive species. Yet post-restoration monitoring has been limited in both temporal and spatial scope. This restrains our understanding of factors modulating the ecological trajectories of projects and our capacity to measure their potential for long-term success. To address this knowledge gap, we monitored during the 2016 growing season plant canopy traits and litter accumulation patterns within a set of freshwater wetlands restored between 1997 and 2016. Using a space-for-time substitution, we assessed how the structural properties of wetland canopies- characterized by their leaf area index, specific leaf area, and leaf water content- varied spatially and temporally. We evaluated feedbacks between plant litter accumulation and the structural properties of wetland canopies. These key indicators of plant above-ground productivity can unravel wetlands' capacity to fulfill key services including soil accumulation and carbon sequestration. An advanced understanding of feedbacks between plant above-ground productivity and litter accumulation patterns is critical to a better prediction of a wetland's response to restoration treatments and long-term capacity to maintain ecosystem services.

Keywords: wetland, restoration, monitoring, litter, leaf area index, specific leaf area

Poster Topic: Habitat & Ecosystem Function Restoration

Use of UAVs in the Design, Construction Observation and Post-Project Monitoring of Salmonid Rehabilitation Projects

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The accessibility of unmanned aerial vehicles (UAVs or Drones) to the general public has grown in recent years, and with it has the opportunity to apply these relatively inexpensive, yet sophisticated devices in natural resource management. One application is the use of UAVs to collect low altitude aerial imagery for river rehabilitation projects. The aerial images can be used: to develop site maps and topographic data; to inform hydraulic modeling and design; to track progress on land and within aquatic areas, and to perform post-project physical and biological monitoring. To demonstrate the potential for this type of technology, a recently designed and constructed salmonid rehabilitation project consisting of gravel augmentation and side channel creation within the Nimbus Basin, along the Lower American River in Fair Oaks, CA was used. Aerial imagery was collected before, during and after construction. Imagery was used to develop topographic datasets and digital elevations models (DEMs) that were geo-referenced using RTK-GPS surveyed points. The DEM, as modified with additional bathymetric survey data, was used for hydraulic modeling to inform the rehabilitation design. During construction, the site was monitored regularly with the UAV to ensure proper construction techniques were being implemented as well as track overall progress. The site was surveyed after construction to document the as-built topographic conditions. In addition, post-project imagery was used to document the utilization of the constructed site by spawning salmonids.

Keywords: Aerial Surveying, UAV, Digital Elevation Model, Design, Rehabilitation, Monitoring

Poster Topic: Integrative Applied Science

SacPAS: Demonstration of a Real-time Decision Support System to Predict and Assess Operational Benefits and Risks to Central Valley Salmon.

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Problem statement: The volume of cold water available in the Central Valley is insufficient to protect all early life stages of temperature-sensitive Chinook salmon. Prior to the spawning season, Reclamation develops a water release schedule based on the weather forecasts. Currently, the forecasts and schedules are difficult to update over the fish spawning and rearing seasons and there are limited analytical tools and models to assess the impacts of their water schedules on fish survival and distribution.

Approach: The work, funded by Reclamation and in collaboration the Columbia Basin Research group at the University of Washington, is developing a decision support system that links a real-time data management system with models to forecast the progress and movement of salmon from spawning through smolt migration. Our immediate focus has been on winter-run Chinook salmon, but already there are applications which will be useful across multiple CVP-operated rivers. The web-accessible system has advanced through rapid prototyping and extensive interagency interaction to configure a system operating for Columbia River Salmon for over a decade.

Results: In its first year, the project has established a website (http://www.cbr.washington.edu/sacramento/) with extensive operational queries and alert functions and models to predict egg emergence and smolt migration. In 2016, the website tracked Sacramento Valley flood weir overtopping during the spring. Also, the website was used to look at spring temperature modeling and potential impacts to winter-run Chinook salmon and results were compared to inform decision making on summer temperature management planning. Finally, temperature analyses on CVP tributaries provides real-time exceedance results. These types of results will be demonstrated at this poster to illustrate the utility of SacPAS for linking data and science to in-season management.

Keywords: egg emergence, smolt migration, decision making, temperature, real-time forecast

Poster Topic: Integrative Applied Science

A Comparison of Two Sampling Gear Types in Liberty Island

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Sampling juvenile fish in tidal wetlands is difficult because no single technique can effectively sample all habitats. In 2016, seine sites in Liberty Island were sampled using a beach seine and lampara net to examine differences in fish CPUE, lengths, and community composition. No differences in CPUE were detected, however fish lengths differed between the two gear types and the lampara net caught more species of fish. This data will inform decisions on which method to recommend for sampling littoral tidal wetlands.

Keywords: Seine Lampara, Fish Sampling Methods Techniques, Littoral

Poster Topic: Integrative Applied Science

Potential GHG Emissions Reductions on Agricultural Lands in the Sacramento-San Joaquin Delta

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Recent development of the Methodology for Quantifying Greenhouse Gas (GHG) Emissions Reductions through Wetland Implementation and Rice Cultivation in the Sacramento-San Joaquin Delta allows for participation in the carbon market. It is the latest chapter in the evolution of strategies for subsidence mitigation and reduction of GHG emissions. In the late 1980s and early 1990s, CO2 flux measurements and subsidence measurement on farmed soils and demonstration of a net carbon gain associated with permanently flooded wetlands led to the creation of a subsidence-mitigation wetland in 1997. Since 1997, extensive data and modeling demonstrates the GHG benefits of conversion of agricultural lands to wetlands and rice and led to conversion of over 1,000 ha to wetlands. The primary benefit results from stopping or greatly reducing the documented ongoing emissions of up to 20 tons CO2 ha^{1} yr^{1}. Preliminary data indicate an additional 5 to 10 tons CO2-equivalents ha^{-1} yr^{-1} as N2O emissions. Baseline emissions were not considered in a recent USGS article and press release which warned about the potential lack of GHG benefit associated with Delta wetlands based on data from a single 3-ha wetland.

For a 300 ha wetland on Twitchell Island constructed in 2013, we used data, models and Methodology accounting procedures to estimate the annual benefit at about 8,000 tons CO2e. Moreover, for 3,700-ha Staten Island we assessed the GHG and economic consequences for agricultural mosaics that included rice and wetlands. Conversion to large areas of rice and wetlands resulted in near GHG neutrality to a net GHG sink for the island and small changes in farm income. Wetlands and rice also provide water fowl habitat and greater sustainability. Available data point to best management practices for maximizing wetland GHG benefit and minimizing aqueous carbon exports.

Keywords: Greenhouse gases, subsidence, wetlands

Poster Topic: Integrative Applied Science

The Delta Research Station: A Glimpse at the Future Hub for Monitoring and Research in the Bay-Delta

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The Delta Research Station (DRS) is a proposed science and research center to be located at the former Army Reserve Center in Rio Vista, California. The DRS will transform this idle site on the banks of the Sacramento River into a vibrant research facility and help reinvigorate an historic Delta city. The DRS will consist of two facilities: an Estuarine Research Station (ERS) and a Fish Technology Center (FTC). The ERS will be home to the Interagency Ecological Program (IEP). The ERS will provide additional and improved facilities for the IEP and bring together State and Federal agency staff working on common Bay-Delta issues. This increased coordination will provide interagency efficiencies and collaborative benefits. The ERS will include office and laboratory space, a marina for research vessels, and shop and maintenance facilities. The FTC will be an aquaculture facility that focuses on developing and testing captive propagation technologies for the Bay-Delta's rare fish species.

Keywords: Delta Research Station, Interagency Ecological Program Rio Vista

Poster Topic: Integrative Applied Science

Raising the Bar and Dropping the Cost of Aerial Imagery for Monitoring and Assessment

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Remote sensing of wetlands (and other landscapes) is an established assessment approach for resource management, protection, and restoration. Resolution, spectral bands, seasonality, and water levels are key imaging specifications. Traditional strategies utilize costly needs-tailored new flights, or buying moderately-priced commercial stock imagery (or free Google Earth) that is hit-or-miss in meeting needs. SF Bay National Estuarine Research Reserve is assessing the efficacy of Terravion's low cost imagery, which provides georectified natural color, color infrared, Normalized Difference Vegetation Index (NDVI), and thermal images. In summer 2016, we flew 13 wetlands covering ~8,000 acres around San Pablo and Suisun bays. We examined data acquisition effort, ease of GIS integration, time to image availability, and information yield relative to cost and traditional imagery. Terravion costs were <5% that of traditional air photo acquisition. Resolution was 20-30cm and Terravion is introducing 10-cm resolution imagery in fall 2016. Compared to traditional products, image color balance and contrast could be improved, which can be addressed with image processing. GeoTIFF imagery is generally available one day after acquisition. The multispectral imagery products greatly improve image analysis capabilities and thus data outputs. New imagery coordination is streamlined. Users upload KML or shape files, minor coordination follows, automated emails announce image availability, data is easily shared, and the Terravion portal provides data management/storage capability and analytical tools. The Terravion platform is a breakthrough: it can support remote sensing monitoring at large scale and with higher frequency at a small fraction of the cost than has ever been possible, opening wide the door to improved quality and highly cost-effective site-scale and regional wetland monitoring.

Keywords: Remote Sensing, Terravion platform, cost-effective, regional wetland monitoring

Poster Topic: Integrative Applied Science

Spatio-Temporal Ecological Modeling of Water Hyacinth Environment on the Performance of a Biological Control Agent

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To investigate the mechanisms of water hyacinth (*Eichhornia crassipes*) control, an efficient Baysian model system is required. Although deterministic models have been used to predict organism control, such models suffer from the inability to account for stochasticity in a system Entomologists and conservationists in related fields have offered multidisciplinary and multi-institutional computer modeling programs to optimize success of biological control agents. In view of the success of such models, it was decided to provide an up to date and comprehensive spatio-temporal ecological model of water hyacinth environment on the performance of a biological control agent. The first section of this presentation details the selection of the salient variables for spatio-temporal ecological models. The second section contains information dealing with biological control (*Coleoptera: Curculionidae Neochetina bruchi*) and weed interactions. The third section provides the results of a test of the model.

Keywords: Water Hyacinth, *Neochetina bruchi*, spatio-temporal modelling

Poster Topic: Modeling

Planning Tools to Evaluate Salmonid Habitat Restoration in the Yolo Bypass

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Significant modifications have been made to the historic floodplains of California's Central Valley for water supply and flood damage reduction purposes. The resulting losses of rearing habitat, migration corridors, and food web production for fish have significantly hindered native fish species that rely on floodplain habitat during part or all of their life history. To support the Yolo Bypass Salmonid Habitat Restoration and Fish Passage Project, a collaboration between the California Department of Water Resources and US Bureau of Reclamation, previous evaluation efforts were improved with the development of a suite of planning tools to analyze benefits and impacts to agriculture, fish, waterfowl, and water quality in the Yolo Bypass. A calibrated two-dimensional hydrodynamic model was developed for the Yolo Bypass, which serves to characterize the effects of increased frequency, depth, and duration of floodplain inundation in the lower Sacramento River Basin and assess the improvements to fish passage throughout the Yolo Bypass. The two-dimensional model also provides the required hydrodynamic inputs into the other planning tools that include an agricultural economics model, a fish benefits model, and a mercury cycling model. Each of the planning tools are in various states of development and refinement as part of an ongoing evaluation process as managers continue to try and find sustainable and locally acceptable solutions for agriculture, fish, recreation, and terrestrial species in the Yolo Bypass. Preliminary results and lessons learned will be shared to include the importance of value engineering and stakeholder engagement.

Keywords: Yolo Bypass, Flood Control, Fish Passage, Fish Habitat, Ecology, Hydraulics

Poster Topic: Modeling

Modeling the Effects of Varying Disturbance Frequency and Magnitude on Population Persistence in Predator-Prey Systems

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Human activities are rapidly and significantly transforming environments, altering historic ecosystem disturbance regimes. Estuaries are particularly vulnerable to disturbances due to resource use and other human activities. Anthropogenic disturbances can alter the physical environment and disrupt ecosystem function, leading to both direct and indirect population impacts. While the effects of disturbance frequency and magnitude on species diversity and competitive interactions have been studied, their effects on predator-prey interactions have not been investigated. To address this, we developed simple dynamic models to examine the effects of varying disturbance frequency and magnitude on prey population persistence in predator-prey systems. We then extended this analysis to a more realistic model of eastern oysters (*Crassostrea virginica*) and their predator, the southern oyster drill (*Stramonita haemastoma*), to assess how disturbances, characterized by changes in estuarine salinity and temperature, affect the predator-prey interaction. Initial results reveal that increasing the magnitude of disturbance increases the probability of prey population extinction more than increasing frequency. Additionally, effects differ depending on whether there are predator-prey cycles and whether the disturbance affects population abundance or demographic rates. The findings of this study will further understanding of the effects of varying disturbances on interacting populations and aid managers in improving long-term population outcomes. This work is relevant to San Francisco Bay-Delta management because these models can be used to aid management of local bivalves such as the Olympia oysters (*Ostrea lurida*). Currently, restoration and conservation efforts are threatened by the Atlantic oyster drill (*Urosalpinx cinerea*), an invasive predatory gastropod. These predators are limited by physical disturbances and gradients, and their impact on Olympia oyster populations will likely be exacerbated by climate change. These oysters provide habitat and invaluable ecosystem services, so it is critical to restoration and conservation management to examine how varying disturbances impact both short-term and long-term population outcomes.

