Poster Abstracts

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Poster Clusters

General Sessions

Sonoma Creek Baylands Strategy Hatches a 6,000-acre Restoration Plan

Renee Spenst[1], Steve Carroll[1], Julian Meisler[2], Melisa Amato[3], Dean Kwasny[4], Jessica Martini-Lamb[5], Carlos Diaz[5]

[1]Ducks Unlimited, Inc., RANCHO CORDOVA, CA
[2]Sonoma Land Trust, Santa Rosa, CA
[3]San Pablo Bay National Wildlife Refuge, Sonoma, CA
[4]Natural Resources Conservation Service, Davis, CA
[5]Sonoma Water, Santa Rosa, CA

rspenst@ducks.org, scarroll@ducks.org, Julian@sonomalandtrust.org, melisa_amato@fws.gov, dean.kwasny@usda.gov, jessica.martinilamb@scwa.ca.gov, carlos.diaz@scwa.ca.gov

San Francisco Bay, an estuary of international importance, has lost 95 percent of its tidal wetlands. In the northern extent, San Pablo Bay, over 80% has been lost. These once teeming and vibrant wetlands were diked for agriculture from the late 1800s to 1950s through the construction of earthen berms and use of pumps to dry the land out. Starved for sediment, drained, and exposed to aerobic processes, the diked baylands subsided several feet below surrounding marshes. When the earthen berms fail, entire parcels can be inundated for prolonged periods.

The landmark Baylands Goals Report set goals for restoration of these lands, and subsequent planning efforts have incorporated adjacent landscapes and increased connectivity. In 2020, Sonoma Land Trust and partners laid out a conservation vision for lower Sonoma Creek from the ridgeline to the confluence with San Pablo Bay. Sonoma Creek Baylands Restoration represents a core of baylands lands that are already or soon will be in public ownership and can be restored. Ducks Unlimited, Inc. and Sonoma Land Trust are leading planning efforts with US Fish and Wildlife Service, Natural Resources Conservation Service, Sonoma Valley County Sanitation District, and tribal partners to develop restoration designs and environmental compliance documents and to gain technical, tribal, and community input through a robust engagement process for up to 6,000 acres, comprised of Skaggs Island, Haire Ranch, Camps 4 and 5, and Hudeman Enhancement Wetlands. California Wildlife Conservation Board and California State Coastal Conservancy are funding partners.

This large-scale project will make use of regulatory efficiencies created by the statewide Cutting Green Tape initiative. The team anticipates regional, state, and federal conservation funding will support rapid planning and implementation. Sea level rise, increasing storm frequency and intensity, and diminishing sediment supply add urgency to the project. Infrastructure will shape design, timeline, and cost.

Keywords: San Pablo Baylands, Sonoma Creek, Sonoma Creek Baylands, Restoration

Poster Topic: Advancing Conservation in the San Pablo Baylands

Bringing Together Science, Policy, and Community to Improve Conservation Outcomes Through the North Bay Baylands Regional Conservation Investment Strategy

Tierra Groff[1], Katie Dudney[1], Jeanette Wiseman[2], Ashley Nguyen[2], Mita Nagarkar[3], Christopher Caputo[3], James Cameron[4], Caitlin Sweeney[5]

[1]Environmental Science Associates, Oakland, CA
[2]Metropolitan Transportation Commission, San Francisco, CA
[3]California Department of Transportation, Oakland, CA
[4]Sonoma County Transportation Authority, Santa Rosa, CA
[5]San Francisco Estuary Partnership, San Francisco, CA

tgroff@esassoc.com, Kdudney@esassoc.com, jweisman@bayareametro.gov, anguyen@bayareametro.gov, mita.nagarkar@dot.ca.gov, christopher.caputo@dot.ca.gov, james.cameron@scta.ca.gov, caitlin.sweeney@sfestuary.org

The North Bay Baylands (NBB) is home to a diverse assemblage of species, including many sensitive and protected species, as well as regional infrastructure supporting local communities. In response to projected to severe impacts from sea level rise, the Metropolitan Transportation Commission, Sonoma County Transportation Authority, California Department of Transportation, and San Francisco Estuary Partnership are developing the NBB Regional Conservation Investment Strategy (RCIS) to improve conservation outcomes and increase the overall resilience of the region to climate change and sea level rise impacts.

The RCIS program, administered by the California Department of Fish and Wildlife, is designed to encourage regional planning for species and habitat conservation and enhancement. This plan develops a region-wide conservation vision that integrates information from existing local conservation plans and federal/state recovery plans with input from interested parties, technical experts, regulatory agencies, tribal nations, and the public.

The NBB RCIS identifies conservation actions specific to the region that will support key North Bay habitats and species. These actions may be used to develop a mitigation credit agreement and as advance mitigation ahead of project impacts. Conservation actions can be integrated into design components of projects to reconnect and restore marsh and upland habitats throughout the NBB. Collaboration with partner organizations and agencies has been integral in identifying priority actions and locations. As a regional planning vision, the NBB RCIS is a conceptual framework for improving climate resilience of tidal and transitional upland ecosystems in urban and rural areas that may be used as an example for the greater San Francisco Bay Area.

Keywords: RCIS, advance mitigation, regional planning, climate resilience, conservation strategy

Poster Topic: Advancing Conservation in the San Pablo Baylands

The Petaluma River Baylands Strategy: Planning for Climate Adaptation and Resilience

Julian Meisler

Sonoma Land Trust, Santa Rosa, CA

julian@sonomalandtrust.org

Historically, the Petaluma River Baylands were home to a large, complex, and biologically diverse landscape of marshes, mudflats, and open water. While some of the historical habitats remain, including the largest intact tidal marsh plain in the San Francisco Estuary, large acreages were diked and drained for agricultural purposes and urban development, and watershed connections, including access to marsh migration space, have been constrained by highway and rail infrastructure.

Nonetheless, the agricultural footprint in the diked baylands is relatively light and the largely rural nature of the adjoining watersheds make the Petaluma River among the most important and promising locations for landscape-scale conservation and restoration in the entire San Francisco Estuary.

In 2023, Sonoma Land Trust and partners completed the Petaluma River Baylands Strategy, a comprehensive analysis of existing and probable future bayland conditions with targeted strategies for restoring habitat, promoting resilience of native species and habitats, and increasing ecosystem services for human communities.

Highly variable elevation, land use, and ownership within the study area necessitated development of individual strategies tailored to areas with similar conditions. These were tied together to create a Landscape Vision prioritizing restoration of estuary–watershed connections, pathways for the baylands to migrate, increased ecological complexity, and restoration of diked baylands to full tidal action. Acknowledging the long history and continued habitation by indigenous peoples, the Strategy includes a geoarchaeological study to broadly identify areas of important cultural significance and ensure collaboration with tribal partners.

Implementation will be a puzzle, as the timing of land availability and transportation improvements are unknown, as are future rates of sea level rise, sediment availability, and a host of other relevant factors. Yet, work is well underway. Caltrans is working toward raising SR-37 and engagement with landowners has initiated projects to restore tidal marsh, seasonal wetlands, and watershed connections.

Keywords: Petaluma River, Baylands, Climate Change, Habitat restoration, Resilience

Poster Topic: Advancing Conservation in the San Pablo Baylands

Connecting San Pablo Baylands Strategies to Advance Regional Resilience

Jemma Williams, Kelli McCune

San Francisco Bay Joint Venture, Richmond, CA

jwilliams@sfbayjv.org, kmccune@sfbayjv.org

Over the last two decades, the San Francisco Bay Joint Venture (SFBJV) has forged lasting and effective partnerships resulting in on-the-ground restoration projects, scientific advancement, and strong environmental policy support for habitat and bird conservation throughout the region. However, conservation challenges continue to mount. Many seemingly "simple" projects remain – needing only a project champion and dedicated funding – but much of what we face are complex undertakings requiring diverse stakeholder engagement, public support, and cross-disciplinary technical expertise. The updated SFBJV Implementation Strategy, Restoring the Estuary to Benefit Wildlife & People (2022) honors the successful trajectory from the past two decades, while also expanding where and how we work to embrace emerging challenges amid the uncertainties of a changing climate.

Specifically, we built upon four foundational goal-setting documents that represent different habitat groups - subtidal, baylands and uplands: The Bayland Ecosystem Habitat Goals (1999), Subtidal Habitat Goals Report (2010), The Baylands Science Update (2015), and the Conservation Lands Network 2.0. We also conducted a spatial analysis that incorporates climate change adaptation by setting goals for estuarine-upland transition zone habitat that provides marsh migration, high tide refugia, and shoreline resilience. We engaged nearly 100 technical experts to provide input, writing, and review, including North Bay technical experts from our poster cluster. We highlighted the San Pablo Bay watershed strategies in Restoring the Estuary because of their opportunities for whole ecosystem restoration and to provide inspiration for sub-regional planning that is essential to achieving our goals. For example, the RCIS builds upon the same guidance documents to highlight investment opportunities. The scientific and management implications of our goal-setting approach is that it is critical to develop and connect strategies across scales in order to engage diverse stakeholders, garner sustained support, and champion the need to accelerate our collective restoration efforts.

Keywords: scale, adaptation, resilience, habitat, restoration, interdisciplinary, sub-region, San Pablo Baylands

Poster Topic: Advancing Conservation in the San Pablo Baylands

The Novato Creek Baylands Strategy: From Vision to Action

Ellen Plane[1], Jeremy Lowe[1], James Muller[2], Roger Leventhal[3], Barbara Salzman[4]

[1]San Francisco Estuary Institute, Richmond, CA
[2]San Francisco Estuary Partnership, San Francisco, CA
[3]County of Marin, San Rafael, CA
[4]Marin Audubon Society, Mill Valley, CA

ellenp@sfei.org, jeremyl@sfei.org, james.muller@sfestuary.org, rleventhal@marincounty.org, bsalzman48@gmail.com

Building on the Baylands Strategy model employed in other North Bay watersheds, the Novato Creek Baylands Strategy (Strategy) aims to enhance tidal habitat and improve flood protection. Diking of tidal marshes along Novato Creek has resulted in the loss of estuarine habitat, a decrease in floodplain storage capacity, and extensive ground subsidence. The levee system is susceptible to erosion and failure, as evidenced by flooding of State Route 37 in 2017, 2019, and 2023. Diking and other watershed modifications have altered peak flows and reduced channel capacity in Novato Creek, and climate change threatens to exacerbate flooding.

The Novato Creek Baylands Vision (SFEI 2015) describes an idealized picture of restored tidal marshes along Novato Creek, with space opened up to store floodwaters. Today, proposed State Route 37 upgrades offer the opportunity to achieve multi-benefit goals for transportation improvements, habitat restoration, and flood protection, but coordination is essential to ensure the upgrades facilitate rather than inhibit restoration goals. The Strategy will build on the Novato Creek Baylands Vision and other recent work to create a deeper analysis of the goals of local stakeholders and the feasibility of restoration opportunities. Developing the Strategy will involve working with tribes, landowners, and land managers, as well as collaborating with major projects in the area, including MTC/Caltrans SR37 improvements, the State Coastal Conservancy/USACE Bel Marin Keys Unit V restoration project, the County of Marin's Deer Island restoration, and SMART.

The Strategy will identify a suite of implementation projects and an associated timeline to facilitate funding, permitting, and restoration of individual parcels as part of a larger coordinated effort. The Novato Creek Baylands Strategy is being led by the San Francisco Estuary Partnership, San Francisco Estuary Institute, County of Marin, and Marin Audubon Society, and is in the early stages of development.

Keywords: Novato Creek, tidal habitat, flood protection, transportation, multi-benefit, restoration

Poster Topic: Advancing Conservation in the San Pablo Baylands

Salt Marsh Harvest Mouse Densities and Habitat Associations Throughout the San Francisco Estuary

Katie Smith[1], Joy Albertson[2], Carla Angulo[1], Cody Aylward[3], Laureen Barthman-Thompson[4], William Claflin[3], Sarah Estrella[4], Jason Hagani[5], Meg Marriott[2], David Riensche[6], Melissa Riley[4], Loren Roman-Nunez[4], Mark Statham[3], Rachel Tertes[2], Erika Walther[7], John Takekawa[5]

[1]WRA, Inc., San Rafael, CA
[2]U.S. Fish and Wildlife Service Refuge System, Fremont, CA
[3]UC Davis Veterinary School, Mammalian Ecology and Conservation Unit, Davis, CA
[4]California Department of Fish and Wildlife, Fairfield, CA
[5]Suisun Resource Conservation District, Suisun City, CA
[6]East Bay Regional Parks District, Oakland, CA
[7]ESA, Oakland, CA

ratsmith@ucdavis.edu, joy_albertson@fws.gov, carla.angulo@wra-ca.com, cmaylward@ucdavis.edu, Laureen.Thompson@wildlife.ca.gov, wbclaflin@ucdavis.edu, sarah.estrella@wildlife.ca.gov, jhagani@suisunrcd.org, meg_marriott@fws.gov, driensche@ebparks.org, melissa.riley@wildlife.ca.gov, Loren.Roman-Nunez@wildlife.ca.gov, statham@ucdavis.edu, rachel_tertes@fws.gov, EWalther@esassoc.com, jtakekawa@suisunrcd.org

The state and federally endangered salt marsh harvest mouse (SMHM) was first described 115 years ago, and despite having a relatively restricted and delineated range (San Francisco Estuary) a comprehensive "census" of the species had never been attempted. SMHM is a species with high seasonality and interannual population fluctuations, so comparing across disparate surveying efforts is difficult. In 2019 a group of researchers applied successfully to the National Fish and Wildlife Foundation for funding to plan and implement the first ever Rangewide Survey for SMHM. The planning process was supported by both an analysis of potential habitat value throughout the Estuary based on historical trapping data, and the recent development of methods for assessing occupancy via fecal DNA. Sampling areas were selected systematically across the species range, and location and scheduling balanced staff availability, safety and accessibility, king tides, and other considerations. In all, 60 sites were selected for live trapping and 25 for fecal DNA sampling. Over 60 biologists and volunteers working across over 9,000 trap nights processed 1,930 rodent captures, resulting in over 650 individual SMHM captured at all but seven of the live-trapping sites. Individual capture of SMHM at the sites ranged from zero to 38, with a mean of 8.92 ± 1.29 (SE). SMHM were also detected at 14 of the fecal DNA sampling locations. Captures were highest in San Pablo Bay, followed by Suisun and South San Francisco Bay, with the Central Bay having almost none. Each Bay other than Central contained one of the top three sites, which were very different with regards to configuration, hydrology, and disturbance. Results of this effort (along with other recent research) indicated that competition and soil moisture may be larger drivers of SMHM density than pickleweed cover, and that isolation can outweigh quality.