Keywords: Modeling, predator-prey, disturbance, eastern oyster, oyster drill, climate change

Poster Topic: Modeling

Advancing the Integration of Vegetation in Floodplain Modeling and Management to Achieve Multi-Objective Benefits for Flood Risk Reduction

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Past efforts at "flood control" were often made at the expense of the ecological integrity of rivers and streams by simplifying the systems, constraining key natural processes, and limiting habitat and ecological niches. Today, increasing scientific and public interest in the ecological, and economic, value of floodplains, and changing regulations, especially those related to the improved management of floodplains with consideration for endangered species, all advocate for restoring and sustaining floodplain functions and processes.

Numerical models can be a powerful tool to help achieve these multi-objective benefits in floodplain management; however, the representation of vegetation in models is often rudimentary. Plants play a key role in how processes and functions are expressed and hydraulic roughness is the principle model parameter describing how plants interact with flood water. Roughness is commonly over-simplified in models leading to missed opportunities for risk reduction and ecological enhancement. Aligning plant characteristics to variations in roughness is a key factor in integrative floodplain design.

We will describe recent engineering and ecological research, and explore design concepts and techniques, that advance the integration of vegetation in floodplain modeling and management. Vegetation on floodplains can be designed, modeled, and ultimately managed to achieve engineering and ecological objectives, such as maintaining flood conveyance while accommodating the establishment and growth of riparian plant communities. Case studies will show how placement of plants can direct overbank flows, improve flood storage, reduce scour and erosion, facilitate sediment transport, and alleviate other flood risk factors, while providing critical habitat.

Keywords: numerical modeling, vegetation, hydraulic roughness, multi-objective benefits, floodplain functions, habitat

Poster Topic: Modeling

Interactions of Ending Overdraft and Delta Water Management

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Effects of ending long-term groundwater overdraft in the Central Valley and Delta water management operations are studied with several management cases using CALVIN, a statewide hydro-economic model for California's inter-tied water supply system. Four hypothetical “no overdraft” scenarios, besides base operations with overdraft, are evaluated under projected 2050 water demands using 82-year monthly historical hydrology .The cases include effects on Delta outflow and Delta exports from a “no overdraft” policy. Furthermore, Delta exports from Delta-Mendota Canal and California Aqueduct are prohibited with a no overdraft policy. Prohibiting Delta exports results in considerable water scarcities south of the Delta. Agricultural water scarcity costs and willingness-to-pay for additional water, and opportunity costs of environmental deliveries are evaluated. More Delta exports, groundwater banking, and water trades are useful adaptations when the long-term overdraft is ended.

Keywords: Overdraft; Delta Exports; Water Supply; Agriculture; Modeling

Poster Topic: Modeling

Developing a High Resolution Bathymetric/Topographic DEM of the San Francisco Bay - Delta for use in CASCaDE II Models

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Climate change, sea level rise and human development all have had effects on the changing geomorphology of the San Francisco Bay – Delta system. The need to further predict scenarios of change led to the development of a high resolution bathymetric/topographic digital elevation model (DEM) of the San Francisco Bay – Delta that served as the foundation of CASCaDE II hydrodynamic and sediment transport models for use in predicting Delta change and better understanding the function of the Delta ecosystem (Fregoso, Wang, Ateljevich, and Jaffe, 2016). The 2016 USGS San Francisco Bay Delta high resolution DEM is the result of collaborative efforts of the USGS and the California Department of Water Resources (DWR). The DEM encompasses the entirety of Suisun Bay; beginning with the Carquinez Strait in the west, east to California Interstate 5, north following the path of the Yolo Bypass and the Sacramento River up to Knights Landing, and the American River northeast to the Nimbus Dam, and the San Joaquin River south to Tracy. The DEM is built on the 2005 USGS DEM comprised of single beam bathymetric surveys, updated to include newer single beam and multibeam bathymetric surveys, and topographic data in the form of lidar surveys. The DEM incorporates the newest available bathymetric survey data at the time of release as well as includes at minimum, 100 meters of available topographic data adjacent to most shorelines. This DEM is a crucial component of USGS's CASCaDE II and DWR's Bay-Delta SCHISM models for predicting change scenarios in the Bay-Delta and will aid decision making for managing the San Francisco Bay –Delta.

Fregoso, T.A., Wang, RF, Ateljevich, E., Jaffe, B.E., 2016, A Seamless, High-Resolution Digital Elevation Model (DEM) of the San Francisco Bay – Delta: U.S. Geological Survey Open-File Report 2016-XX., xx p.(in Review)

Keywords: Bathymetric, DEM, topographic, CASCaDE, model, Delta, GIS

Poster Topic: Modeling

Cost-Effective Shallow Water Bathymetric Modeling

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The high cost of shallow water bathymetric surveying has historically deprived many medium-to-smaller entities and organizations of critical data that could improve management and conservation decisions and help direct research. Additionally, hydrodynamic modeling is limited by the quality of underlying bathymetry. Using an inexpensive fishfinder in combination with commercial GPS equipment we were able to produce a high-quality bathymetric digital elevation model for the formerly poorly-characterized upper reaches of Cache-Lindsey Slough Complex, with uncertainty ranges suitable for research and conservation work. In four days of field work we navigated 36.2 linear km of tidal channels, a total of 2.12 sq. km of water surface at an average ensonification density of 2.78 soundings per 10 sq. m for a total cost less than $3,700. Our methods allow flexibility in increasing or decreasing data density as specific circumstances warrant, and data processing capability dictates. Our equipment setup achieved precision of 7 mm in horizontal positions with 6 mm in vertical elevations for the channel characteristics surveyed. Median total horizontal and vertical uncertainties of 0.813 m and 0.141 m were attained for survey points at the 95% confidence level for a mean depth of 2.69 m. These techniques could benefit a multitude of budget-limited projects in the Delta, and also permit rapid and inexpensive modeling for pilot research and serial hydromorphological dynamics studies.

Keywords: bathymetry, digital elevation, DEM, sonar, modeling, hydromorphology, hydrodynamics, GIS

Poster Topic: Modeling

Biogeochemical Modeling for Nutrient Management in San Francisco Bay

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Ambient nutrient concentrations in San Francisco Bay are high relative to many urbanized estuaries, yet the classic symptoms of eutrophication are typically not observed in the Bay. The source of this resistance is hypothesized to be a combination of the light limiting effects of suspended sediments and the presence of benthic grazers, both of which exert strong controls on the phytoplankton population. However, observations in recent years suggest that this resistance may be declining.

As part of the San Francisco Bay Nutrient Management Strategy, we are developing a process-based, coupled physical-biogeochemical model of the Bay to characterize nutrient cycling and ecosystem response to nutrient management scenarios. The biogeochemical model successfully reproduces many features in the observed distributions of nitrogen species. Some discrepancies between the model and observations appear to be related to episodic blooms not captured by the model. Coast-sourced, upwelled nutrients present in Central Bay in the summer months may also be a source of discrepancies, highlighting the important, seasonal influence of the coastal ocean.

Keywords: nutrients, hydrodynamics, biogeochemistry, modeling, water quality, South Bay

Poster Topic: Modeling

Riparian Forest Dynamics along the Sacramento River, California (USA): Constructing Tree Age Models to Illustrate Successional Patterns

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The riparian ecosystem along the Sacramento River (CA) has been greatly impacted by human activities, however the Middle Reach between Red Bluff and Colusa remains hydrogeomorphically active. This reach hosts young floodplain forests dominated by cottonwoods and willows, as well as later-successional species such as oak, ash and walnut. Despite a qualitative understanding of successional patterns, there remains considerable uncertainty in tree establishment timing relative to floodplain development and the potential impact of post-dam flow changes on that process.

To further our understanding of the Sacramento River's riparian forest dynamics, we: (1) cored >1000 riparian trees and determined ages for dominant species using a combination of standard dendroecological measurements and experimental mathematical corrections; (2) constructed a general pathway of forest community dynamics by comparing the relative species timing of tree ages to their associated floodplain ages; and (3) explored variation in ecological drivers over time, particularly in respect to river regulation following Shasta Dam's construction.

Tree cores showed that most cottonwoods and willows established within 15 years of floodplain creation, but cottonwood had a wider range of colonization times that expected. Box elder and walnuts similarly had short colonization times on floodplains <50 years old, indicating that currently they function as pioneers on recently created floodplains. In contrast, establishment of oak and ash trees occurred much later, at least ~15 to 25 years after the pioneers, respectively. In general, median colonization times for each species agree with the successional pattern suggested by previous research on the Sacramento River, but these new data illustrate variations in this pattern warranting further exploration. This research provides the most detailed view of forest succession within California's Central Valley riparian ecosystem, and can serve as a foundation for future work and to guide preservation and restoration efforts in this important and vulnerable ecosystem.

Keywords: riparian forest ecosystems, river restoration, succession, tree age models

Poster Topic: Modeling

A New Public Domain Hydrodynamic Model for the Yolo Bypass

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Habitat reconciliation on Yolo Bypass proposed by the WaterFix necessitates a hydrodynamic model capable of simulating the full range of flow conditions experienced by the Sacramento River spilling into the Bypass. New bathymetry collected by the UC Davis Center for Watershed Sciences has been combined with existing spatial data to produce an updated digital elevation map (DEM). The model geometry was developed using the HEC-GeoRAS extension of ArcGIS and imported into HEC-RAS 5.0. The model consists of 1D river channels connected to 2D floodplains and is calibrated with available gage data. Irrigation canal details and control structures, important to a low flow model, have been included in the DEM and model geometry. Modifications such as the Fremont weir notch options specified by the California Department of Water Resources (DWR) and US Bureau of Reclamation (USBR) Yolo Bypass Salmonid Habitat Restoration and Fish Passage Project have been modeled. While earlier studies of the Fremont Weir alternatives focused on gate operations and flow rates, this study focuses on area and duration of inundation. This public domain model was partially funded by Yolo County and the UC Davis Center for Watershed Sciences and is available for testing ongoing habitat reconciliation projects.

Keywords: Hydrodynamic Modeling; Reconciliation; Salmonids; Habitat; HEC-RAS; Fremont Weir; Yolo Bypass

Poster Topic: Modeling

Downscaling Wind and Wave Fields for 21st Century Coastal Flood Hazard Projections in San Francisco Bay

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While Global Climate Models (GCMs) provide useful projections of near-surface wind vectors into the 21st century, resolution is not sufficient enough for use in regional wave modeling. Statistically downscaled GCM projections from Multivariate Adaptive Constructed Analogues (MACA) provide daily averaged near-surface winds at an appropriate spatial resolution for wave modeling within the orographically-complex region of San Francisco Bay, but greater resolution in time is still needed. Short-duration high wind speeds, on the order of hours, are usually excluded in statistically-downscaled climate models and are of key importance in wave and subsequent coastal flood modeling. Here we present a temporal downscaling approach, similar to constructed analogues, for near-surface winds suitable for use in local wave models, and evaluate changes in wind and wave conditions for the 21st century. Reconstructed hind-cast winds (1975-2004) using this methodology recreate important extreme wind values within the San Francisco Bay. A computationally-efficient method for simulating wave heights over long time periods was used to screen for extreme events during historical (1975-2004) and 21st century (2010-2100) periods. Projections of extreme over-water wind speeds suggest contrasting trends within the different regions of San Francisco Bay, however, 21st century projections show little change in the overall magnitude of extreme winds and waves.

Keywords: coastal storm modeling, storm wind, storm waves

Poster Topic: Modeling

A Large-Scale, Infrared Quantitative Imaging System for Measuring the Instantaneous Surface Velocity Field in Natural Flows

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The design and implementation of an infrared, large-scale, Quantitative Imaging (QI) system is presented, along with results from an initial field test during the 2014 Georgiana Slough fish guidance study.

A Floating Fish Guidance Structure (FFGS) was constructed and tested in 2014 with the goal of guiding juvenile fish towards the Sacramento River and away from Georgiana Slough (e.g., Perry et al., 2014). This floating structure alters the near-surface flow field along, and downstream of, the FFGS. The effect of turbulence generated by the barrier on fish migration routes is largely unknown.

In order to study the mean and turbulent flow field in the vicinity of the FFGS we deployed a large-scale QI system comprised of a high-resolution (1344x784 pixel), high-sensitivity (NETD < 25 mK), MWIR (spectral range 3-5 μm) camera mounted at an elevation of approximately 20m above the surface of the water. The imaging field-of-view covered the river surface from shore-to-shore near the southern end of the FFGS. Once set up the system was remotely operated.

The QI algorithm tracks micro-gradients in the surface temperature of the water over time as captured in the infrared images, allowing us to construct the 2D flow field in high spatial and temporal resolution. This system has significant advantages over traditional (visible-wavelength) large-scale PIV systems in that temperature gradients are ubiquitous features of the water itself hence there is no need for seed particles or concerns regarding the validity of assuming seed particles passively follow the flow. Additionally there is no dependence on ambient light, so the system can run continuously 24 hours a day.

The results of the QI measurements show excellent agreement with mean flow velocities measured concurrently by ADCP. The turbulent flow field is characterized in order to correlate with fish migration tracks that were recorded by acoustic telemetry.

Keywords: PIV, Quantitative Imaging, LSPIV, turbulence, physical processes, hydrodynamics, infrared, flow

Poster Topic: Modeling

Climate Change Effects on Optimal Bypass Capacity

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Large flood flows in a river can damage flood-prone areas, by overtopping river channels or structural failure. Flood bypasses can efficiently reduce flood risks, accommodating excessive river flow.

Climate change, with warmer temperatures and changes in patterns of precipitation, is compromising California's flood management efforts. Climate change is expected to worsen regional flooding problems, and at the same time, economic growth and urbanization of floodplains will increase potential damages. The long-term floodplain management challenge is to be able to balance increasing flood damages and benefits from using floodplains over periods.