Keywords: salt marsh harvest mouse, tidal-marsh, diked-marsh, rangewide survey, endangered-species

Poster Topic: An Updated State of the Salt Marsh Harvest Mouse

High Density Nesting of the Salt Marsh Harvest Mouse in South Bay Strip Marshes

Laura Coatney[1], Carla Angulo[2], Vanessa Danielson[3], Sean MacDonald[2], Katie Smith[2]

[1]Swaim Biological Inc., Livermore, CA
[2]WRA, San Rafael, CA
[3]Stantec, Sacramento, CA

lcoatney@swaimbio.com, carla.angulo@wra-ca.com, Vanessa.danielson@stantec.com, sean.macdonald@wra-ca.com, Ksmith@wra-ca.com

During habitat enhancement efforts at tidal strip marshes surrounding restored salt ponds in the South San Francisco Bay high density of rodent nests were observed, many of which could be attributed to the salt marsh harvest mouse (SMHM; *Reithrodontomys raviventris*) an endangered San Francisco Estuary endemic. In addition to nests, ample evidence of rodent foraging was observed in many forms. Here we will describe several types of nests, including resting and piping, and provide photos and an analysis of placement and density. Nests were found in low, mid, and high marsh, and on levee tops, in a variety of vegetation types including, and most commonly, pickleweed, alkali heath, and marsh gumplant. Evidence of rodent foraging was also found throughout marsh zones and vegetation types, ranging from hulls of consumed seeds to apparently cached insect eggs. Often observed were what we describe here as “galleys,” locations or platforms where SMHM (or other marsh rodents) harvest, age, cache, and consume plant and insect matter. Photographs as well as instructions for locating and identifying galleys are presented here. These observations vastly expand our knowledge of SMHM nesting and foraging and will improve avoidance and minimization methods for future habitat enhancement efforts.

Keywords: Salt Marsh Harvest Mouse, Salt Ponds, endangered, nesting habitat, foraging

Poster Topic: An Updated State of the Salt Marsh Harvest Mouse

Rising Waters: The Effects of Winter Flooding on Salt Marsh Harvest Mouse Persistence in Managed and Tidal Wetlands

Melissa Riley*[1,2], Katie Smith[3], Sarah Estrella[1], Loren Roman-Nunez[1], Laureen Barthman-Thompson[1]

[1]California Department of Fish and Wildlife, Fairfield, CA
[2]University of California, Davis, Davis, CA
[3]WRA, Inc., San Rafael, CA

melissa.riley@wildlife.ca.gov, ksmith@wra-ca.com, sarah.estrella@wildlife.ca.gov, loren.roman-nunez@wildlife.ca.gov, laureen.thompson@wildlife.ca.gov

The salt marsh harvest mouse (*Reithrodontomys raviventris,* SMHM) is an endangered species, endemic to the wetlands of the San Francisco Bay Area. Habitat loss and fragmentation are some of the largest threats to the species, and these threats can be exacerbated by other factors such as sea level rise. In smaller, fragmented habitats with little high tide escape cover SMHM can be more vulnerable to climatic events such as winter flooding. After heavy winter rains in 2022, we wanted to evaluate the effects on SMHM populations at sites throughout their range. To do this, we re-trapped a subset of sites that were part of the SMHM range wide survey in summer 2022 and sites in Suisun Marsh that are part of long-term monitoring efforts. At all sites, but one, SMHM captures were lower than the previous year, and we found a significant decrease in capture efficiencies. This study highlights the importance of long-term monitoring efforts and regular monitoring of SMHM populations especially as the frequency of stochastic events like seasonal flooding increases. Regular monitoring will help managers gain a more accurate understanding of the status of SMHM, guiding future conservation and management.

Keywords: salt marsh harvest mouse, endangered species, conservation, climate change, flooding

Poster Topic: An Updated State of the Salt Marsh Harvest Mouse

Just Add Water? Practical Habitat Management for Salt Marsh Harvest Mouse

Sarah Gidre[1], Shawn Lockwood[1], Janell Hillman[1], Matt Bozzo[1], Carla Angulo[2], Katie Smith[2]

[1] Santa Clara Valley Water District, San Jose, CA
[2]WRA Environmental Consultants, San Rafael, CA

sgidre@valleywater.org, slockwood@valleywater.org, jhillman@valleywater.org, mbozzo@valleywater.org, carla.angulo@wra-ca.com, ksmith@wra-ca.com

The majority of historical tidal wetlands in the San Francisco Estuary have been substantially anthropogenically impacted. These changes make these areas difficult to restore to tidal action once they are no longer in use, or difficult to manage even when water control infrastructure remains. One such property is Lower Coyote Creek Reach 1A, a mitigation area managed by Santa Clara Valley Water District (Valley Water). This area consists of diked, managed marsh; a shorebird pond; and adjacent uplands, with unmuted tidal marsh directly adjacent to the mitigation area. The diked marsh has been managed for the endangered salt marsh harvest mouse (SMHM) for decades, though SMHM have never thrived there. Following a SMHM survey in 2020 Valley Water worked with biologists from WRA, Inc. to develop updated habitat management strategies. Between 2020 and 2023 Valley Water biologists increased tidal action to the marsh by manually flooding the diked marsh with tidal waters for a one-week period once a month at peak tidal cycle, a significant change from the previous management strategy of flooding 2-3 times per year. During this adjusted management period the mean pickleweed cover across the sampling areas increased from 29±10% to 37±9%, an indication of increased soil moisture. When the property was resurveyed in 2023 SMHM captures doubled (14 to 28), and captures of invasive house mice crashed (155 to 47) indicating success of periodic manual flooding.

Keywords: Salt marsh harvest mouse, habitat management

Poster Topic: Species and Communities - Sensitive Species

Using Noninvasive eDNA Surveys to Produce an Updated Range Map for the Endangered Salt Marsh Harvest Mouse

William Claflin[1,2], Cody Aylward[1], Laureen Barthman-Thompson[3], Jason Hagani[2], Katie Smith[4], Ben Sacks[1], John Takekawa[2], Mark Statham[1]

[1]Mammalian Ecology and Conservation Unit, UC Davis, Davis, CA
[2]Suisun Resource Conservation District, Suisun City, CA
[3]California Dept. Fish and Wildlife, Fairfield, CA
[4]WRA Environmental Consultants, San Rafael, CA

wbclaflin@ucdavis.edu, cmalyward@ucdavis.edu, laureen.thompson@wildlife.ca.gov, jhagani@suisunrcd.org, ksmith@wra-ca.com, bnsacks@ucdavis.edu, jtakekawa@suisunrcd.org, statham@ucdavis.edu

Despite >50 years of listing under the U.S. Endangered Species Act, no systematic survey of the salt marsh harvest mouse (SMHM; *Reithrodontomys raviventris*) has been conducted across the species range. Additionally, the SMHM is morphologically similar to the sympatric western harvest mouse (*R. megalotis*), giving rise to uncertainty in species assignment in historical studies, particularly those not validated by genetic identification. Together, these factors have led to uncertainty about the species occupancy, especially in small and isolated portions of the range. We focused on surveying less optimal marshes that had not been surveyed in decades (or ever) and used an eDNA sampling technique to detect SMHM without undertaking extensive live-trapping efforts. This method involved deploying bait stations to passively collect small mammal fecal samples, followed by genetic analysis to identify the presence of salt marsh harvest mice and sympatric species. We surveyed for salt marsh harvest mice using >1000 bait stations at 79 marsh sites throughout their range. In total we collected and analyzed 770 pooled fecal samples and identified SMHM presence at 225 bait stations at 38 sites spread across the range. We combined the noninvasive survey results with recent genetically validated live trapping data to provide an updated range map of SMHM presence across the San Francisco Bay/Delta.

Keywords: eDNA, noninvasive, survey, salt marsh harvest mouse, reithrodontomys raviventris, endangered

Poster Topic: Species and Communities - Sensitive Species

Implementing Nature-based Solutions for Shoreline Resilience

Jill Sunahara, Eddie Divita, Michelle Orr

Environmental Science Associates (ESA), San Francisco, CA

jsunahara@esassoc.com, edivita@esassoc.com, morr@esassoc.com

This poster presents an overview of nature-based shoreline (NbS) adaptation project success stories and opportunities to advance and implement NbS shoreline resiliency projects in the San Francisco Bay Region and beyond. NbS are a suite of innovative climate change resiliency and adaptation measures that can help protect vulnerable communities and habitats along the San Francisco Estuary shoreline. NbS projects take inspiration from natural landforms and work with natural physical processes. Successful implementation of NbS in the San Francisco Bay Region is complex, with hurdles related to community engagement, governance, regulatory compliance, and others. Shoreline managers around San Francisco Bay are working to scale-up the use of NbS measures, starting with pilot-scale demonstrations that provide critical lessons to inform wider-scale application of these methods. The Giant Marsh Living Shorelines Project and Oro Loma Horizontal Levee Demonstration Project are examples of successful demonstration projects that are now informing larger-scale implementation projects, such as the Heron's Head Shoreline Resilience Project, and First Mile Horizontal Levee Project. However, the process of scaling-up these NbS projects has revealed new obstacles. Large-scale shoreline projects must engage with community members throughout the planning and design phase. Projects like the North Richmond Living Levee Project and Collaborative Shoreline Plan are demonstrating the value of a community-driven planning and design process. NbS projects face challenges navigating federal and state regulations that were not written for a changing climate and rising sea levels. NbS represents a paradigm shift, and regulatory agencies must be supported to embrace new ways of approaching how project effects are evaluated.

Meaningful collaboration with community partners and clear permit pathways is especially critical to successful shoreline adaptation in the San Francisco Bay Region. While significant progress has been made, many challenges remain due to the uncertainty with NbS projects and the changing climate future.

Keywords: Nature-based solutions, permitting, community, living shoreline, horizontal levee, implementation, #esassoc

Poster Topic: Implementing Nature-based Solutions for Shoreline Resilience

Highlighting Regulatory Pathway Priorities for Nature-based Solutions in the San Francisco Bay Area

Jill Sunahara

Environmental Science Associates (ESA), San Francisco, CA

jsunahara@esassoc.com

This poster highlights key messages from a white paper developed in collaboration with the San Francisco Estuary Partnership, USEPA, San Francisco Bay Regional Water Board, BCDC, San Francisco Estuary Institute, and East Bay Dischargers Authority. The white paper spotlights on the key drivers for nature-based solutions (NbS) in the San Francisco Bay Area, key advancements, and outstanding challenges for NbS project permitting, and proposes pathways to improve the regulatory landscape. The white paper highlights the following key messages:
- NbS represents a suite of innovative solutions for communities grappling with complex challenges at the shoreline – climate change adaptation, flood protection, water quality improvements, infrastructure management, habitat enhancement, public access, and recreation.
- Nature-based shoreline adaptation is increasing in pace and scale, driven by increasing urgency to adapt to climate change and by policies and planning directives at national, state, and local levels.
- Regulatory agencies are adapting and responding to this new innovative project type. However, challenges still exist within the regulatory landscape because regulatory agencies must collaborate to achieve shared permitting standards and objectives.
Regulations were not written for a changing climate future in which near-term impacts may be necessary and beneficial to achieve long-term sustainability.
- NbS represents a paradigm shift, and regulatory agencies must be supported to embrace new ways of approaching how project effects are evaluated at temporal scales. While significant progress has been made, many challenges remain due to the uncertainty associated with NbS projects and the changing climate future they are designed to address.

These permitting challenges will be demonstrated through an active multi-beneficial horizontal levee shoreline adaptation project currently in development by the East Bay Dischargers Authority and East Bay Regional Park District, the First Mile Horizontal Levee Project. This project directly addresses Estuary Blueprint Implementation Task 3-3.

Keywords: Nature-based solutions, permitting, living shoreline, horizontal levee, multi-benefit, implementation, #esassoc

Poster Topic: Implementing Nature-based Solutions for Shoreline Resilience

North Richmond Living Levee and Collaborative Shoreline Plan

Eddie Divita[1], Graham Laird Prentice[2]

[1]Environmental Science Associates (ESA), San Francisco, CA
[2]Mithun, San Francisco, CA

edivita@esassoc.com, grahamlp@mithun.com

The North Richmond Living Levee project aims to construct a sea level rise resilient living levee for the West County Wastewater District (WCW) treatment plant and to advance sea level rise adaptation planning along the ~5-miles of North Richmond shoreline. A "living levee" is a Nature-based Solution (NbS) design approach that rethinks flood protection levee design, aiming to provide greater ecological benefits, water quality improvements, and recreational opportunities. The WCW Living Levee is envisioned as the first of a series of projects aimed at reducing the North Richmond community's risk from sea level rise, protecting ecological resources, and providing improved public access and recreational opportunities along the shoreline. This project is funded by the San Francisco Bay Restoration Authority and the WCW District.
The project has prioritized building partnerships with community members, local government, and non-government organizations, resulting in a robust community-driven design effort. Community members were invited and paid to participate in small focus group discussions, monthly working meetings, and a series of site visits. Project partner, The Watershed Project, also facilitated ongoing coordination meetings with tribal representatives and local government agencies in and around the project area. These engagement efforts served to educate the community on the anticipated impacts of sea level rise. It also allowed WCW and the Mithun-ESA design team to better understand the preferences and priorities of community members regarding amenities, access to the shoreline, and workforce development.

The project has produced a 30% design for the Living Levee that features a gently sloped levee with restored wetland habitats, with room for trails, gathering areas, and other requested recreational amenities. The project has also published a Collaborative Shoreline Plan that presents the community's vision for sea level rise adaptation and outlines pathways and priority projects for local agencies, organizations, and community members to achieve this vision.

Keywords: Nature based solutions, Living-levee, Sea level Rise, Community, Resilience, Adaptation, #esassoc

Poster Topic: Implementing Nature-based Solutions for Shoreline Resilience

Case Studies: Using Nature-based Solutions to Enhance Shoreline and Tidal Habitat Resilience

Eddie Divita, Michelle Orr, Mario Accordino

Environmental Science Associates (ESA), San Francisco, CA

edivita@esassoc.com, morr@esassoc.com, maccordino@esassoc.com

Sea level rise and regional shifts in sediment supply are impacting shorelines across San Francisco Bay, leading to erosion and relative subsidence that threaten tidal wetlands and other shoreline habitats. These habitats provide critical ecological functions and act as buffers protecting nearby upland habitats and developed areas from waves and coastal erosion. This poster will highlight several recent and ongoing projects, each of which uses a different set of Nature-based Solutions (NbS) approaches to improve the resilience of shoreline habitats in San Francisco Bay.

The Heron's Head Park Shoreline Project created a 1,600-foot-long coarse gravel beach to protect eroding tidal marsh and tidal pond habitats. Constructed in 2022, the project includes nearshore oyster reefs, rocky headlands, wood habitat structures, and native planting support by Literacy for Environmental Justice, a local NGO. Preliminary findings from post-construction geomorphic changes and ecological response will be presented.

The Giant Marsh Living Shoreline Project was constructed in 2021 to test the effectiveness of nearshore reefs to reduce wave-driven erosion along sensitive shorelines. The project installed 140 individual reef elements designed to provide habitat for native oysters and other benthic species and to resist wave energy. Preliminary findings from post-construction monitoring of wave attenuation will be presented.

The Bothin Marsh Evolving Shorelines Project has evaluated several options to increase rates of natural accretion on tidal marshes at the Bothin Marsh Preserve in order to improve habitat resilience to sea level rise. These include the construction of new channels to reconnect Coyote Creek to the tidal marsh, and beneficial reuse of dredged sediments ("thin lift" sediment placement). This poster will present geomorphic modeling comparing long-term habitat outcomes for each design option.

These projects demonstrate the wide range of NbS approaches currently being developed and implemented across San Francisco Bay.

Keywords: Nature-based solutions, Beneficial Reuse, Oyster Reefs, Sea Level Rise, Resilience, #esassoc

Poster Topic: Implementing Nature-based Solutions for Shoreline Resilience

Current State of the Science on Delta Soil Emissions and Subsidence

Lauren Damon, Campbell Ingram, Anjali Shakya

Sacramento-San Joaquin Delta Conservancy, West Sacramento, CA

Lauren.Damon@DeltaConservancy.ca.gov, Campbell.Ingram@DeltaConservancy.ca.gov, Anjali.Shakya@DeltaConservancy.ca.gov

The Sacramento-San Joaquin Delta Conservancy (Conservancy) is a lead state agency in the implementation of ecosystem restoration in the Delta and supports efforts that advance environmental protection and the economic wellbeing of Delta residents. The Conservancy works collaboratively and in coordination with local communities, leading efforts to protect, enhance, and restore the Delta's economy, agriculture and working landscapes, and environment, for the benefit of the Delta region, its local communities, and the citizens of California. Aligned with statewide initiates to restore habitat, reduce greenhouse gas emissions, and mitigate climate change risks, the Delta Conservancy has been working with our partners to find mutually beneficial, Nature Based Solutions in the Delta.
Wetlands are historic carbon sinks, sequestering carbon from the atmosphere via plants (e.g., Tule) to create the peat soils that currently dominate the Delta region. Recently, these peat soils have been drained for agriculture and exposed to oxygen, causing the stored carbon to be released via microbial activity, resulting in over 1.5 million tons of greenhouse gas emissions annually and over 150,000 acres of Delta islands to subside 20 to 30 feet below sea level. This subsidence threatens critical infrastructure, Delta communities and the region's rich agricultural production. This process continues to occur until the grounds are rewetted, as in the case of wetlands or rice cultivation (Shakya and Damon, 2023).
There are over two decades of data indicating that lands in the Delta are critical in California's urgent efforts to build a resilient, equitable, and carbon neutral future. Science supports that healthy landscapes can sequester and store carbon; limit future greenhouse gas emissions; protect people and nature from the impacts of climate change; and build resilience to future impacts of climate change. This poster seeks to provide a review of that science and summarize solutions.

Keywords: carbon, emissions, greenhouse gas, nature-based solutions, subsidence, climate, delta, wetland

Poster Topic: Adaptation and Resilience

Advancing Nature-based Solutions for Wetland Restoration: An Overview of the Delta Conservancy's Awarded Grants

Anjali Shakya, Lauren Damon

Sacramento-San Joaquin Delta Conservancy, West Sacramento, CA

Anjali.Shakya@DeltaConservancy.ca.gov, Lauren.Damon@DeltaConservancy.ca.gov

The Sacramento-San Joaquin Delta Conservancy (Conservancy) is a lead state agency in the implementation of ecosystem restoration in the Delta and supports efforts that advance environmental protection and the economic wellbeing of Delta residents. The Delta Conservancy works collaboratively and in coordination with local communities, leading efforts to protect, enhance, and restore the Delta's economy, agriculture and working landscapes, and environment, for the benefit of the Delta region, its local communities, and the citizens of California. The Amended Budget Act of 2022 provided the Delta Conservancy with a General Fund allocation of $36 million for projects that support Nature Based Solutions: Wetland Restoration. The goals of this funding are to support restoration, conservation, and climate resilience for wetlands in the Sacramento-San Joaquin Delta. All projects funded under this program support the current State initiatives, including Building Climate Resilience, 30 x 30, and the California Water Resilience Portfolio. The Delta Conservancy has awarded $34 million to projects that when implemented, will restore and enhance an entire island (Webb Tract), provide incentives for farmers to cultivate rice within the Delta (Delta Rice Incentive Program), create wetlands on land too wet to farm (Staten Island), and acquire property to be permanently protected for future restoration (Bethel Island). Collectively, these projects will result in 11,000 acres of lands that halt or reverse subsidence, reduce greenhouse gas emissions, support fish and avian food webs, and implement over two decades of research about Delta peat soils with on-the-ground projects. For more information on the science supporting this restoration, the Delta Conservancy is presenting a separate poster (Damon et. al., 2023).

Keywords: delta, wetland restoration, Nature-based Solutions, subsidence, climate resilience, sustainable agriculture

Poster Topic: Adaptation and Resilience

An Exploration of Nature-based Restoration Solutions in a San Francisco Estuary Tidal Marsh

Becca Morris*[1], Stuart Siegel[1,2], Katharyn Boyer[1], Peter Baye[3]

[1]Estuary & Ocean Science Center, San Francisco State University, Tiburon, CA
[2]San Francisco Bay National Estuarine Research Reserve, Tiburon, CA
[3]Coastal Ecologist, Annapolis, CA

beccamorris02@gmail.com, siegel@sfsu.edu, katboyer@sfsu.edu, botanybaye@gmail.com

More than 90% of the historic wetlands in the San Francisco Estuary have been replaced for agriculture and urban development, leaving communities and infrastructure vulnerable to sea level rise and storms." Hence, a significant restoration effort aims to restore approximately 22,000 hectares of tidal wetlands by 2030. This study explores the impact of nature-based solutions, rather than hard infrastructure like seawalls or levees, on promoting tidal marsh and wetland-upland transition restoration. The goal is to safeguard flood control levee stability by fostering natural processes in tidal marsh growth. The study site is at the Sears Point Nature-based Levee Adaptive Management Project, a 380-hectare wetland restoration located in San Pablo Bay, California. Specifically, we evaluate the use of supplemental natural structures, including large woody debris, placement of dry granular bay mud, and small gravel beaches, along with planted wetland vegetation, to stabilize a severely eroded wetland shoreline along a horizontal levee. The levee was designed to protect against erosional effects from wind-wave energy in a vast marsh-upland transition zone in the restoration site. The effectiveness of nature-based erosion protection was assessed by tracking shoreline vegetation recruitment, monitoring the impact of vegetation and embedded woody debris on sediment accretion and levee erosion, and observing changes in shoreline topography to understand how these natural elements work together for erosion protection. These metrics are evaluated using vegetation surveys, sediment pin measurements, ground-based survey-grade GPS topographic mapping, and UAV aerial digital elevation modeling over two growing seasons. Initial findings indicate that strategically placing woody debris, gravel, and bay mud significantly reduces shoreline erosion. This approach enables substantial recruitment of wetland plant communities within the first year of restoration. The study's results can guide the planning and management of other restoration sites facing erosion and advocate for the effective use of nature-based solutions in shoreline stabilization.

Keywords: wetland, restoration, nature-based adaptation, sea level rise, coastal ecology, nature-based solutions

Poster Topic: Adaptation and Resilience

Utilizing Nature-based Strategies for Shoreline Protection at the Sears Point Restoration Project

Stuart Siegel[1], Dan Gillenwater[2], Peter Baye[3], Roger Leventhal[4], Julian Meisler[5]

[1]San Francisco Bay National Estuarine Research Reserve, Tiburon, CA
[2]Gillenwater Consulting, Park City, UT
[3]Coastal Ecologist, Annapolis, CA
[4]FarWest Restoration Engineering, Petaluma, CA
[5]Sonoma Land Trust, Santa Rosa, CA

siegel@sfsu.edu, dan@gillenh2o.net, botanybaye@gmail.com, roger.leventhal@gmail.com, julian@sonomalandtrust.org

The 970-acre Sears Point Tidal Marsh Restoration was constructed in 2015 and incorporated a new 2.5-mile "habitat" tidal flood protection levee intended to promote establishment of wetland-upland transition habitats. The restoration project utilized natural sedimentation to raise subsided site elevations and in the first few years after tidal restoration, wind waves in the open water basin extensively scoured the new levee, cutting 50 to 150 feet into the levee and preventing durable establishment of the transition zone. To halt this erosion and restore the intended transition zone, the Sonoma Land Trust undertook an adaptive management "nature-based" shoreline restoration and protection project. Constructed in fall 2021, this project utilized large woody debris, granular dry bay mud, coarse gravel beaches, gravel lag armor, brush fencing, cordgrass and creeping wildrye planting, and levee slope regrading to restore levee slopes and provide erosion protection. All materials came from local dredging (marina and flood control channels) and utility and highway tree maintenance in the region and plants were sourced onsite. This poster describes the project design basis, construction considerations, and geomorphic outcomes observed over the first two years post-construction. A separate poster by Rebecca Morris describes the vegetation establishment outcomes across the site.

Keywords: None

Poster Topic: Adaptation and Resilience

Net Emissions Reductions from Dredging and Wetlands Creation - Comparing Greenhouse Gas and Pollutant Emissions Before and After Dredging Over a 50 Year Project Lifetime

Jason Emmons, Tessa Beach, Ellie Covington

US Army Corps of Engineers, San Francisco District, San Francisco, CA

jason.d.emmons@usace.army.mil, tessa.e.bernhardt@usace.army.mil,
ellie.L.covington@usace.army.mil

Criteria Air Pollutant (CAP) Emissions from dredging are regulated under the Clean Air Act (CAA) and new National Environmental Policy Act guidance requires evaluation of GHG emissions from federal actions as well (CEQ 2023). Thresholds for NO_x under the CAA for western states (EPA 2023) as well as new regulations being phased in from the California Air Resources Board (CARB) to require at least Tier II and Tier III engines for all commercial vessels in California are increasing regulation of vessel emissions (CARB 2023). With the increasing regulation of CAPs and new requirements to evaluate GHG emissions, it is important to quantify the expected GHG and CAP emissions from dredging activities in order to better understand the overall effects from modifying and maintaining a channel. To this end, in order to quantify the potential net emissions from before and after dredging, a hypothetical channel and port was developed based on typical west coast channel sizes and vessel calls. The study analyzes operational efficiencies of a modified channel from decreased port vessel calls and associated decreases in idling times while accounting for emissions reductions from beneficial use of dredged sediments to build wetlands from carbon dioxide sequestration. The results show that compared to the no-action alternative of not modifying a channel, improved efficiency after dredging can provide up to a ten-fold greater emissions reduction compared to carbon dioxide sequestration from beneficial use of sediments in wetlands and net negative emissions expected (i.e. less emissions than the no-action alternative) over a typical 50-year federal project lifetime.

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Keywords: Dredging, Emissions, Greenhouse Gas, NEPA, Wetland, Navigation Channel

Poster Topic: Adaptation and Resilience

Sea Level Rise Resilience Across South San Francisco Bay Tidal Marshes

Kevin Buffington, Karen Thorne

US Geological Survey, Davis, CA

kbuffington@usgs.gov, kthorne@usgs.gov

The Don Edwards San Francisco Bay National Wildlife Refuge (Refuge) covers over 4200 hectares across south San Francisco Bay. The tidal marsh within the Refuge provides critical habitat for endangered Ridgeway's rail and salt marsh harvest mouse in addition to valuable flood protection services for adjacent human development. Projections of future sea level rise suggest that these marshes may be at great risk, however, local conditions, such as sediment availability and tidal range, play important roles in controlling vulnerability. We used the WARMER-2 soil cohort model to explore future vulnerability to sea level rise across eight marsh parcels. Multiple soil cores were collected at each parcel, which provided data on soil properties, including bulk density and percent organic matter. ^{210}Pb dating was also attempted with mixed success. Readings from surface elevation tables and marker horizons, along with depth profiles of soil properties, were leveraged for model calibration. Preliminary projections of marsh area across a range of sea level rise scenarios suggest resilience under low and moderate sea level rise, with higher vulnerability as the rate of sea level rise increases. Variation in vulnerability around the Refuge was primarily related to sediment supply and initial elevations.

Keywords: sea level rise, modeling, tidal marsh, south bay, natural resilience

Poster Topic: Adaptation and Resilience

Delta Adapts: Climate Change Vulnerability and Adaptation Strategies in the Upper Estuary and Delta

Daniel Constable[1], Morgan Chow[1], Jeff Henderson[1], Erin Mullin[1], Jessica Rudnick[2], Annie Merritt[1], Chris Kwan[1], Ashok Bathulla[1], James Edwards[1], Charnelle Wickliff[1]

[1]Delta Stewardship Council, Sacramento, CA
[2]California Sea Grant, La Jolla, CA

daniel.constable@deltacouncil.ca.gov, morgan.chow@deltacouncil.ca.gov, jeff.henderson@deltacouncil.ca.gov, erin.mullin@deltacouncil.ca.gov, jessica.rudnick@deltacouncil.ca.gov, annie.merritt@deltacouncil.ca.gov, chris.kwan@deltacouncil.ca.gov, ashok.bathulla@deltacouncil.ca.gov, james.edwards@deltacouncil.ca.gov, charnelle.wickliff@deltacouncil.ca.gov

The Delta Stewardship Council (Council) launched Delta Adapts in 2018 to address climate change impacts in the Sacramento-San Joaquin Delta and Suisun Marsh (Delta). The initiative will produce a regional plan that includes information and strategies that can be used to help communities plan for climate impacts with a focus on infrastructure, farmland, habitat, and the species that call the region home.