This study develops a formulation to examine the effect of climate change on optimal bypass capacity using benefit-cost and risk analysis. The analysis should predict increasing flood risk due to climate change unless current flood management policies are changed. A simplified representation of the Sacramento River and the Yolo Bypass, near Sacramento, is considered. The problem is formulated as an economic optimization model solved using dynamic programming. This analysis examines, from an economic perspective, how flood management can adapt to flood frequency changes, and how bypass capacity changes can help reduce damages over time.

Keywords: Flood management, risk analysis, flood bypass, climate change, capacity optimization

Poster Topic: Modeling

Central Valley Refuge Management under Non-stationary Climatic and Management Conditions

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Sustainable management of Central Valley refuges is critical to maintain the ecosystem balance. These refuges provide habitat for the more that 60% of the migrating waterfowl on Pacific Flyway and are home to nearly 50% of the threatened and endangered species in California. Uncertainties surrounding the future of water management coupled with the increasing cost of and diminishing opportunities for acquiring water threaten the long-term viability of refuge water supply. Global warming and regional hydro-climatic alterations are likely to further limit state's ability to manage water, reduce total volume of available water and intensify competition for surface water. Historically, reduction in surface water supplies is substituted with groundwater pumping. Long-term overdraft and Sustainable Groundwater Management Act (SGMA) provisions will, however, limit future pumping opportunities. This research examines impacts from warm-dry climate, peripheral tunnels, SGMA, and Delta regulations on water deliveries to Central Valley refuges. The study is conducted within a statewide framework using CALVIN – a hydro-economic optimization model of State of California – to capture the physical, environmental and policy constraints in the existing water management system. Sixteen scenarios are analyzed to capture and quantify the hydrologic and economic implications of climatic and management uncertainties on refuge deliveries including (1) climate vulnerability: historical and warm-dry climates; (2) Delta regulations: high and existing Delta Outflow requirements; (3) infrastructure: with and without isolated facility or peripheral tunnels; and (4) groundwater management: with and without long-term overdraft. A separate Spreadsheet Tool is also developed to explore the benefits and implications of inter-refuge trading and optimizing refuge land-use management practices. The research findings identify promising management schemes to buffer against the future uncertainty in refuge water supply, schemes such as expanding groundwater or surface water supplies, identifying potential water trading partners, optimizing land-use operations and collectively managing the Central Valley refuges.

Keywords: central valley, refuges, wetlands, water management, climate change, groundwater, SGMA

Poster Topic: Modeling

Yolo Bypass Model: Providing a Public Model to Evaluate Future Options

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The Sacramento-San Joaquin Delta has been modified severely since initial settlement in the area. Efforts are being made to address the disparity between human suitability and native species' habitat suitability in the Delta. The Yolo Bypass, a ~60,000-acre floodplain in the North Delta that protects Sacramento against flooding, is a recent target for providing habitat to vital native Delta species.

To address this problem, alternatives have been proposed by making modifications to the existing hydraulic infrastructure on the Bypass. Numerical two-dimensional hydrodynamic and water-quality models can assist in evaluating the ecological and economic impact of alterations to the frequency, duration, and size of the flood footprint. A proprietary, commercial numerical model has been developed to evaluate the alternatives and their impacts in recent years. The information that the model is largely built upon is hydrologic gage data and many of the western tributaries to the Bypass are poorly monitored, implying added variability and uncertainty to the model results.

At UC Davis, we have developed a 2D hydrodynamic model using free and publicly available software, HEC-RAS, which can be used by others to evaluate the proposed alternatives to the flooding patterns. In addition to developing the model, we have quantified the potential variability that the lack of gage data introduces to the model results. Improvements to the model terrain have also been made using techniques developed by researchers at UCD.

The model will be an additional tool for stakeholders, landowners, and public interests to collaborate on the appropriate implementation of whichever alternative is deemed best. Additionally, the quantified variability and uncertainty of different missing or sparse data demonstrates the value that added monitoring will provide. The results of this research will provide insight on management practices on one of the largest floodplains in the Sacramento River system.

Keywords: Yolo Bypass, modeling, fish passage, stream monitoring, floodplain management, gages

Poster Topic: Modeling

Quantifying Spatio-temporal Inundation Patterns for Floodplain Restoration on the Lower Cosumnes River, California

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Restoration of floodplain ecosystems within altered riverine landscapes is a global challenge, and one central to solving water management challenges of California broadly and the Delta specifically. Such restoration, intended to support ecological diversity, requires not only the rehabilitation of driving physical processes, but also improved understanding and quantification of the spatial distribution and temporal variability of floodplain inundation patterns. The research presented here formalizes the hydrospatial regime concept, presenting methods for better evaluation of specific physical conditions useful for floodplain management. This new spatio-temporally resolved approach quantifies a floodplain's hydrospatial regime using 2D hydrodynamic modeling (HEC-RAS) and spatial analysis. Pre- and post-restoration conditions are evaluated for the Oneto-Denier floodplain restoration site along the lower Cosumnes River, California. Modeling is performed for selected historical floods representing previously established flood types distinguished by ecologically-relevant variables such as magnitude, timing, and duration. Modeling output is analyzed and compared within and across flood events and restoration scenarios in space and time using metrics relating to depth, velocity, duration, connectivity, and spatial heterogeneity. Spatially-resolved flow-depth relationships allows for further assessment and comparison of conditions. The quantified and visualized hydrospatial metrics illustrate, for example, where and when different physical conditions are likely to be altered with restoration, and which flood types and where within the floodplain are associated with the greatest difference pre- versus post-restoration. They also demonstrate that physical conditions follow different spatial and temporal patterns across different floods and restoration scenarios. Implications include that variability of flow regimes and their interaction with heterogeneous floodplain topography should be considered in Delta restoration management and more broadly. This research advances floodplain hydroecology and restoration sciences and extends readily-applied methods using 2D modeling output to evaluate restoration scenarios, providing needed information and tools to better manage floodplains for variable conditions that benefit ecosystems.

Keywords: Cosumnes River, floodplain restoration, flow regime, hydrodynamic modeling, spatial analysis

Poster Topic: Modeling

The Central Valley Habitat Exchange: Quantifying Benefits for Multiple Species at Parcel and Landscape Scales

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Land use conversion, drought, and climate change are conspiring against many native species once abundant in the Delta and Central Valley. Restoring and protecting habitat is critical for their recovery, and private lands, which make up over 80% of the Central Valley, are a necessary part of the solution. How do we engage private land owners in this effort to effectively address multiple species needs?

We developed and piloted a scientifically based, transparent and accessible tool to assess habitat quality for multiple species native to the Central Valley. The Multispecies Habitat Quantification Tool (mHQT) applies a multi-scaled approach for assessing habitat quality and quantity, and for tracking conservation or mitigation outcomes for native species in the Central Valley. To date, these species include Swainson's hawk and riparian landbirds; tools for other species are under development. The mHQT can assess a specific parcel as well as the relative value of that site on a landscape scale, when compared to other sites. Within the Central Valley Habitat Exchange (CVHE), habitat credits and debits are assigned to the most beneficial locations for species, and parcel scale contributions to species' habitat are tracked over time.

We compared tool scores for Swainson's hawk and riparian land birds to species use and occurrence at six locations in the Delta and Central Valley using ranked comparisons. Our findings support use of the tool as a valid, transparent and accessible means of prioritizing areas and actions to create multiple species benefits. The CVHE is working with private land owners and local planning agencies to apply the mHQT to inform management and to improve planning, tracking, and reporting. The mHQT provides clear and concrete guidelines with response scores that private landowners can use to demonstrate good stewardship, implement conservation and mitigation projects, and to guide land management planning.

Keywords: multiple benefits, habitat mitigation, private lands, quantification tool,

Poster Topic: Natural Resource Management

Desalination Cost Analysis for California

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In 2015, desalination -- from seawater, brackish and other sources -- accounted for 25.7 MAF/yr of worldwide, and 62.1 TAF/yr of California's water production capacity. California's droughts spur conversations on desalination as a panacea. However, two factors have hindered the widespread adoption of desalination: its high costs and environmental effects. In this paper, the CALVIN model of California's water supply system was used to study economical operations with different desalination costs, under different climate scenarios. Given historical hydrology, the use of ocean desalination remains minimal until its costs fall by 40%, after which use increases. Given an overlay of climate change this value decreases to 20%. These results show the viability of cheaper desalination with an increasingly constrained water supply. Should desalination overcome its environmental challenges, it can foster long-term regional sustainability by bringing greater resilience, reliability and local control to areas like the California coast.

Keywords: Desalination, Climate Change, California, Water Supply Management

Poster Topic: Natural Resource Management

Adaptive Immunogenetic Variation in Endangered Salt Marsh Harvest Mouse Populations

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Adaptive immune system variation is frequently characterized in endangered species to assess the potential of limited populations to respond to disease. We have isolated the first adaptive immune system locus from the salt marsh harvest mouse, *Reithrodontomys raviventris*, in the major histocompatibility complex (MHC, Class II DRB). *R. raviventris* is endangered due to habitat limitation and disruption. Because *R. raviventris* is a low-dispersing species endemic to San Francisco Bay Estuary marshes, it is an ideal indicator species of local ecosystem health. Its response to wetland restoration and management can be used as a measure of success. Patterns and levels of functional genetic variation can serve as a metric to monitor this response. To measure baseline levels of genetic diversity, 12 sites were sampled across Suisun, San Pablo, and San Francisco Bays. *R. raviventris* individuals were sequenced at the functionally conserved mitochondrial cytochrome b locus (n=105) and cloned and sequenced at the functionally diversifying MHC locus (n=55). Patterns of genetic diversity show regional differentiation at both mitochondrial and MHC loci, particularly between northern and southern regions, corresponding to subspecies designations. Additionally, northern populations are functionally differentiated at the MHC locus, with unique alleles present in the more isolated sampling areas. Selection tests indicate evidence of positive selection acting on this locus (for antigen binding sites: dN/dS=3.43, p=0.02), suggesting that patterns of diversity may be due to local adaptation as well as genetic drift. Low allelic variation in southern populations may indicate limited adaptive potential. Genetic data can be used to prioritize conservation efforts and to aid habitat management and restoration design, determining if populations should be connected by habitat corridors or preserved as separate adaptive units.

Keywords: endangered species, conservation genetics, immunogenetics, population viability, *Reithrodontomys raviventris*

Poster Topic: Natural Resource Management: Endangered Species

Development and Use of an Environmental DNA (eDNA) Method for Determining Presence/Absence of Freshwater Mussels in the Tidally Influenced Delta

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Environmental DNA (eDNA) analysis is developing into a useful tool for detecting aquatic biota that are invisible to traditional sampling surveys. A rapid, cost-effective method, eDNA allows for surveying of rare or cryptic organisms, such as freshwater mussels, without harming the species. We recently developed an eDNA method that successfully detected California native freshwater mussels in the genera Anodonta, Gonidea, and Margaritifera. To evaluate the eDNA method in tidally influenced waters, we initiated a two part pilot study to characterize the distribution of freshwater mussels in the Sacramento-San Joaquin Delta. In the first component of the study we collected duplicate water samples at ten sites across the Delta, including a site near Stockton where freshwater mussels were previously documented, to determine: (1) a detection rate, and (2) mussel eDNA signal strength. No Gonidea or Margaritifera were detected, but Anodonta spp. was detected at four of the ten sites. The presence of shells and live specimens confirmed the presence of Anodonta at one location where eDNA was detected in both replicate samples.

Due to the non-uniform manner in which eDNA is distributed in the large, tidally influenced Delta it was necessary to refine the eDNA protocol to determine the number and location of sampling sites necessary to accurately determine mussel presence/absences. In the second component of the study we collected eight water samples along a single transect at each of the four sites where mussel eDNA was detected in the first part of the study. These results were used to develop a Delta specific eDNA sampling method.

Our results indicate eDNA is effective for determining mussel presence/absence in tidally influenced waters. Wastewater treatment plants in the Delta can use our eDNA sampling method to determine mussel presence/absence to comply with 2013 Environmental Protection Agency ammonia criteria.

Keywords: Environmental DNA, Freshwater Mussels

Poster Topic: Natural Resource Management: Endangered Species

Salt Marsh Harvest Mice (*Reithrodontomys raviventris*) Distribution, Abundance, and Population Trends in the East Bay Regional Park District

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The Salt Marsh Harvest Mouse (*Reithrodontomys raviventris*) is a state and federally listed endangered species endemic to the salt marshes of the San Francisco Bay Area. As a result of anthropogenic change, its pickleweed-dominated tidal marsh habitat has been greatly reduced. Habitat loss is the primary threat to the Salt Marsh Harvest Mouse. The East Bay Regional Park District manages 40 miles of shoreline, which includes viable Salt Marsh Harvest Mouse habitat. Using standard survey protocols, District staff, interns and volunteers surveyed five sites for Salt Marsh Harvest Mice between 2012 and 2016. During the months of May through August, greater than 100 Salt Marsh Harvest Mice were captured, with a total population index that approximates 2.5 (individuals/trap nights x 100). There was no significant correlation between captures and pickleweed height and coverage; however, populations differed significantly among sites. Continued monitoring is necessary to document their status, distribution, abundance and population trends to help inform conservation efforts for these and other special status species inhabiting tidal wetlands managed by the East Bay Regional Park District.

Keywords: Salt Marsh Harvest Mouse, endangered species, conservation & management

Poster Topic: Natural Resource Management: Endangered Species

Using DNA from Beetle Feces to Improve Cryptic Species Monitoring

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The Valley elderberry longhorn beetle (VELB) is an endangered subspecies inhabiting riparian habitat in the Bay Delta watershed. The loss of >90% of Central Valley riparian habitat has been a major cause of VELB decline. The USFWS monitors VELB abundance but this species is notoriously difficult to survey because adults are rarely encountered and larvae spend most of their lives embedded in the stems of their host plant, the elderberry (*Sambucus spp*). Surveys are limited to counting exit holes made by newly metamorphosed adults emerging from elderberry stems. However, this survey method is inadequate because VELB occupancy of elderberry is low and it is impossible to confirm visually whether an exit hole was produced by VELB or another species or subspecies. VELB overlap in some parts of its range with its non-endangered sister taxa, the California elderberry longhorn beetle (*Desmocerus californicus*; CELB), and exit holes in areas of overlap could belong to either subspecies. As part of a larger project to improve VELB monitoring protocols, we are developing a method that will assign exit holes to species using DNA from the larval frass inside. DNA extracted non-destructively from VELB and CELB museum specimens was used to screen 17 primer sets amplifying 7 putative DNA barcoding loci for single nucleotide polymorphisms (SNPs) that distinguish the subspecies. Once candidate loci are identified, we will genotype a larger number of VELB and CELB to ensure that the SNPs are truly diagnostic throughout each subspecies range. We will present the results of our work to date and describe how this tool can be integrated into the VELB monitoring program.

Keywords: Valley elderberry longhorn beetle, Fecal DNA, DNA barcoding, Monitoring

Poster Topic: Natural Resource Management: Endangered Species

Predation of Salt Marsh Harvest Mice in the Suisun Marsh

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Common predators of the salt marsh harvest mouse (*Reithrodontomys raviventris*) have never been identified. During thousands of hours in the Suisun Marsh, during a three year field study we made opportunistic observations of both nocturnal and diurnal predators. Through visual sightings, auditory observations, as well as observations of sign, including scat and tracks, we identified likely common predators of the salt marsh harvest mouse. We also observed confirmed predation events by a northern harrier (*Circus cyaneus*), a white tailed kite (*Elanus leucurus*) and a yellow bellied racer (*Coluber constrictor*).

Keywords: salt marsh harvest mouse, *Reithrodontomys raviventris*, predators, Suisun Marsh

Poster Topic: Natural Resource Management: Endangered Species

Attenuation of Unionid Mussel Environmental DNA in a River Environment

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Environmental DNA (eDNA) has recently emerged as a useful tool for detecting cryptic or rare aquatic organisms, such as imperiled unionid freshwater mussels. Recent EPA water quality criteria incorporate stringent ammonia toxicity criteria for wastewater receiving water bodies where mussels are present. Thus, there is an urgent need for wastewater dischargers to develop sampling strategies to determine mussel presence or absence in their receiving waters. To ensure a robust sampling design, the attenuation of the eDNA signal from its source is necessary to determine the distance between sample locations. To that end, we conducted a pilot study to evaluate the attenuation of eDNA concentrations downstream of caged mussels in a five-mile study reach in California's Cosumnes River. Collection of eDNA samples during a reconnaissance survey indicated that one unionid mussel species, *Margaritifera falcata*, was present in the lower Cosumnes River. Twenty specimens of another unionid mussel species, *Gonidea angulata*, which was not detected in the Cosumnes River eDNA samples, were collected from the Pit River and temporarily placed into a cage located at the upstream end of the study reach in the Cosumnes River. After allowing eDNA from *G. angulata* to be transported downstream for several days, duplicate eDNA samples were collected at 0.25-mile intervals downstream of the cage. All eDNA samples were analyzed using quantitative polymerase chain reaction (qPCR). Concentrations of *G. angulata* eDNA were highest near the cage and decreased over the five-mile study reach. Field blanks collected during sampling were negative, indicating a low likelihood of false-positive eDNA detections. The attenuation results will be used to inform sampling design for determining unionid mussel presence/absence in receiving waters for Central Valley wastewater treatment facilities.

Keywords: Environmental, DNA, unionid mussels, ammonia, criteria toxicity, attenuation, sampling design

Poster Topic: Natural Resource Management: Endangered Species

Analyses of Longterm Monitoring Data to Address Priority Data Gaps for Endangered Salt Marsh Harvest Mice, *Reithrodontomys raviventris*

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The federally and state endangered Salt Marsh Harvest Mouse (SMHM; *Reithrodontomys raviventris*) is the only mammal species in the world that is endemic to tidal marshes (Greenberg et al. 2006) in San Francisco Bay (SFB). Despite tidal marsh restoration efforts numerous threats to tidal marsh vertebrates remain with highly-fragmented, remnant marshes supporting much of the remaining endemic northern and southern subspecies.

The *Draft Recovery Plan for Tidal Marsh Ecosystems of Northern California and Central California* has identified that the SMHM may be at "risk of extinction due to vulnerability of small populations in the face of random naturally occurring events" (USFWS 2010). As a result, the Draft Recovery Plan called for scientific research efforts pertaining to survival and recovery in order to develop best management practices by the U.S. Fish and Wildlife Service (USFWS 2010). The California Department of Fish & Wildlife's (CDFW) goals are aligned with the USFWS Draft Recovery Plan as outlined in the Strategic Plan to "…focus inventories, research, and resource assessment efforts on high priority habitats, species at risk ..." and to "direct activities toward maintaining, enhancing, and restoring wildlife …."

Here, we directly address the critical, basic research needed "to fill in gaps in the understanding of the current distribution, density, and demographics of the salt marsh harvest mouse," which received the highest priority for recommend actions over the next 5 years (USFWS 2010). We conducted population analyses from mark-recapture monitoring data to inform future standardized monitoring protocols and to address population variability over time in Suisun Marsh with detailed analyses at Cresent Unit. Trap session of 4 nights resulted in higher population estimates than with 3 nights of data. Preliminary mark-recapture analyses show that Hill Slough had the highest population of SMHM, followed by Peytonia, Crescent Unit, Bradmore Is. Reproductive demographics were skewed towards males.

Keywords: Salt marsh harvest mouse, population, distribution, demographics

Poster Topic: Natural Resource Management: Endangered Species

Reducing Human Exposure to Mercury in the Sacramento-San Joaquin Delta

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Elevated levels of mercury in fish are a concern in the Sacramento-San Joaquin River Delta (Delta). Those who eat Delta fish may be exposed to harmful mercury levels. Mercury is a toxic metal that poses serious health risks and is most harmful to infants, children, and the developing fetus. As it will take many years to reduce the levels of mercury in fish, the Central Valley Regional Water Quality Control Board, California Department of Public Health, Office of Environmental Health Hazard Assessment, and Sacramento-San Joaquin Delta Conservancy are taking action now to protect public health by implementing the Delta Mercury exposure Reduction Program (Delta MERP). This program aims to reduce human exposure to mercury through collaborative work with community-based organizations, community members, local agencies, and other entities. Delta MERP activities educate at-risk populations about mercury exposure from eating contaminated fish caught in the Delta and elsewhere. Following interviews with local social service, Tribal, and community-based organizations, the project team developed a multi-pronged approach for education and outreach based on the needs and interests of the organizations. The Delta MERP approach to reduce risk includes developing and distributing multilingual educational materials based on existing fish consumption advisories, building capacity of community-based organizations through small grants to promote culturally relevant outreach in their respective communities, developing and posting signs at fishing locations, sharing information through community stakeholder meetings, providing training, and supporting programs already operating in the Delta to educate about fish contamination.

Keywords: mercury, fish contamination, outreach, public health, environmental justice

Poster Topic: Outreach & Communication

DTSC's Safer Consumer Products Program: Linking Data and Decisions

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The Department of Toxic Substances Control's (DTSC) Safer Consumer Products (SCP) regulations outline a process for DTSC to identify product-chemical combinations on the basis of potential for exposure to a chemical in the product to contribute to adverse impacts to human health or the environment. Manufacturers who wish to continue selling the product-chemical combination in California may conduct an Alternatives Analysis to assess if the chemical is needed in the product and if a safer alternative exists.

The SCP program represents a new and transparent approach to regulating Chemicals of Concern in consumer products. SCP's regulations dictate that DTSC use a narrative standard to evaluate the potential for product-chemical combinations to have adverse impacts. This allows SCP to take a precautionary approach and integrate emerging data and approaches into the product-chemical prioritization process. This integration requires a collaborative relationship with entities collecting these data to ensure DTSC has access to data and that local researchers are aware of SCP's data needs. In turn, SCP can influence the reduction of Chemicals of Concern in the aquatic environments like the Bay-Delta ecosystem by requiring manufacturers to consider the full life cycle of their products when selecting alternatives to avoid regrettable substitutions.

This talk will present a case study to illustrate how the narrative standard works in DTSC's product-chemical identification, including the types of data that are utilized in this process. In doing so, data needs will be highlighted, including conceptual models for a wide range of products and science-based decision-support tools. The case study will also illustrate the need for collaboration between DTSC and Bay-Delta researchers and highlight where stakeholder input is necessary to inform DTSC's decisions and ensure the full potential of the program is realized.

Keywords: chemicals of emerging concern, chemical management, data, precautionary approach

Poster Topic: Outreach & Communication

Effective at Any Scale: Watershed-Based Decision Support Tools

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The Wetland and Riparian Area Monitoring Plan (WRAMP) supports the watershed or landscape approach to aquatic resource monitoring and assessment, as well as the watershed approach to mitigation planning called for by the US Army Corps of Engineers and State Water Resources Control Board. Recent innovations now facilitate broader application of the WRAMP toolset.

WRAMP incorporates tools for project siting and design, project tracking, project assessment, aquatic resource mapping, ambient monitoring design, and synthesis and reporting of aquatic resource condition, and includes tools and methodologies for assessing projects in the landscape or watershed context. Used independently, each tool has its critical function, but used collectively, they are powerfully integrated to address interrelated challenges and concerns that matter deeply to resource managers, policy makers, and the general public alike. For example, the California Aquatic Resource Inventory (CARI) is a common basemap for tracking and assessing wetlands and streams throughout the state. The California Rapid Assessment Method (CRAM) is a standard methodology for assessing wetland condition using rigorously tested modules, each fine-tuned to the type of wetland being evaluated. Project Tracker's online forms enable project managers to easily add new wetland projects and update information for existing projects for public display on the California EcoAtlas and other visualization tools. The Landscape Profile Tool summarizes information about the abundance, diversity, and condition of wetlands, streams, riparian areas and related information in automated reports for user-defined areas.

Collectively, the WRAMP toolset assists in delivering and visualizing accurate and timely data to implement the watershed- or landscape-approach to aquatic resource planning and protection.

Keywords: watershed context, landscape context, wetlands monitoring, and assessment tools

Poster Topic: Outreach & Communication

California EcoRestore

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Today's Delta looks little like it did 150 years ago. The Delta a is a highly changed and engineered environment supporting threatened and endangered species, the state's agricultural industry, and water supply for millions. A key aspect of the Governor's Water Action Plan is aggressive ecosystem restoration to benefit fish and wildlife species recovery. Building on the goals set in California's Water Action Plan, the California EcoRestore initiative will coordinate and advance at least 30,000 acres of critical habitat restoration in the Delta over the next four years. The program aims to address the Delta's legacy impacts, as well as effects from the ongoing operation of the state and federal water projects. California EcoRestore is a California Natural Resources Agency initiative implemented with support from agencies including the Department of Water Resources, Department of Fish and Wildlife, Delta Conservancy, and Delta Stewardship Council.

Driven by world-class science, and guided by adaptive management, this initiative will pursue habitat restoration projects with clearly defined goals, measurable objectives, and financial resources to help ensure success. California EcoRestore's initial goal is to advance Delta habitat restoration associated with existing mandates, pursuant to federal biological opinions, as well as additional habitat enhancements. A broad range of habitat restoration projects will be pursued, including projects to address aquatic, sub-tidal, tidal, riparian, flood plain, and upland ecosystem needs, as well as fish passage improvement in the Yolo Bypass and other key locations.

Much of the costs of EcoRestore will be borne by the state and federal public water agencies currently required to mitigate the ecological impacts of the State Water Project and the Central Valley Project in the Delta. Funding for habitat enhancements unassociated with mitigation will come primarily from State Propositions, and local, federal, and private investment.

Keywords: Restoration, habitat, conservation, enhancement, delta, tidal, wetland, floodplain, fish passage

Poster Topic: Outreach & Communication

Funding Science and Restoration in Bay-Delta Ecosystems: An Overview of New CDFW Grant Programs

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Numerous stressors have contributed to the decline in condition and function of key ecosystems throughout California, including the San Francisco Bay/Sacramento-San Joaquin Delta (Bay-Delta). The California Department of Fish and Wildlife (CDFW) is implementing three new competitive grant programs to provide funding for multi-benefit ecosystem restoration and protection projects that contribute to efforts to reverse the impacts of these stressors.

The *Wetlands Restoration for Greenhouse Gas Reduction Grant Program* was developed in response to the Global Warming Solutions Act of 2006 and supports projects that restore or enhance natural ecosystems in order to reduce greenhouse gas emissions and provide ecological co-benefits.

The *Watershed Restoration Grant Program* and *Delta Water Quality and Ecosystem Restoration Grant Program* were developed in response to the Water Quality, Supply, and Infrastructure Improvement Act of 2014 (Proposition 1). Proposition 1 provides funding to implement the three objectives of the California Water Action Plan: more reliable water supplies, restoration of important species and habitat, and a more resilient and sustainably managed water infrastructure.

These grant programs are contributing to implementation of the California Water Action Plan, State Wildlife Action Plan, California EcoRestore, federal recovery plans, and other relevant State and federal initiatives. Through the first grant cycles of these programs, as of June 2016, a total of $52.4 million was awarded to 36 projects statewide, 13 of which ($26.2 million) occur within the Bay-Delta. These Bay-Delta projects include scientific studies designed to address priority science needs consistent with the Delta Science Plan and projects to plan and implement habitat restoration actions. Key activities of the grant programs will include tracking implementation and communicating outcomes to inform future management decisions.