The first phase of Delta Adapts was a climate change Vulnerability Assessment, released in 2021, to analyze the vulnerability of the Delta and Suisun Marsh to climate impacts through the end of the century. The assessment found that without significant action climate change will impact (1) people, places, and assets, (2) ecosystems, especially tidal wetlands that are subject to changing flows and sea level rise, (3) agricultural crops and economies, and (4) a reliable water supply for the Delta and the State. The Assessment also revealed that climate impacts will disproportionately affect communities that were identified as “socially vulnerable” by using socioeconomic, health, and demographic data. These communities have fewer resources to respond to and recover from climate impacts.
In early 2024 the Council will release an Adaption Plan that identifies a range of strategies that State and federal agencies, local governments, and communities can deploy to improve regional adaptation and effectively respond to the identified climate vulnerabilities. These strategies will identify potential actions in the upper estuary and Delta focused on ecosystem function, water supply reliability, agricultural land uses, and flood risk reduction. By implementing a suite of these strategies, Californians can help ensure a more resilient estuary over the coming century.

Keywords: Climate Change, Adaptation, Vulnerability, Delta

Poster Topic: Adaptation and Resilience

Sea Level Rise Project - Canal Alliance

Ryan Barbosa, Edgardo Vazquez*

Canal Alliance, San Rafael, CA

ryanb@canalalliance.org, edgardov@canalalliance.org

Problem Statement:
This initiative aims to assess the viability of various adaptation strategies in addressing imminent flooding risks within the Canal neighborhood of Marin County, California. The project emphasizes active participation, centering the needs of the Canal neighborhood's majority—low-income Latinx immigrant class renters—whose voices have historically been marginalized in planning processes, yet stand to be most affected by sea level rise.

Approach:
The project is explicitly engaging youth in the Canal neighborhood, and our poster will include photos and information about our youth engagement strategy. Our youth engagement will include exchanges between high school students from the Canal and UC Berkeley students, high tide days to collect data about the risk of tidal flooding, and developing a curriculum for grade school students to engage with sea level rise planning.

Results:
Specific results are not yet available as the project is in its engagement and planning stages, explicitly focusing on youth engagement and data collection. We want to further corroborate our outreach and analysis of data findings on curriculum development for grade school students.

Conclusions:
We believe that this approach not only fosters an ongoing dialogue about this issue among young people but also effectively conveys the message to their parents and families.
The Canal Community Resilience Planning Project represents a collaborative endeavor involving the City of San Rafael, Canal Alliance, the Multicultural Center of Marin, the County of Marin, and researchers from the University of California, Berkeley.

Keywords: Resilience, Flooding, Adaptation, Marin, Latinx, Youth, Engagement, Data, Curriculum, Planning

Poster Topic: Adaptation and Resilience

Supporting Estuary Health and Climate Resilience in DWR's Multi-benefit Habitat Restoration Projects

Michelle Jesperson, Tyler Anthony, Charlotte Biggs

State of California Department of Water Resources (DWR), Sacramento, CA

michelle.jesperson@water.ca.gov, Tyler.Anthony@water.ca.gov, charlotte.biggs@water.ca.gov

One of the overarching goals of the Estuary Blueprint is to create healthier habitats for wildlife by connecting creeks, restoring wetlands, repurposing sediment for habitat projects, and more. Another overarching goal is to increase the regional resilience to sea level rise, drought, wildfires, and other impacts of climate change. Implementing projects that restore habitats and critical physical processes is primary strategy that can be employed to improve estuary health, build resilience to climate change, support native wildlife, and provide other climate mitigating benefits like carbon sequestration.

The Department of Water Resources (DWR) is a leading partner in many habitat restoration projects in the upper Estuary, including the Delta and Suisun Marsh. DWR is focused on implementing a comprehensive suite of habitat restoration actions to support the long-term health of the Delta and its native fish and wildlife species. This poster will highlight the successes of DWRs efforts since 2015 to accelerate habitat restoration projects in the Delta. To date, DWR has completed or has projects underway to restore approximately 28,000 acres including 10,000 acres of tidal and freshwater wetlands, with an additional 8,500 acres in planning stages to complete by 2030, including another 4,000 wetland acres. The Department is looking closely at how these restoration efforts can also build resilience to climate change by factoring in sea level rise and considering opportunities to maximize carbon sequestration in project design. The poster will provide an overview of the completed projects and projects in planning and design stages. The poster will also highlight recent efforts to calculate estimates of carbon sequestration benefits of its wetland restoration projects and provide project examples where carbon sequestration at the wetland project site is being assessed and measured.

Keywords: None

Poster Topic: Adaptation and Resilience

Delta Drought Response Pilot Program: A Novel Approach to Building Resiliency to Drought

Rachel Lane[1], Lindsay Kammeier[2], Martha Ozonoff[1], Rachel Wigginton[1]

[1]Sacramento-San Joaquin Delta Conservancy, West Sacramento, CA
[2]State Water Resources Control Board, Sacramento, CA

Rachel.Lane@deltaconservancy.ca.gov, lindsay.kammeier@waterboards.ca.gov, martha.ozonoff@deltaconservancy.ca.gov, rachel.wigginton@deltaconservancy.ca.gov

The Delta Drought Response Pilot Program (DDRPP) launched in January 2022 as a response to the continued risk of drought in the Delta Watershed. The Office of the Delta Watermaster worked collaboratively with the three Delta Water Agencies—the North Delta Water Agency, the Central Delta Water Agency, and the South Delta Water Agency—to conceptualize the pilot program, and it was implemented by the Sacramento-San Joaquin Delta Conservancy (Delta Conservancy) during the 2022 and 2023 water years. The program was developed in partnership with the Delta Conservancy, the Office of the Delta Watermaster, the California Department of Water Resources, the California Department of Food and Agriculture, The Nature Conservancy, local researchers and extension experts, and in coordination with Delta water users. The goals of the DDRPP were to conserve water on a net basis, protect Delta water quality, promote soil health, and mitigate drought impacts on fish and migratory birds. To achieve these goals, the Delta Conservancy provided incentive payments to farmers to carry out water conservation and bird benefits practices in the legal Delta, resulting in 94 projects with farmers. The Delta Conservancy awarded $19 million in grants, enrolled nearly 25,000 acres in water conservation practices, and over 6,000 acres in bird benefits practices. The DDRPP Oversight Committee used OpenET, a non-invasive satellite-based method to estimate evapotranspiration (ET), to evaluate consumptive water use. We will highlight key findings from DDRPP including the different water conservation practices and bird benefit actions carried out by Delta farmers, consumptive water use changes resulting from these actions, and location specific characteristics (e.g. soil type or elevation) and other factors that influence consumptive water use changes. These results will inform future emergency drought responses and help to improve understanding of consumptive water use in the Delta.

Keywords: Evapotranspiration, Working Lands, Drought, Delta Conservancy, Grant Program, Delta Watermaster

Poster Topic: Adaptation and Resilience

Championing Messy and Complex Shorelines

Cristina Bejarano, John Gibbs, Peter Trio, Can Liu

WRT, San Francisco, CA

cbejarano@wrtdesign.com, JGibbs@wrtdesign.com, PTrio@wrtdesign.com, CLiu@wrtdesign.com

There are multifaceted challenges across the SF Estuary that come together along our politically messy and complex shorelines. Consensus-building and decision-making as a community has never been more important and the complexity is compounded by forces such as sea level rise, housing crises, recreational access, habitat loss, jurisdictional overlap, historic fill, contamination, and cost. The approach highlights recent projects grappling with these variables to build a clear decision-making process, aiming to break down silos and weave together the intricate interplay between human activities, habitat preservation, and resilience strategies.

To convey these complex issues to the community, project teams rely on clear graphics and frameworks to understand the diverse tradeoffs and symbiotic interconnectedness inherent in shoreline management. Recognizing the vital functions performed by shorelines, the research explores win-win scenarios and strategies for advancing multi-benefit projects.

The poster delves into three examples, including the Risk Assessment and Adaptation Prioritization Plan (RAAPP) with the East Bay Regional Park District, Bothin Marsh with ONE TAM (Marin County Parks and GGNPC), and Estuary Park with the City of Oakland. The RAAPP covers shoreline decision-making at a large-scale. Bothin Marsh illustrates the balancing act required to enhance community resilience while addressing multiple goals, such as retaining sediment, adapting public access, and ensuring habitat longevity. Special attention is given to minimizing the impacts of trails and public access without disrupting crucial habitat and landscape processes. The Estuary Park project is highlighted for its integrated, multi-benefit design solution, incorporating elevated embankments, beaches, and a buffering transition zone to enhance aquatic ecology.

Concluding insights emphasize team leadership, effective translation of scientific knowledge, and the navigation of diverse agency jurisdictions. Empowering communities, fostering community champions, and ensuring fluency in adaptation concepts emerge as critical components in creating a unified vision, building consensus, and fostering collaboration to advance shoreline management efforts.

Keywords: decision-making, graphics, consensus, community, resilience, balance, habitat, sediment

Poster Topic: Community Engagement

Overcoming Barriers to Equitable Adaptation in the Sacramento-San Joaquin Delta

Tara Pozzi*[1], Mark Lubell[1], Lindsay Correa[2]

[1]UC Davis, Davis, CA
[2]California Department of Water Resources, Sacramento, CA

tbpozzi@ucdavis.edu, mnlubell@ucdavis.edu, lindsay.correa@water.ca.gov

As climate change continues to progress, the ability of human communities to adapt to its impacts effectively and equitably is ever salient. Several barriers exist in the current governance of climate adaptation to achieve equitable outcomes for Sacramento-San Joaquin Delta communities. The connections between these barriers and their relationship to equitable outcomes remain unanswered. This study uses a qualitative case study approach to answer two questions: 1) What are the key barriers to equitable outcomes for climate change adaptation in the Delta? and 2) What are potential strategies to overcome these barriers? We answer these questions by drawing from the barrier's literature and empirical evidence from 41 semi-structured interviews. Interviews were conducted from May to August 2023 with individuals from Tribes, community-based organizations, non-governmental organizations, and multiple types of government agencies across the Delta and Suisun Marsh. Using a manual natural language processing approach, we identify recognitional/structural, procedural, and distributional equity challenges and map these onto categorized adaptation barriers induced from the interview data. We then discuss potential strategies to address the most prominent barriers to equitable adaptation. This study provides a science-based approach for prioritizing efforts to transform the current governance landscape and we anticipate the initial findings could be used to target specific, actionable steps forward in achieving equitable adaptation outcomes for the Delta.

Keywords: equity, climate adaptation, barriers, qualitative analysis, human communities

Poster Topic: Community Engagement

Institutional Barriers and Social Opportunities for Restoring the Estuary

Robin Freeman[1,2], David Ralston[1,2,3], Honomi Ijima[1], Steve Rauh[1]

[1]David R. Brower, Ronald V. Dellums Institute for Sustainable Policy Studies and Action, Oakland, CA
[2]Merritt College, Oakland, CA
[3]Bay Area Air Quality Management District, San Francisco, CA

robinf5713@aol.com, dralston@baaqmd.gov, honomiijima510@gmail.com, steverauh@live.ca

Problem: Address Institutional Barriers to Restoring the Estuary.
Approach: 50 years of socio-cultural observations during restoration practice and education.
Results: Human imagination and emotions are critical pre-conditions to include within culturally appropriate ecological management.
Conclusions: Support the growing access and social narratives now possible between neighborhood scale stewards and agency managers.

Based on 5 decades of experience, this poster explores barriers, opportunities, and where to place resources to meet estuary goals. The Bay is our defining geographic feature. It gives rise to narratives at scales from neighborhoods to the science of the global climate. These stories are the public background for the funding for implementation, research, policies, and ultimately how the Bay is used. Stacked climate disasters, new equity initiatives, and civil stress are shifting our public narratives. How do we adapt our regulatory structural legacies to support projects that have both scientific and shared public benefits? Like most sectors, Estuary Science communications can engage more effectively with the social psychological, or emotional effects of their missions. In addition to recent research on the positive health effects of natural places and the measurable effectiveness of “social” marketing, our research shows links between supporting small-scale participation in environmental projects and the reduction of dissatisfaction with government agencies.

Keywords: community, narratives, restoration, equity, access, psychology, inclusion, citizen science, participation,

Poster Topic: Community Engagement

Science for Communities Event: Lessons Learned and Determining Future Pathways for Environmental Justice Participatory Research in the Delta

Hannah Chaney, Megan Thomson

Delta Stewardship Council, Sacramento, CA

hannah.chaney@deltacouncil.ca.gov, megan.thomson@deltacouncil.ca.gov

The Delta Stewardship Council hosted the 1st Science for Communities Workshop (SFC 1.0) in October of 2022. The goal of this event was to help address social and environmental issues community members face within the Delta and surrounding areas by fostering relationships between community-based organizations (CBOs) with academic and agency scientists. The event accomplished this by bringing together six CBOs (California Indian Environmental Alliance, Little Manila Rising, Public Health Advocates, Restore the Delta, Sacramento Regional Coalition to End Homelessness, and Sustain our Abilities) and 32 scientists from state agencies or universities, and the community. During the event, CBOs were able to share environmental justice related research topics that they would like to explore within the Delta region. CBO representatives also shared resources to help address these issues and presented the results of their collaboration. CBOs and scientists were paired based on research topic interest and scientist expertise to undertake joint research projects. Four out of the six CBOs selected research interests that directly relate to water quality and contamination in the Delta. Other research interests included addressing how negative environmental impacts affect public health and socioeconomic status in disadvantaged communities and how climate change will impact people with disabilities within the Delta. In a post-event survey, 77% of the surveyed attendants said they would attend again and 63% cited their primary motive in attending was to network with members of the community. Feedback from the CBOs following the event is that they would like to see more participation from marginalized and younger members of local communities in addition to more networking opportunities. This poster will outline the research topics the CBOs shared during SFC 1.0 and have selected in anticipation of the SFC 2.0 event, evaluation material and community feedback from the SFC 1.0, and trajectories for improving SFC 2.0.

Keywords: Participatory Research, Community Involvement, Environmental Justice, Partnership, Water Quality

Poster Topic: Community Engagement

Lake Merritt Underwater - Views Before and After Environmental Catastrophes of 2022-2023

Adrian Cotter[1], Katharine M. Noonan[1,2,3], David Wofford[1,2], Anthony M. Bald[1,2,3,4]

[1]Lake Merritt Underwater Observatory, Oakland, CA
[2]Rotary Nature Center Friends, Oakland, CA
[3]Lake Merritt Institute, Oakland, CA
[4]St. Paul's Episcopal School, Oakland, CA

drainage@gmail.com, ktnoon@aol.com, workingchange@yahoo.com, abald@spes.org

Lake Merritt is a tidal estuary in highly urbanized Oakland California. It has suffered from poor water quality and trash pollution since colonial times. Recently, the threat of harmful algal blooms and extreme weather related to climate change have introduced new challenges. Programs to engage the public in both the science and the conservation measures needed to address the underlying problems remain limited.

In 2018 we established an informal environmental education program called the Lake Merritt Underwater Observatory (LMUO) to connect people who visit Lakeside Park at Lake Merritt to the living communities normally out of view. We acquired a Trident ROV (remotely operated vehicle) that recorded underwater video footage and could be operated by students and casual visitors. We were able to continue our program safely through the pandemic and acquired videos of underwater life near shore and in deep water in different parts of the lake in different seasons.
Here we focus on videos collected before and after two environmental catastrophes:
August 2022, the harmful phytoplankton species *Heterosigma akashiwo* entered the estuary from San Francisco Bay causing a 5-day anoxic condition at both top and bottom of the water column. An unprecedented fish kill seen on the shoreline was national news and spurred city action and new management plans.

January 2023, a series of atmospheric rivers hit Oakland causing rapid freshening of the almost marine lake and flooding of shore habitats. We involved community college, K-8 classes and groups and adults visiting the lake for recreation in viewing the devastation of invertebrate and plant communities immediately following both events and the uneven return of species in the year that followed. We hope the experience will inspire youth to pursue environmental and technology careers in the future.

Keywords: Lake Merritt, Trident ROV, Community Science, Atmospheric Rivers, Harmful Algal Bloom, Fish Kill, Heterosigma akashiwo, HAB, environmental education

Poster Topic: Community Science

Delta Science Tracker - Fostering Collaboration and Transparency in the Sacramento-San Joaquin Delta Science Community

George Isaac, Maggie Christman

Delta Stewardship Council, Sacramento, CA

george.isaac@deltacouncil.ca.gov, maggie.christman@deltacouncil.ca.gov

The Sacramento-San Joaquin Delta, a critical and complex ecosystem, hosts a multitude of scientific endeavors conducted by diverse entities, including government agencies, academic institutions, non-governmental organizations, and private research groups. Despite concerted coordination efforts, a standardized inventory to track these activities has been notably absent. This deficiency hinders accountability and impedes opportunities for collaboration and coordination. Addressing this gap, the Delta Science Tracker emerges as a pioneering web-based platform, generously supported and spearheaded by the Delta Science Program. This publicly accessible hub is designed to centralize comprehensive information about science activities across the Delta landscape, providing an invaluable resource for researchers, managers, decision-makers, and the public alike.

The Delta Science Tracker's primary objective is to improve communication and connectivity within the Delta science community. In a landscape where the breadth and diversity of scientific work can be overwhelming, this platform offers a structured, easily navigable interface, enabling stakeholders to discern and engage with relevant projects and expertise.

In line with the Delta Science Plan's visionary concept of 'One Delta, One Science,' the Delta Science Tracker embodies a shared commitment to building a collective body of scientific knowledge. This dynamic resource has the capacity to adapt and inform future water and environmental decisions, thereby ensuring the long-term sustainability and resilience of the Sacramento-San Joaquin Delta. Furthermore, in an era marked by escalating uncertainty regarding climate, water supply, and the Delta's native ecosystem, the imperative for multi-institutional collaboration has never been more apparent. The Delta Science Tracker serves as a catalyst for enhanced collaboration by connecting managers, policymakers, and scientists across disciplines and geographies. This collaborative approach is vital for making informed decisions that will shape the future of the Delta ecosystem and water resource management.

Keywords: Collaborate, Coordinate, Centralize, Network, Communicate, Inventory, Track,

Poster Topic: Community Science

Oyster Base Camps bring Olympia Oyster Restoration to Community Scientists

Jivan Khakee, Casey Harper

Wild Oyster Project, San Francisco, CA

jivan@wildoysters.org, casey@wildoysters.org

Abstract: Olympia Oyster (*Ostrea lurida*) populations have declined to less than 1% of historical estimates in the San Francisco Bay Area. A primary limitation for population restoration is the lack of suitable habitat for recruitment. Current methods of restoration have primarily focused on large scale reef structures. These projects are largely removed from public involvement with respect to both construction and monitoring. The Wild Oyster Project has installed several Oyster Base Camps, styled after Oyster Garden projects on the US East Coast, at private and public locations around the Central Bay to encourage local stewardship and restoration of oyster populations via a community science approach. We have found successful recruitment of oysters at multiple sites that would otherwise be inaccessible to established forms of oyster restoration in San Francisco Bay. Furthermore, we have found that other reef dependent organisms recruit to Base Camps quickly after implementation. While our current sample sizes are small, this project indicates increased viability of not only sites, but a community science approach to Olympia Oyster Restoration in San Francisco Bay.

Keywords: olympia oyster, restoration, community science, volunteer, habitat, stewardship, subtidal

Poster Topic: Community Science

Community-based Model for Monitoring Watershed Health

Satoko Mills

The Watershed Project, Richmond, CA

satoko@thewatershedproject.org

Traditionally, agencies and project sponsors contract with environmental consulting firms to conduct environmental monitoring in watersheds. This approach produces reliable data but does not offer community members a way to connect and understand the health of their creeks and watersheds. Projects benefit from the lived expertise of local residents and community members, but those residents don't often have the opportunity to learn scientific monitoring and analysis protocols.

The Watershed Project (TWP) is a non-profit organization whose mission is to inspire communities to understand, appreciate, and protect our local watersheds. TWP engages volunteers in a variety of community science opportunities such as creek water quality monitoring and oyster monitoring. Volunteers of all ages receive gear and field-based training, and learn how to interpret water quality data, benefits of oysters and green infrastructure (GI), and how to care for our watersheds. Monitoring events may be paired with stewardship events such as restoration and cleanup activities.

Our community science volunteer program is growing based on the interest and enthusiasm of participating community scientists, youth interns, and partner groups. Each new participant adds to the growing number of community members who understand how to measure and advocate for the health of our creeks. Participating interns learn transferable technical skills in fieldwork and data analysis early in their careers. These volunteers have collected an enormous amount of data–10 years of oyster data and 5 years of creek water quality data–yielding observable trends we can present in K-12 classrooms, at public presentations and community events, and in policymaking.

Our program demonstrates that community science volunteers and interns can collect reliable and valuable data about the health of our watersheds. Community scientists are enthusiastic, knowledgeable supporters of creek and watershed health, and their engagement is vital to long-term watershed stewardship.

Keywords: Community Science, Monitoring, Water Quality, Oyster, Green Infrastructure, Stewardship, Engagement

Poster Topic: Community Science

Plankton Blooms in Lake Merritt – Community Science Monitoring 2022-2023

Katharine M. Noonan[1,2], David Wofford[1], Janai Southworth[1,3], Anthony M. Bald[1,2], Andrew Young[2]

[1]Rotary Nature Center Friends, Oakland, CA
[2]Lake Merritt Institute, Oakland, CA
[3]San Francisco Microscopical Society, San Francisco, CA

ktnoon@aol.com, workingchange@yahoo.com, janai.southworth@gmail.com, abald@spes.org, andynamex@gmail.com

Phytoplankton are essential to life on earth. They form the basis of marine food webs and through photosynthesis release oxygen to the atmosphere and into aquatic ecosystems where it fuels cellular respiration that most life forms depend on. In Oakland California, a phytoplankton species, *Heterosigma akashiwo,* entered the estuarine "lake" in August 2022 via the Lake Merritt Channel as part of a spreading East San Francisco Bay bloom. Within days the explosive phytoplankton bloom (HAB) had expired. However, ensuing bacterial decay caused dissolved oxygen in the lake to plummet to near zero. This resulted in an unprecedented highly publicized massive fish kill in the heart of a major city.
The microscopic life of Lake Merritt has been studied scientifically for well over a century; however, the public paid little attention until now. As part of environmental education programs at Lake Merritt a local nonprofit Rotary Nature Center Friends collected and archived microscope images of plankton in the field since 2021. We participated in two governmental plankton monitoring programs which provided professional assessments of the species present in the samples we collected: a SFRWQB EPA grant funded program and the CDPH Redtide program. Our examination of fresh plankton added to the picture of changing plankton populations in the lake. Young people participated in carrying out the protocols for collection and sending samples to professional labs. They also helped to view and collect images of fresh plankton.

Preliminary results suggest that plankton populations change often in the lake. In addition to the August 2022 HAB, in the first quarter of 2023 we observed at least three "blooms" in which one type of phytoplankton dominated. By providing young people with authentic experiences using microscopy and participating in real scientific monitoring we hope to inspire the next generation of environmental researchers and stewardship professionals.

Keywords: Plankton, HAB, Dissolved Oxygen, Heterosigma akashiwo, Lake Merritt, Water Quality, Fish Kill, Rotary Nature Center Friends, Oakland CA

Poster Topic: Community Science

Dissolved Oxygen in an Urban Tidal Estuary - Oakland CA's Lake Merritt 2022-2023

Katharine M. Noonan[1,2], David Wofford[1], Janai Southworth[1,3], Andrew Young[2], Anthony M. Bald[1,2,4], Maryam Saad[1,5], Rohan Tyagi[1,5], Sheesam Gurung[1,5], Emerson Zamensky[1,6], Sydney Tamplin[1,6], Allison Shields[1,6], Leander McNeely[1,7], Emma Diana Smith[1,6], Olivia Pietz[1,6], Carmen Hamm[1,6], Betsy Schulz[8]

[1]Rotary Nature Center Friends, Oakland, CA
[2]Lake Merritt Institute, Oakland, CA
[3]San Francisco Microscopical Society, San Francisco, CA
[4]St. Paul's Episcopal School, Oakland, CA
[5]New Voices Are Rising, Rose Foundation, Oakland, CA
[6]CA Volunteers - California Climate Action Corps Alumni, Sacramento, CA
[7]California State University East Bay, Hayward, CA
[8]Emiliano Zapata Street Academy, Oakland, CA

ktnoon@aol.com, workingchange@yahoo.com, janai.southworth@gmail.com, andynamex@gmail.com, abald@spes.org, safaah017@gmail.com, rohantyagi0827@gmail.com, sheesamg@gmail.com, emerson.zamensky@colorado.edu, sydneytamplin@yahoo.com, allirshields4@gmail.com, leandermcneely@gmail.com, emmadianasmith@gmail.com, oliviapietz@gmail.com, hamm.carmen@gmail.com, betsyschulz4@gmail.com

Lake Merritt is a brackish water tidal estuary in the center of Oakland CA. It has long suffered from low water quality and was declared an “impaired body of water” by the U.S. E.P.A. in 1997 due to low dissolved oxygen (DO) and trash. Water quality has improved in subsequent years through city and regional programs to reduce trash and employ green infrastructure to deal with runoff.
In August 2022, Lake Merritt suffered a catastrophic fish kill caused by a Harmful Algal Bloom (HAB) of the phytoplankton species *Heterosigma akashiwo*. DO plummeted to near zero at both the top and bottom of the water column. In order to understand the conditions that might spark a HAB and possibly predict a recurrence, Oakland Public Works, with the help of Laketech.com and the Lake Merritt Institute installed water quality monitoring buoys that provided 24/7 monitoring of DO, temperature, salinity, chlorophyll and turbidity.

Our project addressed the need for additional information about spatial variation and seasonal DO changes at mid-lake and near the shore stations. It addressed the benefits of involving the local community, especially youth, in the science of stewardship of the lake, encouraging participants to pursue science and technology careers.
We used a calibrated sonde to measure water quality parameters at mid-lake and shore stations from August 2022 to the present. We found that:

- Dissolved oxygen varied with location along the shore as well as with depth in mid-lake.
- During daytime hours of monitoring, the water quality objective of 5 parts per million dissolved oxygen was nearly always met.
- Dissolved oxygen did not approach zero at both the top and the bottom of the water column during our monitoring.

We conclude that community monitoring can contribute to understanding the conditions surrounding HABs and benefit community and youth development.

Keywords: Lake Merritt, HAB, Dissolved Oxygen, Community Monitoring

Poster Topic: Community Science

Tracking Aquatic Invertebrates in an Urbanized Estuary - Keeping an Eye on Oakland's Lake Merritt in 2022-2023

Katharine M. Noonan[1,2], David Wofford[1], Anthony M. Bald[1,2,3], Richard Hasegawa[1], Maryam Saad[1,4], Rohan Tyagi[1,4], Sheesam G[1], Sophie Ramirez[5], Jessie Cerna Rivera[5]

[1]Rotary Nature Center Friends, Oakland, CA
[2]Lake Merritt Institute, Oakland, CA
[3]St. Paul's Episcopal School, Oakland, CA
[4]New Voices Are Rising, Rose Foundation, Oakland, CA
[5]Achieve Program, San Francisco, CA

ktnoon@aol.com, workingchange@yahoo.com, abald@spes.org, richard.hasegawa@berkeley.edu, safaah017@gmail.com, rohantyagi0827@gmail.com, sheesamg@gmail.com, sjimenez@achieveprogram.org, ktnoon@gmail.com

Lake Merritt is a brackish water tidal estuary in Oakland CA. From 1962-1972, James Carlton carried out detailed studies of its marine and estuarine life providing an extensive description of species and communities present at that time. A re-survey of the lake was conducted in 2016 by James Carlton of Williams College MA and Andrew Chang of the Smithsonian Environmental Research Center (SERC) Tiburon CA, and an additional SERC team, to see how the lake communities had changed in 50 years. They reported shifts in community composition, new non-native species, and a notable increase in species common to higher salinity environments.