Keywords: Restoration, Funding, Ecosystem, Watershed, Habitat, Fish, Water, Wildlife, Science, Planning

Poster Topic: Outreach & Communication

Seasonal Patterns in Sediment Deposition across Two San Francisco Bay Estuary Tidal Marshes

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Sediment deposition is an important component of accretion processes that allow tidal marshes to maintain their relative elevation as sea levels rise. Suspended sediment concentration (SSC), elevation, tides, and distance to sediment source interact to determine deposition rates across the marsh. Seasonal variation in SSC, driven primarily by precipitation and wind, has great influence on deposition rates. Seasonal changes brought by drought or climate change may thus indirectly affect tidal marsh sediment deposition, changing wetland vulnerability to sea-level rise. We sought to estimate the influence of seasonality and tidal seasonal cycles on sediment flux by measuring sediment deposition over the course of one year across a tidal marsh surface. In the fall of 2015 we deployed sediment traps along transects perpendicular to large tidal channels and across a range of elevations at two tidal marshes in the San Francisco Bay estuary (salt marsh at Petaluma River and brackish marsh at Rush Ranch), replacing traps at 1-2 month intervals to capture seasonal variation. Similar to previous studies, in our first year of sampling we found sediment deposition was highest close to the tidal channel and decreased as you moved away from the water source. We also found that sediment deposition was highest during periods with more precipitation. We will continue this study through the winter of 2016/17 to see how the results may change in dryer winter conditions. Our results will inform modeling efforts to incorporate seasonality and variation in precipitation and tidal heights into projections of marsh elevation under sea-level rise and future precipitation climate change scenarios. In addition, our results can be used as a guide for future efforts to measure sediment flux by identifying seasonal periods most representative of annual deposition rates.

Keywords: Sediment deposition, tidal marshes, sea-level rise, drought, precipitation, seasonality

Poster Topic: Physical Processes

Seasonal Variations Between Perimeter and Channel Dynamics in South San Francisco Bay

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Lower South San Francisco Bay is interesting from a nutrients perspective because there is a large input of nutrients from rainwater runoff and wastewater treatment plant dumpings. It is curious that South San Francisco Bay has been seemingly resistant to algal blooms in the past when its nutrient levels have been on the higher end when compared to other estuaries. I believe stratification in South SF Bay plays a key role in the onset of algal blooms. Therefore, it is important to characterize the stratification that we see in the bay now in order to move forward in future models which try to predict algal blooms.

South SF Bay is also of the general estuary community's interest because of it's bathymetry and dimensions. South San Francisco Bay consists of a deeper channel down the center, and then shoals off along the perimeter into a wetland ecosystem. Also, the length of the estuary is of similar length to the length of the tidal excursion. Hydrological studies completed on South SF Bay can also give us insight on how estuaries with lengths of similar length to their tidal excursions will behave physically.

I have collected a years worth of salinity and temperature data at site just south of the Dumbarton Narrows. Combined with CIMIS data in nearby locations, I found that the channel water in South SF Bay has an adjustment period of about 14 days when perturbed by an extreme event, such as a storm. The perimeter has an even longer adjustment period due to continual freshwater input from the rainfall runoff. I observed that in the winter, the system is constantly adjusting whereas in the summer, the bay is in a more consistent state.

Keywords: hydrodynamics, lower south bay, stratification, climate change, fieldwork

Poster Topic: Physical Processes

Settling Velocities of Fine Sediments in San Francisco Estuary Margins

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In San Francisco Bay, suspended sediment can transport contaminants and nutrients, limit light availability for primary production, and accumulate in or erode mudflats and tidal wetlands. To predict sediment dynamics and transport, models must include sediment settling velocities. However, fall velocities are still predicted mostly empirically and they are challenging to observe in-situ, thus they remain parameterized in models with high uncertainty.

Previous work in San Francisco Bay found that settling velocities ranged between 0.5 and 10 mm/s. However, this work was conducted along the "backbone" of the bay, and may not apply throughout San Francisco Bay's extensive shoals, mudflats, and intertidal regions. We measured settling velocities at margin regions around San Francisco Bay to assess the potential for spatial variability.

Preliminary results from a 24 hour field experiment in a channel slough of South San Francisco Bay suggest that sediment in margin regions may be slower settling (0.3-0.4 mm/s) than sediments in the bay center, consistent with results from San Mateo shoals. An improved understanding of sediment characteristics, settling velocities, and spatial variability throughout San Francisco Bay will help us develop more accurate and predictive models of sediment transport. As managers consider marsh restoration projects, dredged material disposal locations, and the possibility of impacts from nutrient loads, understanding sediment transport is key to making informed management decisions.

Keywords: suspended sediment dynamics, settling velocity, flocs

Poster Topic: Physical Processes

Wavy River Bed: The Sacramento River at Georgiana Slough – 2010 to 2016

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Highly detailed multibeam bathymetry has been performed on an annual basis at this intersection since 2010. The junction of the Sacramento River at Georgiana Slough is important for Delta fish migration and fresh water conveyance. Time series bathymetry will allow scientists to properly model the flow dynamics of the river, plan for the installation and maintenance of proposed guidance structures, and to help understand potential biological impacts. As we unveil the detailed channel topography and track changes over time, we are able to reduce model uncertainties and explore how different processes may be interwoven together: Do changes in bathymetry affect the flow split? What does that mean for fish migrating downstream? Understanding sediment movement and depth changes at this and other locations will allow for better decisions when managing the health of the Delta ecosystem.

Keywords: bathymetry, multibeam, sonar, elevation, fish, sediment, Sacramento River, Georgiana Slough

Poster Topic: Physical Processes

The Cache Creek Resources Management Plan: 20 Years of Applied, Integrated, Science for Adaptive Management

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The Cache Creek Resources Management Plan (CCRMP) is a framework of goals for stewardship and management of Cache Creek. Developed by Yolo County, it is composed of seven elements, covering agriculture, aggregate resources, riparian and wildlife resources, water resources, floodway and channel stability, open space and recreation, and the cultural landscape. Part of the CCRMP is the establishment of a Technical Advisory Committee (TAC) made up of a Geomorphologist, Hydraulic Engineer, and Biologist. Together, the TAC provides the scientific basis on which the adaptive management strategy of the CCRMP is founded. Yolo County Staff and TAC have just completed a retrospective analysis of data collected during the 20-year period of the CCRMP and are applying this knowledge to better management of Cache Creek in the future. Using such data as LiDAR and topographic surveys, aerial imagery, vegetation mapping, long-term water quality analyses, and stream gage and flooding records, the TAC and Yolo County have developed an understanding of how human actions have impacted Cache Creek for both the positive and negative, and are applying this knowledge to balance the multiple economic, ecological, and flood control benefits the creek provides.

Keywords: Cache Creek, Water Quality, Adaptive Management,

Poster Topic: Research Synthesis & Data Management

Text Mining of IEP Articles for Characterizing the Association of Native and Non-Native Fish Species and Water Quality Parameters in the San Francisco Estuary

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Interagency Ecological Program (IEP) newsletter provide highlights and in-depth articles about species conservation, restoration and other important topics in the San Francisco Estuary, a habitat for diverse native and non-native fish species. The increasing number of publications demands in methods for efficient analysis of the large information. Text mining could help resource managers, scientists, and the public derive potentially valuable insight from unstructured data for making better conservation and recovery management decisions. The primary goal of this study is to gain knowledge on the temporal association pattern of selected fish species and water quality parameters in the San Francisco Estuary. Text mining techniques are employed to extract topic of interests from articles in the IEP newsletter, and key-words association analysis conducted between selected fish species (Delta Smelt, Chinook Salmon, Coho Salmon, Longfin Smelt, Striped Bass, Tidewater Goby, White Sturgeon, and Sacramento Perch) and water-quality parameters. Out of 126 articles published and retrieved between 1989 and 2015, about 103 are analyzed using text-mining packages available in R. The documents are clustered based on publication years (1989-1999, 2000-2009, and 2010- 2015) and profiled with cluster of informative terms for the comparison between the variables. The obtained result shows a variability of water-quality parameters and species association with publication year and species type. We noted the term “Sulfur” showing in the articles associated more (0.93) with Coho Salmon, which may indicate the need for further analysis on a specific term-species association. In conclusion, text mining has great potential for supporting species conservation efforts, uncovers valuable information hidden in literatures, reports and integrates with other biological data.

Keywords: Text mining, characterize, fish species, water quality, San Francisco Estuary

Poster Topic: Research Synthesis & Data Management

Enhancing the Vision for Managing California's Environmental Information

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The Environmental Data Summit, convened under the auspices of the Delta Stewardship Council's Delta Science Program in June 2014, witnessed remarkable participation from experts across California, the nation, and even the world. Summit attendees from the public, private, federal, and nonprofit sectors shared their views regarding the urgent needs and proposed solutions for California's data-sharing and data-integration challenges, especially pertaining to the subject of environmental resource management in the era of "big data." After all, this is a time when our data sources are growing in number, size, and complexity. Yet our ability to manage and analyze such data in service of effective decision-making lags far behind our demonstrated needs.

In its review of the sustainability of water and environmental management in the California Bay-Delta, the National Research Council (NRC) found that "only a synthetic, integrated, analytical approach to understanding the effects of suites of environmental factors (stressors) on the ecosystem and its components is likely to provide important insights that can lead to enhancement of the Delta and its species" (National Research Council 2012).

A white paper emerged from the Summit as an instrument to help identify such opportunities to enhance California's cross-jurisdictional data management. As a resource to policymakers, agency leadership, data managers, and others, this paper articulates some key challenges as well as proven solutions that can be implemented to overcome those obstacles. Primarily featured are tools that complement the State's current investments in technology.

Keywords: Big Data, Analyze, Integrated, Decision-making, Data-integration, Data-sharing, Open Data, Transparent

Poster Topic: Research Synthesis & Data Management

Enhancing Regional Capacity for Habitat Project Tracking, Assessment and Reporting

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This project significantly expanded EcoAtlas (www.ecoatlas.org), the state-wide repository for habitat project data, to include hundreds of projects for habitat protection, enhancement, and restoration throughout the Central Valley and San Francisco Bay-Delta regions. Through increased partnership, this effort has enhanced the breadth of information housed in EcoAtlas for natural resource managers, such as acres of distinct habitat types, species benefited, funding sources, and progress towards project targets.

As new projects are developed and existing projects enter new phases, information can be easily updated by project managers through Project Tracker's online forms (ptrack.ecoatlas.org). The ability to view both the landscape context and project-scale details provides information needed for better planning and decision-making. By integrating different data sources, EcoAtlas enables the visualization and spatial querying of project data, and affords improved analyses of changes in habitat extent and condition; landscape-scale conservation planning; prioritization of habitat projects; evaluation of progress toward meeting conservation objectives; partnership building; and leveraging of restoration resources.

By providing the tools needed to track and analyze landscape change and measure success of these efforts, we will improve California's ability to conserve important habitats strategically in the future.

Keywords: habitat project tracking, visualization tools

Poster Topic: Research Synthesis & Data Management

San Francisco Estuary and Watershed Science and The State of Bay-Delta Science Update, 2016

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"The most powerful paradigm structure of our time is the network -- the network of connections among ideas and people." -- Paddy Ashdown, TEDx Brussels, 2011.

San Francisco Estuary and Watershed Science is an academic, online-only, open access journal that strengthens the most important connectivity among people within the scientific community -- the sharing of a network of vetted scientific ideas. *SFEWS* facilitates this sharing in a way that adds value and has a powerful effect on the understanding of the Bay-Delta estuary's natural environment, its inhabitants, and the scientists who study this important region. How? *SFEWS* at its basis facilitates the connection of vetted scientific ideas AND the people behind them. Recently *SFEWS* has published an update of the most penetrating research surrounding the San Francisco Bay and Sacramento-San Joaquin Delta. *The State of Bay–Delta Science 2016* (*SBDS*) is a collection of papers that summarizes the scientific understanding of the Sacramento–San Joaquin Delta, emphasizing progress made during the past decade. *SBDS 2016* has been published in at least two issues of the 2016 publication year and will be available as a full set online.

Keywords: SFEWS journal, academic research, scholarly publishing, State of Bay-Delta Science

Poster Topic: Research Synthesis & Data Management

The USGS Research Vessel Polaris Retires; We Reflect on What She Taught Us

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Last year the U.S. Geological Survey retired the *R/V Polaris* after 47 years of service. Hundreds of scientific articles and dozens of graduate-student theses have been produced from data collected aboard the *R/V Polaris* and, collectively, they teach much of what we have learned about how the Bay works. After 1100 *Polaris* cruises since 1969, we have documented a remarkable range of Bay conditions. We queried our database to find the extreme high and low observations of salinity, temperature, chlorophyll, water clarity, nutrients, dissolved oxygen and phytoplankton. Here we explore these extreme observations to highlight what we have learned about the Bay, its variability, and the drivers of that variability. For example, statewide air temperatures reached record highs in 2014-15. Synchronously, the *R/V Polaris* data also showed record high water temperatures across the entire Bay system. The highest salinities we've measured were during summer of the 1977 drought, and lowest during the 1998 El Niño when surface salinity was 2 near the Golden Gate. The largest spring bloom in South Bay, by far, also developed during the 1998 El Niño. We just (May 2016) measured our all-time highest chlorophyll in the lower Sacramento River. We will explore these and other record highs and lows within our water quality data and the physical and ecological circumstances surrounding them.