Recently, Lake Merritt has been subjected to 1) a harmful algal bloom (HAB) that decimated fish and many invertebrate populations and 2) a historic series of atmospheric river events causing prolonged freshening and shoreline flooding. The detailed scientific surveys provided by Drs. Carlton and Chang provide a baseline from which to view changes occurring after these recent ecological catastrophes. Rotary Nature Center Friends, an educational non-profit, has involved the local community - local students (K-college, public and private) and interested adults of all ages - in recording the presence of invertebrates on the iNaturalist platform. We were making observations, as part of a public outreach event on the day of the fish kill.

Since October 2022, we continue to track invertebrate species at Lake Merritt under a broad citizen-science umbrella: an iNaturalist project, Harmful Algal Bloom in Lake Merritt: Are there any survivors?, California Academy of Sciences sponsored City Nature Challenge and Snapshot CalCoast events and Biodiversity Days. Preliminary results indicate that recovery of ecological communities in the lake has been surprisingly quick but uneven. We have recruited iNaturalist enthusiasts among teens and college students, an under-represented demographic, and encouraged the next generation of naturalists, nature-lovers, and science professionals.

Keywords: Dock Fouling, Aquatic Invertebrates, Salinity, Dissolved Oxygen, Oakland, Lake Merritt, Estuary,

Poster Topic: Community Science

Baylands Change Basemap: Mapping Progress Toward Habitat Restoration Goals

Pete Kauhanen, Alex Braud, Cristina Grosso

San Francisco Estuary Institute, Richmond, CA

petek@sfei.org, alexb@sfei.org, cristina@sfei.org

The Baylands Change Basemap will update the existing map of tidal marsh, tidal flats and diked baylands to reflect the many changes in baylands distribution and abundance that have occurred over the last two decades. It will depict information regarding land use and infrastructure relevant to baylands restoration and management opportunities and constraints. This mapping effort leverages advancements in automated Object-Based Image Analysis, enabling cost-effective regular updates and change detection, significantly increasing the value of this approach.

Co-created with the San Francisco Estuary Regional Wetlands Monitoring Program's (WRMP) Geospatial Workgroup, the Baylands Change Basemap will be a fundamental component of the WRMP, serving as a common reference map to help coordinate baylands protection and restoration for all interests. It will be used commonly by public agencies to visualize and track baylands projects in EcoAtlas. Furthermore, this foundational map will continue to feed into co-developed metrics to assess bayland resilience and change in support of WRMP goals.

The current existing map of tidal marsh, tidal flats and diked baylands illustrates the complex baylands ecosystem that is highly valued by a large community of public and private interests. However, the previous map is outdated and does not represent the many changes in baylands distribution and abundance that have occurred over the last two decades. This leaves gaps in our synoptic understanding of the full impact of more recent San Francisco bayland habitat erosion, accretion, and restoration.

This new Baylands Change Basemap is necessary for the regional community of planners, regulators, managers, and scientists to track and assess the progress of restoration and protection efforts, relative to each other and over time, in the context of ongoing climate change.

Keywords: habitat classifications, map, gis, automation, geography, restoration, baylands, SF Estuary Regional Wetlands Monitoring Program, metrics, analysis

Poster Topic: Data/Tools

www.baydeltalive.com Constituent Tracker and Remote Sensing Data

Dave Osti

34 North, Truckee, CA

david@34north.com

The Bay Delta Live Constituent Tracker:
Water quality variability in the Delta is, at its core, governed by the movement of water quality fields that move at timescales that vary from the rapid twice daily movements of the tides. These tidal movements (which can be on the order of 8 miles in the western Delta) also respond to changes in river flows, the spring/neap (14 day) cycle and pumping. All of these factors can quickly change the water quality constituent field. These changes often happen much faster than the response of water project operations, with response times that can take days or weeks. In collaboration with USGS (concept and algorithm development) and DWR (transect data), this project describes a water quality constituent tracking tool that assimilates real-time time-series data collected at fixed stations in the Delta. The development of this project aims to advance the Bay-Delta Live (BDL) data management platform and leverage the Delta's sensor network and also provides data and decision support tools for viewing and analyzing continuous water quality conditions at finer spatial scales. This data assimilation tool may be incorporated into existing monitoring programs to evaluate current conditions, assess turbidity, salinity and nutrient conditions, supplement or replace DWR early warning turbidity transect operations, as well as help to evaluate changes due to wetland restoration, flow alteration, gate installations and other management actions.

NASA/JPL Remote Sensing Water Quality Data Project:
In collaboration with 34 North, USGS, NASA/JPL and DWR, this research and development project implements remote sensing data into the data platform for turbidity, water temperature and chlorophyl data. Field data that is supplemented by remotely sensed information can be used to obtain a more complete understanding of water conditions. This will include a turbidity estimate derived from remotely sensed data captured by three Earth observing satellites.

Keywords: water quality, turbidity, remote sensing, data, electrical conductivity, bay delta

Poster Topic: Data/Tools

High-resolution Classification of Wetland Vegetation and Detritus

Robert Shortt*, Dennis Baldocchi

UC Berkeley, Berkeley, CA

robert_shortt@berkeley.edu, baldocchi@berkeley.edu

Wetland restoration projects with high growth rates have a tendency to accumulate dead litter within the canopy several years after restoration. This litter layer is hypothesized to inhibit photosynthesis and delay phenology, reducing carbon uptake in these systems and thus their ability to accrete soil and raise elevation on subsided land. With multispectral UAV imagery and LiDAR dataset captured in March and August of 2023, this study examines how vegetation can be characterized not only in its greenness but also in its proportion of live-to-dead biomass. These classifications are further compared with spatial "footprint" estimates of CO2 fluxes to test the degree to which regions of dead litter are correlated with reduced photosynthesis. Results are yet to be derived, but management strategies can be better informed by the degree to which this litter reduces a wetland project's ability to achieve its stated goals, or its null effect.

Keywords: Wetlands, Restoration, Eddy Covariance, Machine Learning, Remote Sensing, Climate Change, Mitigation, Greenhouse Gases, Soil Accretion

Poster Topic: Data/Tools

Review of the Monitoring Enterprise in the Sacramento-San Joaquin Delta

Delta Independent Science Board

Delta Independent Science Board, Sacramento, CA

edmund.yu@deltacouncil.ca.gov

The 2009 Delta Reform Act directs the Delta Independent Science Board (ISB) to review scientific research and monitoring that support adaptive management of the Delta. Recognizing the need for a comprehensive review of Delta monitoring activities, the ISB reviewed the suite of monitoring programs in the Sacramento-San Joaquin Delta (referred to as the monitoring enterprise). The purpose of this review was to assess if information collected from monitoring is meeting the needs of the management agencies; if coordination, efficiencies, data quality, and data accessibility could be improved; and how monitoring data can better support the implementation of adaptive management. This review includes a comprehensive inventory of all monitoring activities and was informed by a literature review, public comments, brown bag seminars and panels, a monitoring workshop, a survey, and subsequent interviews with experienced scientists and managers involved in Delta monitoring. The Delta ISB developed an adaptive management framework for monitoring that would better meet the needs of management and stakeholders and apply the five best practices identified in the review: (1) formally tie monitoring to goals, objectives, and questions; (2) be informed by stakeholder needs and capabilities and include alternative forms of data and knowledge; (3) adapt as new information, science, and technology become available; (4) include data management, analysis, storage and synthesis; and (5) ensure that data are accessible. In addition, the Delta ISB recommends the following three transformative changes for the monitoring enterprise to better link monitoring to management: (1) develop priority management-informed science needs and questions for the monitoring enterprise and synthesize information around these questions in biennial reports or at a summit, (2) reimagine monitoring designs that are guided by priority management-informed science needs and a system-wide conceptual model; and (3) strengthen the integration, organizational and funding structure to support monitoring, analysis, and adaptive management.

Keywords: Monitoring; Delta; Peer Review; Adaptive Management

Poster Topic: Data/Tools

The San Francisco Estuary Microbiome: A Catalogue of Complete Genomes of Uncultured Bacteria, Archaea, Viruses, and Picoeukaryotes for Understanding Response to Climate Change

Lauren Lui[1], Torben Nielsen[1], Miten Jain[2]

[1]Lawrence Berkeley National Laboratory, Berkeley, CA
[2]Northeastern, Boston, MA

lmlui@lbl.gov, torben@lbl.gov, mi.jain@northeastern.edu

Problem Statement:
As terrestrial-aquatic interface (TAI) the San Francisco Estuary (SFE) is key to biogeochemical cycling for Northern California. Many important biogeochemical processes peak in TAIs, including net primary production (e.g., photosynthesis), denitrification, and greenhouse gas emissions. Of interest to water quality management and conservation, the SFE has high nutrient loadings, especially nitrogen and phosphorus, that are higher than other estuaries already impaired by eutrophication syndrome. This along with increased algal toxins and primary production in recent years supports the hypothesis that the SFE is at a critical tipping point and better models are urgently needed to investigate the health of the ecosystem. Despite the key roles that microbial communities play in biogeochemical cycling, existing models of the SFE only infer microbial activities, rather than use microbial data as input.

Approach:
Very few environmental sequencing studies exist of the microbial communities of the SFE, and most use either marker genes or second-generation sequencing technology. We are using third-generation sequencing technologies (Pacific Biosciences and Oxford Nanopore Technologies) to fill the void of missing SFE microbial genomes. A highly-resolved database of SFE microbiome genomes will enable assigning functional roles to strains and the ability to quantitatively track them through spatio-temporal datasets, allowing us to determine where and when specific biogeochemical functions are likely taking place in relation to changing environmental conditions.

Results and Conclusions:
Our preliminary results of samples from USGS stations demonstrate that we can decompose a metagenome into its constituent genomes, including 40,000 viruses and complete picoeukaryotic genomes (e.g. *Ostreococcus tauri).* We also assembled complete mitochondrial and chloroplast genomes and portions of eukaryotic genomes (sea mammals, bivalves, etc.), which could be used for eDNA studies. This data and analysis will improve SFE biogeochemical modeling and ultimately aid management to help keep the estuary resilient to climate change.

Keywords: environmental sequencing, eDNA, metagenomics, microbiome, algae, modeling, nanopore, pacbio, biogeochemistry

Poster Topic: Data/Tools

Delta Conservancy Community Enhancement Grant Program

Martha Ozonoff, Maya Garrett, Sarah Lesmeister

Sacramento-San Joaquin Delta Conservancy, West Sacramento, CA

martha.ozonoff@deltaconservancy.ca.gov, maya.garrett@deltaconservancy.ca.gov, sarah.lesmeister@deltaconservancy.ca.gov

The Sacramento-San Joaquin Delta Conservancy (Conservancy) works collaboratively with local communities to protect, enhance, and restore the Delta and Suisun Marsh's economy, agriculture and working landscapes, and environment. The Conservancy's Community Enhancement Grant Program prioritizes funding for public access projects that address recreation and tourism, historic and cultural preservation, and environmental education. The Program is funded through the California Drought, Water, Parks, Climate, Coastal Protection and Outdoor Access for All Act of 2018 (Proposition 68) and a general fund allocation supporting community access, climate resilience, and natural resource protection projects. To date the program has provided $15 million to support 12 projects, with four active proposals in development. Example projects include the Building Restoration of the 1883 Clarksburg Schoolhouse and Creation Delta Welcome Center will retrofit the historic Clarksburg Schoolhouse to provide interpretation of Clarksburg's history and culture, natural environment, and agricultural industry. Once built, the Schoolhouse will host student fieldtrips from communities across the Delta. The Pacific Flyway Center's Walk in the Marsh project will construct wildlife viewing platforms, interpretive signage, raised boardwalk, bridges, and a pathway trail system through the wetlands of the Suisun Marsh. Once constructed, the Walk in the Marsh will be a destination for school children, families, and outdoor recreationalists from across northern California. The Delta Aquatic Center of Stockton's grant will support the pre-construction planning activities for a LEED Certified aquatic center and ADA accessible boat ramps in the severely disadvantaged community of west Stockton. Once built, the facility will make Delta waterways more available for individuals of all abilities and incomes by providing access to person-powered watercraft.

Keywords: Delta Conservancy, community, grants, public access, tourism, recreation, historic preservation

Poster Topic: Education and Outreach

Middle Schoolers Meet the Estuary at the Wings Landing Tidal Habitat Restoration Project

Abby Dziegiel, Tom Taylor, Ryan Lopez, Skip Moss, Forest Halford

Natural Resources Group, Inc., Clovis, CA

adziegiel@natural-resources-group.com, ttaylor@natural-resources-group.com, rlopez@natural-resources-group.com, smoss@natural-resources-group.com, fhalford@natural-resources-group.com

Many children in vulnerable and underserved Bay-Delta communities have limited opportunities to access the greater San Francisco Estuary, despite their proximity. Youth engagement with the estuary is critical to stewardship both now and into the future. Our challenge is to raise awareness of the importance of the estuary among students, whose experiences of the estuary (or lack thereof) will be integral to future decision-making and actions in this region.

Natural Resources Group Inc., in coordination with DWR, has implemented an annual summer program that introduces local middle school students to the Suisun Marsh. The program includes a kayak tour to the Wings Landing Tidal Habitat Restoration Project, and fosters creativity and scientific exploration through hands-on activities in the surrounding marsh uplands.

Since 2021 we have hosted local 6^{th}-8^{th} grade students with an annual capacity of 40 students per year. In one part of the program, students study wetland plants and experiment with field equipment like track traps, trail cameras, zooplankton nets, and minnow traps. In the second part, students paddle out to the restored marsh with a professional kayak instructor and nature guide. Funding for this program is secured through 2025, with plans to extend it further.

Most students we encounter have limited realization of their neighboring marsh and have spent little or no time in the Suisun Marsh prior to the program. During the program, students gain positive experiences in the estuary, and carry these memories into their future. Each year students discover a newfound appreciation for nature, and some are emboldened to lean into their existing interests in the natural sciences. As scientists, land managers, and stewards, we can make a difference if we engage with our communities with concerted efforts and consistent funding that reach and influence each new cohort of future scientists, advocates, and stewards.

Keywords: Wings, Landing, restoration, Suisun, Marsh, outreach, education, access, NRG, DWR

Poster Topic: Education and Outreach

Outdoor Education Programs

Haymar Lim, Daniella Perez Garcia

Save The Bay, Oakland, CA

hlim@savesfbay.org, dperezgarcia@savesfbay.org

Save The Bay has been running outdoor education programs with the goal of educating and inspiring young people into becoming lifelong stewards of estuarine ecosystems since 1998. Partnering with teachers across the Bay Area, we have run field trips for thousands of students at our different project sites where they have access to public lands on the shoreline, our native plant nurseries, and active restoration sites. Established approaches to outdoor education used since the beginning of our education programs, such as fostering place-based connections through guided exploration, hold lessons that have remained incredibly relevant to students. However, those approaches alone are not enough in the face of changes like imminent sea level rise. Indeed, the needs of the communities we serve have grown more pressing and the individual needs of our students are now informed by greater climate anxiety. We have intentionally worked to shift our programs towards meeting these changing needs through an intersectional and multi-faceted approach. As an organization actively working to restore bay habitat, Save The Bay has the rare opportunity to bring students from the communities with the greatest sea level rise risk out to the shoreline where they can take part in habitat restoration that makes a real difference in protecting their communities. Save The Bay has successfully used grant funding to pay for student transportation costs and bring out a lot of schools that have not had access to our field trips. We have implemented hiring and compensation policy to recruit Spanish speaking staff to better connect with students from underserved communities. We approach our program activities with a deeply student-centered philosophy. These decisions were informed by a regular feedback loop involving teachers and field educators. We continue to learn and hope that our education program can provide lessons for greater community engagement.

Keywords: outdoor education, community engagement, student habitat restoration

Poster Topic: Education and Outreach

Seismic Velocity Measurement and Profiling of the Eastern Shoreline of San Francisco Bay for Earthquake Hazard Assessment

Mitchell Craig[1], Koichi Hayashi[2]

[1]California State University, East Bay, Hayward, CA
[2]OYO/Geometrics, San Jose, CA

mitchell.craig@csueastbay.edu, khayashi@geometrics.com

Seismic surface wave surveys were conducted along the eastern shoreline of San Francisco Bay for earthquake hazard assessment. Shallow surveys were performed at 20 locations including Fremont, Hayward, San Leandro, Oakland, Emeryville, and Richmond. Sites include undisturbed marsh, former oxidation ponds, and areas filled with dredge spoils. Surveys provided estimates of shear wave velocity (V_S) versus depth. Deeper surveys were carried out at four sites. Near-surface surveys used combined active (MASW) and passive (microtremor) methods and had a target depth of 30 m. A typical recording spread was a linear array of 48 vertical geophones (4.5 Hz) with 2 m spacing. Products for each site include a velocity-depth profile, V_{S30}, and UBC site class. Deeper surveys were conducted using the passive method and provided V_S profiles to depths of 800 to 1500 m.
V_{S30} at the near-surface sites ranged from 124 to 251 m/s, with a mean of 197 m/s and standard deviation of 33 m/s. Fourteen of the 20 sites lie in Class D ($180 < V_{S30} \leq 360$ m/s) and the remaining six in Class E ($V_{S30} \leq 180$ m/s). Observed V_{S30} were clustered about the D-E boundary, with most in the range 158 - 198 m/s. Fundamental mode dispersion curves were dominant at most sites except sites with fill over mud, where higher modes were significant. Higher modes were included in dispersion curve modeling for eight of the 20 sites.
Deeper passive surveys were conducted using 2 Hz vertical geophones. to prepare a 2D VS profile and to map depth to bedrock. Fifty seismographs were deployed. The total footprint of the survey was 3 x 1 km. Data were processed to prepare a 2D V_S profile 500 meters deep. The profile shows that lower-velocity sediments thicken with distance from the Coyote Hills.

Keywords: earthquake hazard, resiliency, levees, seismic, East Bay, flood control

Poster Topic: Flood Management

Balancing Sediment Transport, Flood Protection and Water Resources: Redesigning the Alameda Creek Flood Control Channel

Kees Nederhoff[1], Bjorn Robke[2], Mick van der Wegen[2], Toine Vergroesen[2], Lauren Schambach[1], Rohin Saleh[3]

[1]Deltares USA Inc., Silver Spring, MD
[2]Stichting Deltares Netherlands, Delft
[3]Aquaflow, CA

kees.nederhoff@deltares-usa.us, bjorn.robke@deltares.nl, Mick.vanderWegen@deltares.nl, toine.vergroesen@deltares.nl, Lauren.Schambach@deltares-usa.us, rohin@aquaflows.net

The Alameda Creek Flood Control Channel, constructed over 50 years ago by the US Army Corps of Engineers, has faced issues like inadequate sediment transport to the San Francisco Bay, necessitating continuous dredging. Alameda County Flood Control District (ACFCD) has been evaluating three redesign alternatives for nearly a decade, focusing on optimizing sediment transport while maintaining flood protection. This study aims to comprehensively characterize the hydrodynamics, sediment transport, and morphodynamics of current conditions and compare them to these and other alternatives. Using the Delft3D Flexible Mesh model, configured with high resolution and detailed boundary conditions, we analyzed multiple design scenarios. The model was validated with observed morphodynamic changes, topo-bathymetry changes from 2006-2019, and local knowledge. This poster presents the model setup, validation and redesign alternatives for Alameda Creek's low-flow channel, considering sediment transport rates, flood risk reduction, and natural creek functions restoration. This work not only provides insights for the ACFCD but also sets a foundation for understanding regional dynamics within the San Francisco Bay's ecosystem. Concerns about the channel's depth affecting nearby water resources, crucial for local water supply, are also addressed, underscoring the study's significance in sustainable environmental management.

Keywords: Sediment Transport, Hydrodynamic Modeling and Flood Control Management

Poster Topic: Flood Management

Invasive Snails Proliferate Across Santa Clara County Creeks

Kylee Nielsen*, Sarah Gidre, Jen Watson

Santa Clara Valley Water District, San Jose, CA

krnielse@calpoly.edu, sgidre@valleywater.org, jwatson@valleywater.org

The New Zealand mudsnail (*Potamopyrgus antipodarum*; NZMS) is a highly invasive species that is prevalent in waterbodies across the Western United States. NZMS can rapidly multiply through asexual reproduction and can survive harsh conditions such as desiccation and digestion. This rapid proliferation results in a variety of negative impacts on ecosystems including outcompeting native macroinvertebrates, altering stream algae in ways likely to affect entire stream food webs, reducing survival of tadpoles, and reducing trout condition when ingested. They have been found to tolerate a variety of water conditions including brackish environments. Early detection surveys are practical methods for understanding invasion extent and informing management of NZMS. These surveys prioritize immediate and rapid detection of NZMS while being cost-conscious and efficient. Through the summer of 2023, six creeks across Santa Clara County that are managed for native steelhead (*Oncorhynchus mykiss*) were surveyed for NZMS. In total, 54 creek sites and 15 reservoir sites were sampled and NZMS were detected at 54% of creek and 0% of reservoir sites. The spread and growth of NZMS populations in Santa Clara County will be crucial to monitor in order to effectively reduce potential impacts to native fish and benthic macroinvertebrate populations as a result of their invasion. Practicing careful decontamination protocols will be key to limiting the future spread of NZMS.

Keywords: New Zealand Mudsnail, Invasive, Streams, Creeks, Steelhead, Decontamination

Poster Topic: Invasive Species

Lessons Learned and Considerations for Ballast Water Sampling for Compliance Assessment with the Discharge Performance Standards

Lina Ceballos Osuna, Jackie Mackay, Raya Nedelcheva, Chris Scianni, Jonathan Thompson

California State Lands Commission, Sacramento, CA

lina.ceballos@slc.ca.gov, jackie.mackay@slc.ca.gov, raya.nedelcheva@slc.ca.gov, chris.scianni@slc.ca.gov, jonathan.thompson@slc.ca.gov

In 2022, California adopted federal ballast water discharge standards limiting the number of organisms that can be discharged by vessels into California's waters. The State Lands Commission's Marine Invasive Species Program (MISP) has been developing testing and sample analysis procedures to assess compliance with these newly implemented discharge standards. Enforcement of these new regulations is dependent on scientifically sound and legally defensible sample analysis procedures. Routine compliance checks, to enumerate organisms in treated discharges are currently the only way to truly know if a ballast water treatment system is meeting discharge standards and effectively reducing the spread of nonindigenous species. Here we present preliminary results and lessons learned from the first year of ballast water sampling for compliance assessment from vessels discharging ballast water at ports within the San Francisco Estuary.

Keywords: ballast water, invasive species, treatment systems, discharge performance standards

Poster Topic: Invasive Species

Decreasing the Risk of Aquatic Invasive Species introductions from Vessels Arriving at San Francisco Estuary Ports

Jonathan Thompson

California State Lands Commission, Sacramento, CA

jonathan.thompson@slc.ca.gov

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, ballast, water, aquatic, introductions, marine, nonindigenous, nonnative, risk

Poster Topic: Invasive Species

Propagule Pressure of Invasive Common Reed (Phragmites Australis) in Suisun Marsh: Seedset, Germination Success, and Seedling Susceptibility to Herbicide

Virginia Matzek, Michael Weatherford, Gabriel Rodkey

Santa Clara University, Santa Clara, CA

vmatzek@scu.edu, mweatherford@alumni.scu.edu, grodkey@alumni.scu.edu

Problem Statement: Brackish wetland ecosystems around San Francisco Bay have been increasingly invaded by the species known as common reed or phragmites (*Phragmites australis*). In Suisun Marsh, long-term management has consisted of herbicide spraying, mowing, discing, and occasional burns, but treatments have been unsuccessful at halting the spread of phragmites.

Approach: We sought to determine if intensive management had diminished the propagule pressure of existing phragmites stands by decreasing seed number or seed viability, or, conversely, if the long history of herbicide use had resulted in herbicide resistance in the invader. We collected inflorescences of phragmites from areas with a long history of intensive control (>10 years of spraying) and from sites where little or no spraying (0-3 years) had occurred. We stripped inflorescences of florets, measured seedset, and did germination trials to test seed viability. We also subjected seedlings to glyphosate as a test of acquired herbicide resistance.

Results: We found that inflorescences from the high-intensity treatment were less numerous and had fewer seeds on average than those from low-intensity sites, although high-intensity inflorescences tended to be larger and have heavier seeds. Coupled with decreased patch area and decreased inflorescence density of *P. australis* within patches in heavily treated areas, the propagule pressure of the invader diminished by 73%, from 4486 seeds per m2 of marsh to 1214 seeds per m2 of marsh. We found no significant differences in germination rate between the low-intensity and high-intensity treatment areas. Results from the herbicide trials showed no difference in herbicide damage levels in long-sprayed populations, suggesting that herbicide resistance is unlikely to be a factor in the continued persistence of phragmites in Suisun Marsh.

Conclusions: We conclude that current control methods reduce the potential proliferation of new invasion fronts within Suisun Marsh but are not applied sufficiently to halt marsh-wide spread.

Keywords: Phragmites, invasive, propagule, seed, herbicide, management, pond, tidal, spread

Poster Topic: Invasive Species

Flow Management: How Sacramento-San Joaquin Delta Outflow Influence Non-native Submersed Aquatic Vegetation Abundance and Distribution

Yuexuan Liu*, Kyle Phillips, Brian Williamshen, Kimberly Luke, Teejay O'Rear, John Durand

University of California, Davis, Davis, CA

ooyliu@ucdavis.edu, kapphillips@ucdavis.edu, bowilliamson@ucdavis.edu, kaluke@ucdavis.edu, taorear@ucdavis.edu, jrdurand@ucdavis.edu

Submersed aquatic vegetation (SAV) is substantial component of the Sacramento-San Joaquin Delta ecosystem. Non-native SAV negatively affects the Delta ecosystem by competing with native plants and phytoplankton, providing habitat for non-native invertebrates and fishes, reducing turbidity, and clogging waterways. To conserve ecosystem services and native aquatic assemblages of the Delta, it is important to study factors that could influence the spread of non-native weeds for future management. Sacramento-San Joaquin Delta outflow is expected to influence the abundance and distribution of non-native SAV by washing plants downstream during high flows, but this effect has not been observed in past studies. I will analyze the effect of outflow on weed distribution using monthly weed volume data collected from trawls in the North Delta over the past 10 years and comparing them with average monthly Delta outflows. We predict that months with high average outflows will decrease non-native SAV abundance. Our findings could inform environmental flow management decisions that aim to control non-native SAV.

Keywords: Delta outflow, Invasive weeds

Poster Topic: Invasive Species

Storms, Droughts, Blobs, HABs, and Invasions: Environmental Influences on Invasions in San Francisco Estuary Sessile Invertebrate Communities Since 2000

Andrew Chang[1], Clinton Arriola[2], Gail Ashton[1], Jeffrey Blumenthal[1], Lina Ceballos[1], Jessika De Jesus[1], Stacey Havard[2], Natasha Hitchcock[2], Elena Huynh[1], Erica Keppel[2], Kristen Larson[2], Kelly Lion[1], Linda McCann[1], Michelle Marraffini[1], Katherine Newcomer[2], Michele Repetto[2], Anthony Rietl[3], Sharon Shiba[3], Brian Steves[2], Brianna Tracy[2], Gregory Ruiz[2]

[1]Smithsonian Environmental Research Center - West, Tiburon, CA
[2]Smithsonian Environmental Research Center, Edgewater, MD
[3]California Dept Fish and Wildlife, Sacramento, CA

ChangAL@si.edu, arriolac@si.edu, ashtong@si.edu, blumenthalj@si.edu, Lina.Ceballos@slc.ca.gov, dejesusj@si.edu, havards@si.edu, hitchcockn@si.edu, huynhe@si.edu, keppele@si.edu, larsonk@si.edu, lionk@si.edu, mccannl@si.edu, michelle.marraffini@pg.canterbury.ac.nz, newcomer.katy@gmail.com, repettom@si.edu, Anthony.Rietl@wildlife.ca.gov

Invasions by non-native species are well-known drivers of significant ecological change worldwide. Yet ecological communities are also strongly controlled by environmental conditions. Thus, despite considerable available information on marine invasions in the San Francisco Bay region, it remains challenging to detect new invasions and estimate actual changes in invasion patterns, such as rate and spread. These data are key to understanding invasion processes and informing management and policy aimed at prevention of new invasions and responses to existing invasions. How are introduced species abundance and diversity in San Francisco Bay related to environmental changes?