Keywords: San Francisco Bay, long-term data, water quality, nutrients, phytoplankton

Poster Topic: Research Synthesis & Data Management

Reducing Dissolved Organic Carbon and Mercury Export from Subsided Delta Islands with Coagulant–Wetland Treatment Systems

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Water discharged from subsided Delta islands affects water quality in the San Francisco Bay-Delta by contributing dissolved organic carbon (DOC), disinfection byproduct precursors (DBPPs), and mercury (Hg). These constituents of concern (COC) have been identified as key components affecting drinking-water safety and environmental health. From July 2012 to November 2013, we conducted field tests of a treatment system that used in-situ coagulation followed by passage through constructed wetlands to remove COCs from the water column and sequester them in wetland sediments via natural settling of particulate material. The replicated field study on Twitchell Island in the central Delta consisted of nine 4,000 ft^2 wetlands comparing COC removal from island drainage waters due to passage through wetlands alone (control), and removal by the addition of iron (Fe)- or aluminum (Al)-based coagulants followed by wetland passage. In the treated inflow waters, both Fe and Al coagulation removed DOC, particularly more humified components, and also significantly decreased DBP precursors, dissolved methyl Hg (MeHg), and dissolved total Hg (THg). The coagulant removal efficiency of both DOC and dissolved MeHg improved with greater inflow concentrations of those constituents. For the study period, concentrations of DOC, DBPPs, and Hg at the Fe and Al treated wetland outflows were significantly lower than in the undosed inflow water, although release of these COCs was observed during wetland passage during summer months. Load calculations, which accounted for losses through seepage and effects of precipitation and ET, confirm that dosed wetland cells were usually sinks for both MeHg and DOC whereas the control wetland cells were usually sources. Coagulation technology could be used at wetlands sited in the Delta to reduce subsidence and improve wildlife habitat; these wetlands could then also serve to reduce DOC and Hg loadings coming off of the islands.

Keywords: DOC, methylmercury, mercury, DBPP, chemical dosing, wetland, water treatment

Poster Topic: Water and Sediment Quality

Clues to Physiological Pathways in Diatoms from Stable Isotope Investigations - Influence of Irradiance and Nitrogen Source

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Two species of diatoms common to Suisun Bay, *Entomoneis paludosa* and *Thalassiosira weissflogii*, were grown in a matrix of four different irradiance levels, at three different nitrogen concentrations, using two different sources of nitrogen. The two sources of nitrogen were nitrate and ammonium. While growth rates varied significantly with irradiance level, concentration and type of nitrogen did not have significant effects. Growth rates were lowest at either low or high irradiances, and greatest at the intermediate irradiance, for both species. In addition, the difference in growth rate with N source was greatest at intermediate irradiance, and was twice as large for *T. weissflogii* as it was for *E. paludosa*. Because the difference in growth rate when using ammonium compared with using nitrate was more pronounced in *T. weissflogii*, the impact of growing on ammonium versus nitrate was examined in further detail in this species using the natural abundance of the stable isotopes ^{15}N and ^{13}C. Carbon isotope enrichment in *T. weissflogii* particulate matter differed markedly with irradiance levels whereas enrichment in nitrogen isotopes did not. In contrast, enrichment in nitrogen isotopes differed markedly with concentration and type of nitrogen in the growth medium. These isotope enrichment patterns are interpreted and discussed in the context of the cellular physiology of estuarine phytoplankton.

Keywords: *Entomoneis paludosa*, *Thalassiosira weissflogii*, Nutrients, Irradiance, Stable isotopes

Poster Topic: Water and Sediment Quality

Sources and Transformations of Dissolved Organic Matter in the San Francisco Bay Estuary as Indicated by Biomarkers

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Dissolved organic matter (DOM) fuels the microbial loop, and estuarine environments contain some of the most diverse sources, concentrations, and reactivities of DOM in the world. We conducted three transects through the San Francisco Bay Estuary (SFBE) in order to investigate the roles of sources, hydrologic and seasonal changes on the DOM composition. Sampling started with a riverine endmember, with higher density sampling at low salinities and 13 samples taken in total across an axial transect from river to coastal ocean. The winter transect (Dec 2014) at maximum winter discharge allowed the study of DOM dynamics largely in the absence of photodegradation processes and low levels of algal production; the summer transect (June 2015) captured significant photodegradation and algal production; the spring transect revealed the signal of stored DOM from the snowmelt cold water flows. Multiple studies indicate that algal primary production alone cannot support the SFBE foodweb, hence other sources of organic matter must be considered, including autochthonous and allochthonous DOM. Terrestrial DOM export in SFBE were revealed by dissolved lignin dynamics. Dissolved lignin were concentrated using solid phase extraction (Agilent Technologies, Bond Elut PPL), followed by alkaline CuO oxidation. With great improvements in real-time gas chromatograph pressure adjustments that allow Retention Time Locking (Agilent Technologies), and advanced tools in metabolomics (Automated Mass Spectral Deconvolution and Identification System (AMDIS), Metabolomics Ion-based Data Extraction Algorithm (MET-IDEA)), we were able to catalogue every compound other than lignin phenols in the chromatogram resulting from CuO oxidation. This study will provide desperately needed new tools for quantitative sourcing of DOM with biomarkers.

Keywords: DOM, San Francisco Bay Estuary, Lignin, biomarker

Poster Topic: Water and Sediment Quality

Predicting the Ecological Implications of Leachates from North Pacific Gyre Plastics from In Vitro and In Vivo Models

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Marine plastics are one of the most common and persistent pollutants in ocean waters and beaches worldwide and are estimated to be present between 60-95% in the marine environment. Plastic marine debris may pose a threat to aquatic life as many plastics contain endocrine-disrupting compounds including nonylphenol, bisphenol A and various phthalates, and have been shown to adsorb common persistent organic pollutants. Plastic samples recovered from the North Pacific Gyre along with UV-irradiated virgin plastic and non-irradiated virgin plastic were extracted and concentrated using solid phase extraction (in methanol) and nitrogen evaporation. *In vitro* assays using luciferase-reporter estrogen receptor-dependent (ER) agonist cells (BG1Luc4E2) revealed significantly higher activity in UV-irradiated virgin plastic leachates than gyre plastics and virgin plastics (EEQ= 159.0, 7.7 and <0.1 ng/L , respectively). Beta-lactamase-reporter GeneBLAzer® CYP1A1-Bla (aryl hydrocarbon-receptor or AhR) assays revealed greater activity in gyre-recovered plastics than in virgin plastic and UV-irradiated virgin plastic (TEQ= 2, <0.1 and <0.1 ng/L, respectively). *Oryzias latipes* (Japanese medaka) fish were used as an endocrine-disruption *in vivo* model for these plastic leachates. To better understand the in vivo responses of plastic leachates and adsorbents, larval Japanese medaka (1-5 dph) were exposed to 0.01% methanol plastic extracts for 5 days. Induction of vitellogenin mRNA (VTG; an estrogen-dependent yolk precursor) and cytochrome P450-1A mRNA (CYP1A; an aryl-hydrocarbon-dependent enzyme) were measured using quantitative real-time polymerase chain reaction (q-RT-PCR). These results indicate the occurrence of AhR and ER ligands on plastics and that UV light may alter the impacts of plastics on biological systems.

Keywords: eco-toxicology, plastic, marine debris, endocrine disruption, in vitro

Poster Topic: Water and Sediment Quality

Changes in DOC Concentration, Composition, and Reactivity During Passage Through Constructed Wetlands of the Central Delta: Implications for Drinking Water Quality

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Wetland restoration in the Central Delta would not only provide habitat benefits to fish and wildlife, but would help ameliorate and potentially reverse subsidence. However, wetlands have the potential to add dissolved organic carbon (DOC) to Delta waterways which can negatively impact downstream drinking water quality because a fraction of this DOC pool reacts upon disinfection to form harmful disinfection byproducts (DBPs). In the Central Delta, water pumped off the subsided islands is already high in DOC due to inputs from organic peat soils. We examined whether passage of agricultural drainage waters through constructed wetlands on Twitchell Island altered surface water DOC concentrations, and by examining the chemical composition of the DOC gained insight into its likely source (i.e. peat soils, plants, algae). We also related this to the reactivity of the DOC pool with respect to trihalomethane (THM) and haloacetic acid (HAA) formation. The constructed wetlands were primarily vegetated with cattails, and the hydraulic residence time over the 1-year study period was on average 3 days. Water samples were collected monthly from the inflows and outflows of three replicated cells.
Passage of water through the wetlands increased DOC concentrations from 20% to 55% during summer months, but in the winter there was little change. Despite little to no change in DOC concentration in the winter there was a shift in composition suggesting inputs from degrading plant material. Compositional changes in DOC were less consistent across summer months. There were only minor changes in the reactivity of DOC with respect to THM and HAA formation. Changes in DOC concentration, composition, and reactivity in these constructed wetlands can be compared to adjacent wetlands that were treated with iron- and aluminum-based coagulants to target removal of DOC and DBP precursors while also improving rates of sediment accretion to reverse subsidence.

Keywords: Water quality Wetland restoration Dissolved organic carbon

Poster Topic: Water and Sediment Quality

Elevated Se Concentrations in Biological Tissue Occur during Unprecedented Drought in the San Francisco Estuary

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In the San Francisco Estuary, a five-year drought severely diminished the flow of freshwater into the estuary, which correlated with the increase in concentration of selenium (Se), a chemical contaminant from agricultural and industrial sources (e.g. oil refineries), in water and biological tissue. For this study, we examine a 21-year time series of Se concentrations in the estuarine bivalve *Potamocorbula amurensis* collected from two locations throughout the estuary spanning a range of flow conditions and water year classifications. This time series includes wet years (from before and after oil refineries reduced selenium loads), dry years, and critically dry years (i.e drought years). Our objective is to assess how different water year types, especially drought years, and different sources of selenium affect the Se concentration of clams, an important exposure pathway for Se in higher trophic levels. We found that severe drought correlated with clam tissue selenium concentrations rising above Se levels prior to managed reductions of Se in oil refinery effluents. During drought, tissue Se concentrations remain persistently high at levels exceeding toxicological thresholds (they ranged from 2 μg/g to 22 μg/g, with 62% of the 1,271 samples exceeding recommended thresholds) while seasonal variability in tissue Se concentrations decreased. Although the drought correlated with elevated Se concentrations at each site respectively, spatial patterns persisted across water year types where bivalves collected closer to the freshwater delta and the agricultural irrigation drainage sources had lower Se concentrations than those collected near oil refinery effluent discharge points (mean of 8.84 ± 1.00 μg/g near freshwater delta and mean of 13.80 ± 1.03 μg/g near oil refinery discharge). These results suggest that understanding the effects of drought and the significance of different sources of contaminants in estuarine systems will become critical for managing water quality in the face of climate change.

Keywords: Drought, Selenium, bioaccumulation, water quality, climate change, invasive species, bivalves

Poster Topic: Water and Sediment Quality

The Sensitivity of a Resident California Freshwater Mussel (*Anodonta oregonensis*) to Ammonia and Possible Regulatory Implications

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USEPA published final revised freshwater national recommended water quality criteria for ammonia in 2013. The inclusion of new toxicity data for freshwater unionid mussels in USEPA's 2013 recommended criteria resulted in substantially reduced revised criteria for ammonia; however, the mussel genera included in USEPA's dataset are not indigenous to California, or the western United States. Nevertheless, species of indigenous unionid mussels (*Anodonta*, *Margaritifera*, and *Gonidea* genera) are historically widely distributed throughout California, including the Sacramento-San Joaquin Delta and associated watersheds, yet little is known as to the sensitivity of these indigenous mussels to ammonia. In order to explore this question, acute toxicity testing of juvenile *Anodonta oregonensis*, a species historically present in California, was conducted. While significantly more sensitive than other invertebrate and vertebrate animals, *Anodonta oregonensis* appears to be substantially less sensitive than many of the non-resident mussels included in USEPA's toxicity dataset for ammonia. The regulatory implications of this result are explored through a hypothetical recalculation of USEPA's ammonia criteria.

Keywords: ammonia, toxicity, regulatory implications, mussels

Poster Topic: Water and Sediment Quality

Net Ecosystem Fluxes of Methyl Halides from a Coastal Salt Marsh with Invasive Pepperweed

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Terrestrial emissions of methyl bromide (CH_3Br) and methyl chloride (CH_3Cl) are believed to constitute the 'missing' source of these compounds to the atmosphere, but the variability of emission rates from natural ecosystems has led to large uncertainties in scaling up. Since April 2016, surface-atmosphere fluxes for methyl halides have been measured at Suisun Marsh, a coastal salt marsh in northern California, USA. Flux measurements are performed in two ways: tower based relaxed eddy accumulation (REA) for net ecosystem fluxes and static flux chamber measurements for plant-scale fluxes. The study site is invaded by perennial pepperweed (*Lepidium latifolium*), a methyl halide emitting species, covering a significant part of the flux source area. Both, REA and chamber samples are analyzed for methyl chloride (CH_3Cl) and methyl bromide (CH_3Br) using gas chromatography with electron capture detector (GC-ECD). The analytical precision [ppt] and REA flux detection limits [$\mu mol\ m^{-2}\ d^{-1}$] are on the order of 3.9/0.6 for CH_3Cl and 0.01/0.2 for CH_3Br.

Chamber measurements confirmed that methyl halide emissions of pepperweed are large, but that the native alkali heath (*Frankenia salina*) is a much stronger emitter, when normalized by biomass. REA measurements show that during the summer, the studied marsh is a substantial methyl halide source with net fluxes of ~20 $\mu mol\ m^{-2}\ d^{-1}$ (CH_3Cl) and ~1 $\mu mol\ m^{-2}\ d^{-1}$ (CH_3Br). Notably, these fluxes are comparable with reported chamber based emissions from southern California salt marshes. Furthermore, a positive response to light and temperature was found. The presentation will also expand on the diurnal variability and seasonality of the measured fluxes.

Keywords: terrestrial emissions, methyl bromide, methyl chloride, Suisun Marsh, perennial pepperweed

Poster Topic: Water and Sediment Quality

Drivers of Phytoplankton in the Sacramento River: Comparing Phytoplankton Abundance and Composition in the Presence and Absence of Treated Wastewater Effluent

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Ammonium in treated wastewater effluent entering rivers and estuaries has been implicated as a stressor on phytoplankton growth and a factor responsible for declines in diatom populations, but much of this evidence comes from controlled laboratory incubations and enclosure studies and has not been explicitly evaluated in-situ. In the Bay Delta, ammonium from the Sacramento Regional wastewater treatment plant (WWTP) discharges to the Sacramento River, the main source of water entering the estuary. To assess immediate effects of effluent on phytoplankton at the whole-river scale, in October 2013 and June 2014 we diverted WWTP discharges from the river to create a ~15 km segment of effluent-free (-EFF) river and used a Lagrangian approach to compare changes in -EFF water parcels to effluent containing (+EFF) water parcels as they transited downstream from Sacramento to Isleton. Changes in phytoplankton chlorophyll-*a*, species composition, and productivity were tracked, along with nutrients, zooplankton, and benthic grazer abundances. Over the 5 days of travel down the study reach, chlorophyll-*a* concentrations declined from 15–25 µg L-1 to ~2.5 µg L-1, with the greatest decline occurring upstream of the WWTP. There was no statistical difference in phytoplankton chlorophyll-*a* nor species composition between the +EFF and -EFF parcels during either experiment, indicating that declines in phytoplankton observed were not attributable to effluent inputs alone. Estimated grazing losses to zooplankton and clams could not account for the measured declines. This result, together with the prevalence of benthic and facultative planktonic diatoms, suggest that along the study reach hydrodynamic factors may play an underappreciated role in phytoplankton losses through settling in the tidally affected downstream stretch of the river. These results highlight the advantages of in situ, whole-river scale, Lagrangian experiments to understand the dynamic and complex interplay between physical, chemical, and biological factors that control phytoplankton populations.

Keywords: phytoplankton, ammonium, effluent, wastewater, nutrients, foodweb, hydrodynamics, Sacramento River

Poster Topic: Water and Sediment Quality

Spatial Patterns of Phytoplankton, Nutrients, and Cell Health From the Sacramento River to Suisun Bay: Are There Biological Hotspots?

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Several hypotheses have been put forward to explain the "bad Suisun" hypothesis, the observation that Suisun Bay is less productive than other parts of the San Francisco Estuary. Factors that have been invoked include the loading of ammonium from wastewater treatment plants, the salinity gradient, presence of other contaminants, the role of benthic grazing by clams, and light-limitation. As part of an IEP and Bureau of Reclamation funded project, we completed four surveys of the Sacramento River and Suisun Bay in August, October, January, and May (2014-2015). Strong gradients in phytoplankton species composition were observed, as well as persistent "hotspots" of low phytoplankton health, as derived from variable fluorescence, as well as gradients in the subsurface light field and nutrient concentrations. Phytoplankton isolated from these cruises were used in a series of physiological experiments to directly test the role of nitrogen source (ammonium versus nitrate) and irradiance. Here we present the field data, with a summary of the laboratory experimental results presented within the context of the environmental conditions, to answer the first-order question of whether there is a persistent gradient in phytoplankton health/abundance related to physical or chemical factors. Consistent with the laboratory results, we find weak evidence for a direct response to ammonium concentration, and strong evidence for light-limitation embedded within physical gradients driven by salinity, with persistent "hotspot" locations of lower phytoplankton health consistent with localized changes in the environment.

Keywords: Bad Suisun Phytoplankton Ammonium Nitrate Light Limitation Variable Fluorescence

Poster Topic: Water and Sediment Quality

Using Multivariate Analysis to Understand the Yolo - Cache Slough Complex's Water Quality Variability

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Tidal wetland restoration in the Yolo Bypass - Cache Slough Complex (YBCS) has the potential to increase dissolved organic matter concentrations. This could possibly increase disinfection by-products in municipally treated water, posing public health risks. California Department of Water Resources (DWR) is monitoring water quality conditions at eleven discrete sampling locations in the YBCS. These sampling locations were selected to evaluate drinking water quality in an existing tidal marsh habitat that surrounds ecologically-driven restoration projects. Data was collected bimonthly during two critically dry water years. It was categorized and assessed by 'all', 'wet', and 'dry' months for interannual variability. The purpose of this project was to evaluate baseline water quality conditions and provide a sound basis for post-restoration comparisons. Multivariate statistics identified which stations, and which of the six key water quality constituents accounted for a majority of the temporal and spatial variability. Although it was hypothesized that the temporal and spatial variations in the watershed were affected by tidal influences, preliminary results indicate hydrodynamics from Lisbon Weir and Sacramento River inflows from Miner Slough had a greater effect on the constituents' concentrations. However, additional influences such as natural biological processes, and anthropogenic point and non-point source discharges, also contributed to the variation. Across sampling locations, these additional influences were seen within DIN:DOP and DOC:ON ratios, and NO3-N to ON concentrations. The project's preliminary results showed that phosphorus and nitrate concentrations were not limiting, suggesting light limitation similar to that found in other parts of the Delta. Results also suggested anthropogenic influences through the stoichiometry of the monitored analytes. Agriculture is the primary land use surrounding YBCS, in addition to being located near two wastewater treatment facilities. Therefore variability in NH4-N, and NO3-N concentrations greater than ON concentrations, were used as potential signals demonstrating anthropogenic influences.

Keywords: Water Quality, Anthropogenic, Cache Slough Complex, Interannual Variability

Poster Topic: Water and Sediment Quality

South Bay Salt Ponds Restoration: Tracking Changes in Surface Water Mercury Contamination in Response to Reconnecting Tidal Flow to Historic Wetlands

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The drainage basin of the Guadalupe R. includes the New Almaden Mining area, which was the largest historic mercury (Hg) mining region in North America. The Guadalupe R. ultimately drains into South San Francisco Bay via Alviso Slough, one of the most mercury contaminated waterways in the San Francisco Bay region. The lower portion of Alviso Slough is bordered by former salt production ponds that are currently being restored to wetland or managed pond habitat. Concerns about Hg remobilization and enhanced bioaccumulation, potentially resulting from current restoration management actions, have driven numerous Hg investigations in this area for the last decade. In December 2010, the first pond (A6) along Alviso Slough was reconnected to full tidal flushing via multiple levee breaches. In June 2011, a larger Pond complex (A5/A7/A8) was restored to muted tidal flushing via an adjustable notch structure. This opening of this adjustable notch (maximum opening of 40 ft) was incrementally increased from 5 ft. in 2011 to currently 25 ft in 2016. This presentation documents changes in surface water total mercury and the more toxic methylmercury, in both Alviso Slough and the A5/A7/A8 complex, from 2006 thru 2016 (discontinuous), in response to these management actions. Results indicate a significant and sustained decrease in both total Hg and methylmercury (particulate + dissolved) within the pond complex since the initial opening of the adjustable notch. Conversely, total Hg increased in Alviso Slough modestly but significantly during the same period, with most of the change attributable to the Pond A6 breach. Methylmercury in Alviso Slough exhibited a short lived spike in concentration after the opening of the notch, which had decreased to pre-notch levels by 2015 (2016 data pending). This study exemplifies how adaptive management strategies can be employed to support ecosystem restoration goals.

Keywords: salt ponds, mercury, methylmercury, adaptive management

Poster Topic: Water and Sediment Quality

A Change in Character: Agricultural Sediments Release Compositionally Distinct Dissolved Organic Matter

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Agricultural practices increase sediment export to surface waters through soil erosion. The release of organic matter (OM) from mineral particles via desorption is a critical component of OM cycling since dissolved OM (DOM) fuels aquatic ecosystems and is a precursor for disinfection by-products formation. This study assessed the elemental and molecular composition of DOM released during abiotic desorption experiments from sediments and soils of an irrigated agricultural watershed of northern California (Willow Slough). Relative to mineral-bound OM, desorbed DOM was nitrogen-poor (lower carbon:nitrogen ratios) and depleted in amino acids and lignin phenols (lower carbon-normalized yields). Water-extracted DOM appeared substantially more degraded than its parent particulate OM with increased molar contributions of acidic amino acids, non-protein amino acids, and acidic lignin phenols, all molecular indicators of a more extensively processed OM pool. Lignin compositional ratios were significantly altered during desorption, which affects their use as biomarkers for vascular-plant sources of DOM. Specific optical parameters, including spectral slope, specific UV absorbance at 254 nm ($SUVA_{254}$), and fluorescence index (FI), did not constitute useful proxies for the desorbed DOM pool, while absorption coefficients and fluorescence peak intensities were strongly correlated with extracted DOM concentrations and composition. This study highlights the profound impact of desorption on DOM composition which, if not accounted for, could lead to misinterpretations of common biomarkers and optical proxies used to predict the composition and quality of DOM. In the agricultural Sacramento and San Joaquin watersheds, sediment mobilization is enhanced. Our findings suggest that sediment inputs to the Bay-Delta ecosystem contribute a biogeochemically distinct source of DOM to the Bay-Delta, with potential impacts on aquatic health and drinking water quality.

Keywords: dissolved organic carbon, desorption, biomarkers, amino acids, lignin, absorbance, fluorescence

Poster Topic: Water and Sediment Quality

Optimizing Sampling Methods for Monitoring Pollutant Trends in San Francisco Bay Urban Stormwater

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The Small Tributaries Loading Strategy (STLS) focuses on urban stormwater loadings from small tributaries. Since 2002, the STLS has monitored seven watersheds in the Bay Area to determine annual loadings of PCBs and Hg, in coordination with the San Francisco Bay Municipal Regional Permit (MRP). To-date, STLS monitoring has primarily been geared towards determining concentrations and annual loads from representative watersheds across the Bay Area. The sampling approach has yet to be fully optimized for detecting trends over time. In this study, we evaluated the variability and statistical power for detecting trends in PCBs (concentrations and particle-ratios) based on baseline STLS data from four of the seven watersheds. First, the influence of three climatic factors (low flow, storm stage, and season) on within-year and among-year estimates of variability (standard deviations, SDs) of PCBs was assessed. Subsequently, three variability scenarios (low, moderate, and high variation) were developed for power analysis. The goal of the power analysis was to determine the optimal sample size and revisit frequency that would be required to observe declining exponential trends in PCBs with > 80% power in 25 years. Results indicated that removal of low flow samples had little influence on variability estimates. However, storm stage and season reduced both within-year and among-year SDs for certain watersheds. The power analysis revealed that only under the low variability scenarios would it be possible to achieve >80% power with less than 8 sampled storms per year. This study provides insight into the variability of pollutant concentrations in Bay Area urban stormwater. A preliminary sampling design that could be used to track trends in response to future best management practices for stormwater will be presented.

Keywords: Stormwater, Water Quality, Trends, Power Analysis, PCBs

Poster Topic: Water and Sediment Quality

Ammonium and Nitrate Sources and Patterns in the Bay Delta Using Stable Isotope Techniques

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The Sacramento River is a unique and complicated system. Understanding it through ongoing monitoring is an essential way to gauge its health and identify nutrient sources that impact its biogeochemistry. The USGS Isotope Tracers Project uses stable isotopes as a tool to better understand this system. During this study, water samples were collected on a monthly basis by the Isotope Tracers Project as part of an ongoing research project with the USGS Water Quality of San Francisco Bay Program. Samples were collected at established monitoring stations beginning near the Golden Gate Bridge and ending in Rio Vista. This presentation focuses on water samples collected for $\delta^{15}N$ of ammonium and nitrate from August 2011 to May 2014. $\delta^{15}N$ ammonium observations suggest that as ammonium moves from the Sacramento River into the bay, nitrification alters the $\delta^{15}N$ of the ammonium pool. This is suggested by the increasing $\delta^{15}N$ ammonium signature as water moves from Rio Vista into the North Bay. When $\delta^{15}N$ ammonium comparisons were made between years and between seasons, overall trends remain consistent across a wide range of flow conditions. Nitrate concentrations from the bay also suggest nitrification as water moves into the bay. The main sources of nitrogen are from agricultural and waste water treatment plants; however, concentrations and isotopic composition do vary based on location, time of season, tidal conditions, and biological activity. Nitrogen stable isotope analysis provides valuable insight into sources of ammonium and nitrogen cycling that concentration measurements alone do not provide. Since multiple variables play different and unique roles in the concentration and dynamic movement of these two crucial nitrogen sources, understanding the stable isotope biogeochemistry can give us better insight into overall health and behavior of the bay, and especially behavior in drought conditions.

Keywords: ammonium, nitrate, isotope, nitrification, Sacramento river

Poster Topic: Water and Sediment Quality

Targeted and Non-Targeted Analysis of Aqueous Film Forming Foam (AFFF)-Related PFAS in a Wastewater Treatment Plant

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Recently, poly- and perfluoroalkyl substances (PFASs) derived from aqueous film forming foams (AFFF) were measured at relatively high levels in effluent in some San Francisco Bay Area wastewater treatment plants. A follow-up study was commissioned to investigate the fate of PFASs at an airport wastewater treatment plant before, during, and after a major AFFF introduction event. In addition to routine analysis of PFASs by LC-MS/MS, additional transformation products were identified using high resolution quadrupole time of flight mass spectrometry (QTOF/MS). Using a combination of targeted and non-targeted approaches, molecular features that were extracted from the raw total scan chromatography were tentatively identified with compounds from an in-house PFAS database. For compounds without a database match, chemical formulas were generated based on exact mass, isotope distribution, isotope spacing, and retention time (if available). We preliminarily identified the presence of various PFASs in AFFF formulations, such as 6:2 fluorotelomermercaptoalkylamido sulfonate (FtTAoS), 6:2 fluorotelomer sulfonamide alkylbetaine (FTAB), and two transformation products from the biological oxidation of 6:2 FtTAoS. The integrity of the analysis was validated by standardized sample analysis procedures using Agilent MassHunter Qual and Mass Profiler Professional (MPP) software for multivariate analysis, and high match scores (>90) for the assignments. Available isotope labeled and natural PFAS standards were used as positive controls. This is the first study to examine real time, microbially-mediated transformation reactions in a full scale system. The use of unknowns analysis is critical in establishing transformation reactions and their rates because there are only a few commercially available analytical standards that are applicable to the PFASs present in AFFF.

The views expressed herein are those of the authors and do not necessarily reflect those of the California Department of Toxic Substances Control.

Keywords: poly- and perfluoroalkyl substances (PFASs), aqueous film forming foams (AFFF)

Poster Topic: Water and Sediment Quality

Management Implications for Small Urban Reservoirs Based on a Multi-Year Study of Three East Bay Watershed-Reservoir Pairs

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Watersheds and associated reservoirs in the urban San Francisco Bay (SFB) area are severely stressed due to the recent California drought. Small reservoirs in the SFB provide a variety of services including flood control, recreation, and irrigation water storage; however, major freeways, historic mines, and continued development are changing contaminant loads. Approximately 200 upstream urban reservoirs are directly connected to the SFB-Delta.

We investigated three SFB watershed/reservoir systems to assess how reservoir management may mitigate or exacerbate contaminant discharge to coastal urban environments impacted by acid mine drainage, freeways and development, and natural parklands. Study sites include Lion Creek/Lake Aliso, San Lorenzo Creek/Don Castro Reservoir, and Wildcat Creek/Lake Anza. We collected water quality data (including standard geochemistry, nutrients, and trace element levels) from reservoir inlets and outlets at each of these systems bimonthly. We also measured depth profiles of pH, conductivity, temperature, and dissolved oxygen within each lake bimonthly. We collected and analyzed sediments from each lake for nutrient and trace element concentrations.

Results suggest urban reservoirs are important controls on pollutant cycling in urban watersheds and downstream water quality. Reservoir stratification varies over the course of a year and leads to reducing conditions prevailing during warm summer months and oxidizing conditions dominating during cool winter months. The redox state of these reservoirs determines whether metals and nutrients are mobilized or retained by sediments.

With drought lowering flows, reducing conditions are expected to expand during summer months. Because reducing conditions mobilize many metals and retain nutrients, summertime reservoir management style is most critical for downstream bay water quality, particularly for reservoirs with large acid mine drainage loads. Trade-offs will have to be made between in situ watershed/reservoir water supply for recreation or irrigation and downstream water quality for Bay health.

Keywords: reservoir, nutrients, metals, watersheds, East Bay, redox, management, water, sediment

Poster Topic: Water and Sediment Quality

Nutrient Budget Study of Nitrogen Related Constituents in the Sacramento River at Hood

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Nutrients composed of nitrogen and phosphorus are a necessary part of a thriving ecosystem. However, when concentrations of these constituents increase beyond background levels, it can cause issues for ecosystem health and drinking water quality. In aquatic habitats, excess nutrients can result in an increase in biomass production. These increases in biomass can clog waterways, block sunlight to lower levels in the water column, and decrease the oxygen availability for aquatic species.

This study is the first step in a greater limnology project of the SWP to understand the sources, transformations, and sinks of nutrients in the SWP. The project entails the assembly of an extensive dataset of nutrients and flow data at key stations throughout the Delta and SWP system, from which nutrient budgets and additional analyses are being developed. The focus of this study is reviewing and analyzing the nutrients at key stations throughout the Delta and SWP, and developing a nitrogen dataset for in-depth analysis sources and processes effecting concentrations and loads of nitrogen compounds in the Sacramento River at Hood.

The study objectives include:

- Develop a comprehensive dataset of flow and the nutrient constituents;
- Understand the sources of nitrogen nutrients contributing to constituents;
- Analyze the data for flow, concentration and loads relationships; and
- Analyze the data to determine long term trends of the nitrogen constituents and loads at Hood, and develop conclusions about those trends to aid in improved management of water quality for the SWP Urban Water Contractors.

The nutrients included in the analysis are Ammonia, Nitrate, Nitrate+Nitrite, Total Kjeldahl Nitrogen, Total Nitrogen, Nutrient data was obtained from DWR's Water Data Library, Interagency Ecological Program (IEP), and United States Geological Survey (USGS). Flow data for the load was obtained from DWR Water Operations Office and the Metropolitan Water District of California.

Keywords: Nutrient, nitrogen, nitrate, nitrate+nitrite, ammonia, total kjeldahl nitrogen, concentration, load

Poster Topic: Water and Sediment Quality

Coagulant and Sorbent Efficacy in Removing Mercury from Surface Waters in Cache Creek

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Cache Creek, located in California's Coast Range, is an important source of mercury (Hg) to the Sacramento-San Joaquin Delta. Cache Creek is contaminated with Hg from several sources including historical Hg and gold mines, native Hg in the soils, and active hot and cold springs high in dissolved Hg concentrations. We investigated the use of coagulants and sorbents to immobilize Hg from priority sources within the Cache Creek watershed. Three sites were selected, representing both particulate and dissolved sources of Hg: a suspended particulate Hg source sample from the Cache Creek Settling Basin (CCSB) collected during storm flow and two contrasting dissolved Hg source samples collected during base flow from downstream of a geothermal spring and at the emergence point of a connate water spring. Both dissolved samples had similarly high dissolved Hg concentrations (ca. 500 ng/L) but differed in other chemical characteristics. Three coagulants were chosen for testing with the particulate sample: (i) ChitoVanTM HV 1.5% (shell-based); (ii) FerralyteTM 8131 (ferric sulfate-based); and (iii) UltrionTM 8186 (aluminum-based). The initial turbidity of the particulate sample was ~350 Formazin Nephelometric Units (FNU). At optimum dose rates, ChitoVan reduced turbidity by 73-82%, Ferralyte reduced turbidity by 94-97%, and Ultrion reduced turbidity by 99%. The dissolved source samples were passed through three sorbents: (i) chitosan flakes, (ii) coconut shell-based activated carbon, and (iii) coal-based activated carbon. In-line columns were packed with each material and untreated sample was passed through each column at three different flow rates (1.0 L/min, 0.5 L/min, and 0.1 L/min). If sorbent results are as effective as those for coagulation, these materials could be used as cheap and readily available products to aid in Hg removal from Cache Creek, thus decreasing Hg loads to the Sacramento-San Joaquin Delta.

Keywords: mercury removal, Cache Creek watershed, coagulation, sorbents,

Poster Topic: Water and Sediment Quality

Sediment Accretion in Constructed Wetlands of the Central Delta: Comparisons between Untreated Cells and Those Treated with Iron and Aluminum Based Coagulants

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Subsidence of organic rich soils in the Sacramento-San Joaquin Delta threatens levee stability and freshwater supply. One of the main causes of subsidence is oxidative loss of organic matter that began with the reclamation of wetlands for agricultural use. There is great interest in land management approaches–including constructed wetlands–that will halt or reverse subsidence. Another issue related to these subsided lands is the export of drainage waters high in dissolved organic carbon (DOC), which negatively impacts drinking water quality. We examined the feasibility of using constructed wetlands receiving drainage water treated with metal-based coagulants to not only sequester DOC, but also accrete the organo-metal material along with wetland biomass, thereby providing additional subsidence mitigation benefits. Nine wetlands were constructed on Twitchell Island, each which received local drainage water that was either untreated (Co), or treated with polyaluminum chloride (Al) or ferric sulfate (Fe) coagulants. The wetlands were flooded for 26 months, and treatments were added continuously to inflow waters for the last 14 months. Following this period, sediment samples were collected from near the inlet, center, and outlet of each cell to determine sediment composition and the height of newly deposited material. The Al cells had the greatest accretion at about 14 cm across the length of the cells. While similar accretion rates were measured at the inlet of the Fe cells, at the center and outlet locations accretion was below 3 cm. Accretion in the Control cells was markedly lower at about 3.5 cm near the inlet and less than 1 cm near the outlet. There were differences in sediment composition (C, N, P, Fe and Al) both between treatments and by location within the treatments. Overall, this study shows that constructed wetlands which receive coagulants can store carbon and accrete material at rates exceeding untreated wetlands.

Keywords: constructed wetlands, sediment accretion, subsidence mitigation, metal-based coagulants

Poster Topic: Water and Sediment Quality

Non-targeted Analysis of Water-soluble Compounds in Ambient Bay Water and Wastewater to Identify Emerging Contaminants

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Non-targeted analysis is a novel set of techniques designed to identify new potential contaminants of emerging concern without *a priori* knowledge of their occurrence in the environment. It is a key element of the strategy that guides monitoring for emerging contaminants conducted by the Regional Monitoring Program for Water Quality in San Francisco Bay (RMP).The RMP previously conducted a non-targeted analysis of fat-soluble compounds in bivalve tissue and seal blubber, and is now conducting a non-targeted analysis of water-soluble, polar organic contaminants in ambient San Francisco Bay water and wastewater. The San Francisco Bay will be the first ecosystem to be studied via non-targeted methods for both water- and fat-soluble contaminants.

In 2016, Polar Organic Chemical Integrative Samplers (POCIS) were deployed at three locations in the San Francisco Bay watershed influenced by different contaminant pathways: urban stormwater runoff (San Leandro Bay), agricultural runoff (Napa River), and wastewater effluent (Lower South Bay). These passive samplers were used to provide an integrated, semi-quantitative assessment of pollutants entering the Bay over the course of approximately three weeks. Grab samples were collected before and after deployment to provide a quantitative snapshot of contaminants for comparison. 24-hour composite samples of wastewater effluent were also collected from several wastewater dischargers.

Samples were analyzed using cutting-edge Orbitrap liquid chromatography high resolution mass spectrometry (LC-HRMS). Compounds identified through this method may include, but are not limited to, detergents and other surfactants, pesticide and pharmaceutical breakdown products, and plastic additives. Preliminary results from this non-targeted analysis will be presented.

Keywords: emerging contaminants, non-targeted analysis, passive sampling, polar organic compounds

Poster Topic: Water and Sediment Quality

Record-High Observations of Water Temperature and Specific Conductance, San Francisco Bay, CA

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The U.S. Geological Survey (USGS) operates a network of eight stations in San Francisco Bay at which water quality is monitored. All of these stations are equipped with specific conductance and water temperature sensors; many also report turbidity and dissolved oxygen levels. Many feature sensors at more than one altitude above the bay floor. In each case, observations are made every fifteen minutes, telemetered in near-real-time, and made available via USGS's NWIS online database: http://waterdata.usgs.gov/nwis.

The period of record varies by parameter and site; the oldest station, at the San Mateo Bridge, dates from 1989. Analysis of Water Year 2014 and 2015 data revealed that most stations saw record-high values of water temperature and specific conductance during these years, which fell within a significant drought period. While there are numerous factors that likely contributed to the records being broken, low inflow of freshwater from the Sacramento-San Joaquin Delta appears to be one contributor, as there is clear inverse correlation between annual inflow from the Delta and annual mean specific conductance. There is also a clear spatial variation in the significance of this effect, with stations closer to the Delta impacted more significantly by changes in Delta outflow than those closer to the Golden Gate.

Reference:

Downing-Kunz, M.A., Work, P.A., and Shellenbarger, G.G., 2015, Record-high specific conductance and temperature in San Francisco Bay during water year 2014 (ver. 1.1, December 28, 2015): U.S. Geological Survey Open-File Report 2015–1213, 4 p.

Keywords: Water temperature, salinity, specific conductivity, San Francisco Bay

Poster Topic: Water and Sediment Quality

Simple Mass Budget Model to Evaluate Long Term PCB Fate in the Emeryville Crescent Sub-embayment

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PCB concentrations in the open waters and sediments of San Francisco Bay have shown some evidence of decline since the phase-out and ban of PCBs in the 1970s. However, during the same period, PCB concentrations in the tissues of sport fish have not changed. A hypothesis for the apparent lack of response in fish tissue PCB concentrations is the presence of ongoing loads and legacy deposits of PCBs in enclosed shallow subtidal and intertidal habitats at the edges of the Bay where prey fish spend much of their lives. In order to examine the potential for load reductions to improve PCB concentrations in these shallow habitats, we applied a simple mass budget for one such area in Emeryville Crescent, a small semi-enclosed sub-embayment with known past PCB source areas just north of the San Francisco-Oakland Bay Bridge. There are large uncertainties and gaps in much of the available data, but our initial assessment suggests the ambient PCB concentrations of the area could potentially recover quickly, reaching within 10% of a new steady state in 10 to 15 years with declines in PCB loading. Sediment and biota surveys are planned to test some of these expectations. Despite the uncertainties, the simple mass budget has proven a valuable tool for prioritizing future data collection and identifying critical areas for future, more detailed, mechanistic or empirical model development. Similar applications of simple models in other areas of the Bay and Delta may be useful for synthesizing available information and prioritizing future pollutant management and monitoring plans.

Keywords: PCB fate, load reductions, shallow habitats

Poster Topic: Water and Sediment Quality