We conducted repeated, standardized surveys of fouling communities throughout the San Francisco Estuary over 24 years spanning a wide range of environmental conditions, including two major droughts, several wetter winters, and a major marine heat wave, and an unprecedented low DO-driven die-off driven by a harmful algal bloom (HAB).

Non-native species were prevalent throughout the estuary but achieved greater dominance following dry winters. Community composition at any given site during the summer (May to October) was predicted by environmental conditions, especially the previous winter's precipitation (linked to salinity levels) and mean temperatures. Composition patterns following a HAB and subsequent low DO event resembled those following other major disturbances such as wetter winters. Rarefaction analyses and richness estimators indicate that the number of species detected varied both as a function of the number of sites sampled in a given year and with environmental conditions, suggesting that standardized sampling across a broad range of conditions over time is needed. In addition, several southern species were detected during a marine heat wave, suggesting a possible role of shifting conditions in facilitating potential new invasions. This large dataset allows us to better understand the influence of physical characteristics on invasion patterns in the San Francisco Estuary.

Keywords: Invasions; salinity; temperature; diversity

Poster Topic: Invasive Species

Mobilizing a Rapid Response to the Threat Posed by *Paspalum vaginatum* to Tidal Marsh Conservation and Restoration in the San Francisco Estuary

Drew Kerr

Kerr Ecological Solutions, Pinole, CA

drewkerr@comcast.net

Remnant California tidal marshes often occur as patches of wildlands fragmented by urbanization and constrained by human development from their natural landward migration in response to sea level rise. Their position on the wildland-urban interface (WUI) within an open aquatic system receiving twice-daily tidal exchange exposes them to many stressors including invasive plant degradation. Seashore paspalum (*Paspalum vaginatum*) is proving to be a successful invader of estuarine and brackish marshes in both northern and southern California. This invasive grass, likely a turf industry cultivar escaped from commercial or residential horticultural introduction, was first reported in California from Riverside in 1994, and coastal areas in 2002-2003 (San Diego County & Orange County). It was recently identified in the San Francisco Estuary after being highlighted during the 2020 Cal-IPC Symposium Weed Alerts. Paspalum forms thick, dense mats that exclude other vegetation once established, expanding into surrounding native vegetation via stolons. In the San Francisco Estuary, paspalum has demonstrated the ability to dominate the mid-elevation pickleweed plain, already smothering several acres of tidal marsh in the Estuary and lining tidal flood control channels for over two miles. While established paspalum meadows on the marsh plain indicate the longer-term potential of the invader, colonization of recently breached South Bay Salt Pond (SBSP) restoration sites is even more alarming, where paspalum can alter the trajectory of marsh development by colonizing open mud, impeding the establishment of a diverse native plant assemblage. Initial management efforts began in 2021-2022 with pilot project funding from SBSP to delimit the extent of these infestations to inform early treatment. Don Edwards National Wildlife Refuge subsequently acquired some early detection/rapid response funding for 2023-2024 to expand management to the entire known infestation (~ 8 acres), located entirely in the far southeastern corner of the Estuary.

Keywords: Paspalum vaginatum, seashore paspalum, tidal marsh, invasive plants, restoration

Poster Topic: Invasive Species

San Francisco Estuary Invasive Spartina Project: Progress Update and Beginning Phased Treatment at the Final Sites

Tobias Rohmer[1], Drew Kerr[2], Jennifer McBroom[1], Jeanne Hammond[1], Brian Ort[1]

[1]Olofson Environmental, Oakland, CA
[2]Kerr Ecological Solutions, Pinole, CA

toby@olofsonenvironmental.com, dwkerr@spartina.org, jen@olofsonenvironmental.com, jeanne@olofsonenvironmental.com, brian@olofsonenvironmental.com

The San Francisco Estuary Invasive *Spartina* Project (ISP) was initiated in 2000 by the State Coastal Conservancy and U.S. Fish and Wildlife Service in response to the rapid spread of non-native *Spartina* in tidal marshes and mudflats of the San Francisco Estuary. This collaboration of many partners around the Estuary began coordinated treatment in 2005, reducing the net area of invasive *Spartina* by 97% by 2022, from a peak of 805 acres down to 20.7 acres. However, treatment has proceeded slowly at selected sites to protect the endangered California Ridgway's rail (*Rallus obsoletus obsoletus*). In 2018, after annual Ridgway's rail monitoring had shown populations had stabilized, ISP began phasing in treatment at ten sites that had previously been restricted to help reduce impacts to rails. By 2022, hybrid *Spartina* was reduced by 83% at these Phase 1 sites, totaling 11.1 acres removed from the Estuary. The ISP's 2023-2033 Biological Opinion approved Phase 2, allowing treatment to resume at the six remaining sites that have been restricted since 2011. Treatment began at three of those sites in 2023; the other three sites will be added over the next several years.

Simultaneously, ISP's Restoration Program rapidly enhances habitat for Ridgway's rail and other wildlife in tidal marshes affected by the invasion and subsequent removal of non-native *Spartina*. ISP partners design and install plantings aimed at establishing vegetation to benefit nesting, foraging, and roosting rails, and provide high tide refuge. To date, the program has installed nearly 600,000 native plantings at over 40 marshes. New restoration projects intended to create tidal wetlands can also create additional invasive *Spartina* habitat. Invasive *Spartina* continues to threaten the success of these new projects, especially in the south bay, highlighting the importance of invasive *Spartina* monitoring and treatment if these projects are to achieve their restoration goals.

Keywords: Spartina, hybrid Spartina, tidal marsh, invasive plants, restoration, Ridgway's rail

Poster Topic: Invasive Species

American Canyon Wetland Restoration Project: Improving Habitat and Public Access Constrained by Aging Infrastructure

Isaac Swanson[1], Katie Dudney[1], Michelle Orr[1], Eddie Divita[1], Linnea Tucker[1], Erica Ahmann-Smithies[2], Alexandra Ikeda[2], Jason Holley[2]

[1]Environmental Science Associates, San Francisco, CA
[2]City of American Canyon, American Canyon, CA

iswanson@esassoc.com, kdudney@esassoc.com, morr@esassoc.com, edivita@esassoc.com, ltucker@esassoc.com, esmithies@cityofamericancanyon.org, aikeda@cityofamericancanyon.org, jholley@cityofamericancanyon.org

This poster will present the conceptual design for restoring tidal marsh and ecotone slope habitat, managing wastewater overflow, and improving sea level rise resilience and public access at the American Canyon waterfront. This work was funded by a Measure AA grant from the San Francisco Bay Restoration Authority.

The American Canyon wetlands were diked in the early 1900's and reconnected to tidal action in 2006. The City's waterfront is home to popular segments of the Bay Trail and special status species that rely on its marsh and transition zone habitats. Currently, undersized culverts under the Bay Trail restrict tidal flows into a portion of the wetlands, resulting in safety hazards, erosion, habitat impacts, and water quality issues that are likely to worsen with rising sea levels. The site provides an opportunity for habitat restoration in addition to increasing community access and resiliency to sea level rise.

This project evaluated alternatives for improving habitat, public access, and resilience at the American Canyon wetlands. ESA developed a conceptual design based upon hydrologically connecting the North Pond with North Slough, raising segments of the Bay Trail, building ecotone slopes, creating public access trails on existing levees, undergrounding wastewater overflow storage, and integrating a public kayak launch with a soon-to-be-built Ecology Center along the City's waterfront. Project planning and design was supported by a team of technical experts, public agencies, community organizations, and members of the public.

The case study highlights challenges and opportunities for enhancing habitat, increasing resilience, managing wastewater overflow, and expanding public access within the constraints of sensitive habitat, rising seas, and outdated sewage and tidal conveyance infrastructure. ESA will present an overview of strategies for balancing competing project priorities, highlighting the value of early input from regulatory agencies.

Keywords: tidal marsh restoration, Bay Trail, Bay Water Trail, resilience, waterfront

Poster Topic: Planning and Permitting

How Can We Encourage More Projects Along San Francisco Bay to Take Advantage of BCDC's Fill for Habitat Policies?

Jenn Hyman, Katherine Pan

San Francisco Bay Conservation and Development Commission (BCDC), San Francisco, CA

jennifer.hyman@bcdc.ca.gov, katherine.pan@bcdc.ca.gov

Approach: BCDC was created in the 1960s to stop filling of SF Bay. With sea level rise, the area of the Bay will be expanding, and with much gratitude to taxpayer funding of Measure AA and the tireless work of many public agencies, non-profits and others too numerous to list, many former salt ponds and drained agricultural lands around the Bay are being restored, providing for additional expansion of the Bay. Restoration of lands that can be flooded by the Bay have many benefits, now and in the future, including:
Creation of wildlife habitat
More enjoyable public access experience
Upland migration of mud flats and tidal marsh and associated wildlife
Dampening of wave energy, reducing flood risk on upland developed areas
Avoidance of shoreline hardening and its associated adverse ecological and hydrodynamic impacts
Widening the Bay can, on a cumulative basis, avoid raising Bay tide levels as described by Hummel and Stacy (2021)
BCDC's Fill for Habitat policies were added to the Bay Plan in 2020, to facilitate restoration projects. BCDC's Shoreline Protection policies also require that nature-based solutions be considered first. Currently many agency-led restoration projects are taking advantage of the Fill for Habitat policies, but very few development projects are. Privately funded development projects tend to harden shorelines around the Bay, and during permitting applicants have anecdotally shared their reasons for not using nature-based solutions with BCDC staff.

Results: In this study, we present several development projects that have included living shorelines as case studies for successful incorporation of nature-based shoreline protection. We also present the reasons development applicants have shared with us for why they have not included it.

Conclusions: We consider options for overcoming development applicants' reasons for not implementing nature-based shoreline protection and propose financial and regulatory incentives that could promote nature-based shoreline protection.

Keywords: incentives, BCDC, nature-based, shoreline, development, habitat, restoration, benefits, living, fill

Poster Topic: Planning and Permitting

Shoreline Adaptation Project Mapping Program: Tracking Shoreline Resilience in SF Bay

Todd Hallenbeck, Viktoria Kuehn

San Francisco Bay Conservation & Development Commission, San Francisco, CA

todd.hallenbeck@bcdc.ca.gov, viktoria.kuehn@bcdc.ca.gov

A recognized challenge of advancing the San Francisco Bay Area's progress towards sea level rise resilience is the lack of comprehensive information about existing and planned shoreline adaptation projects in the region that is available in an easily accessible, updateable, or sharable forum. This poses a challenge to coordinating sea level rise adaptation towards a regional strategy, ensuring equitable outcomes for adaptation, and communicating the region's need for resources. Extensive progress has already been made in tracking information on habitat restoration projects, many of which include adaptation and flood risk reduction goals, using a California environmental management mapping platform called EcoAtlas. The models and workflows that identify, catalog, and map habitat restoration project information serve as a template for how details from other sea level rise adaptation efforts can be integrated with restoration project tracking to develop a comprehensive picture of shoreline adaptation. The Shoreline Adaptation Project Mapping Program (SAPMAP) aims to address this challenge by building off the models in EcoAtlas to better share information on the state of shoreline adaptation. The goal of SAPMAP is to spatially track adaptation projects, communicate regional progress on shoreline resilience goals, and support a living network of community-based partners poised to lead sea level rise adaptation during planning, implementation, construction, and monitoring. This resource contributes to the Estuary's Blueprint Goal two – as aggregating and visualizing the state of adaptation project implementation is essential to bolster the resilience of the Estuary's ecosystems, shorelines, and communities to climate change. BCDC will share key takeaways and lessons learned from developing the program, and applications that SAPMAP may contribute to, including a case study of how SAPMAP has been used to develop a regional adaptation funding strategy.

Keywords: sea level rise, adaptation, shoreline, communication, mapping, regional

Poster Topic: Planning and Permitting

Efficient Permitting Roadmap: A Guide to the Regulatory Process for Habitat Restoration on the North-central California Coast

Wendy Kordesch[1], Max Delaney[2], Maria Brown[2]

[1]Greater Farallones and Cordell Bank National Marine Sanctuaries, Affiliate, San Francisco, CA
[2]Greater Farallones and Cordell Bank National Marine Sanctuaries, San Francisco, CA

wendy.kordesch@noaa.gov, max.delaney@noaa.gov, Maria.brown@noaa.gov

Too many habitat restoration projects remain in the planning phase across the North-Central California Coast, while there's an urgent need to take action to address climate change impacts and biodiversity loss. A complex regulatory framework is often cited as one of the key barriers to success.
To accelerate the pace of environmentally beneficial restoration work across the region, the North-central California Coastal Sediment Coordination Committee (NCCSCC), a first-of-its-kind collaborative of 17 federal, state, and local agencies, developed two new initiatives to provide information that is easy to access and helps users navigate the regulatory process. The first is an Efficient Permitting Roadmap; a 'how to' guide and clearinghouse of information for navigating a well-coordinated, comprehensive, and efficient permitting and environmental review process for habitat restoration. The user-friendly format provides project planners with more accessible information and the ability to reduce time spent navigating regulatory requirements. The second is the CORESED, a new streamlined opportunity to meet with multiple regulatory staff to discuss restoration projects, facilitated by the NCCSCC. The CORESED facilitates engagement with regulators and generates proactive, effective, and efficient partnerships based on strategic planning throughout the development and implementation of a project.

The Roadmap and Committee have been commended as a forward-thinking model for the state to increase coastal resilience to climate change in a timely manner. Here, we describe the content of the Roadmap, its recommendations, how to meet with the CORESED, and its applicability both within and beyond its geography so agencies and project managers can leverage the knowledge gained and reproduce its successful initiatives.

Keywords: Habitat Restoration, Permitting, Regulation, Coastal Resilience, Sediment, Adaptation, Climate Change

Poster Topic: Planning and Permitting

Planning for Grand Challenges to Delta Science

Tricia Lee[1], Rachael Klopfenstein[1], Laurel Larsen[2], Henry DeBey[1]

[1]Delta Science Program - Delta Stewardship Council, Sacramento, CA
[2]UC Berkeley, Berkeley, CA

tricia.lee@deltacouncil.ca.gov, rachael.klopfenstein@deltacouncil.ca.gov, laurel.larsen@deltacouncil.ca.gov, henry.debey@deltacouncil.ca.gov

The Delta Science Program is currently facilitating the development of the 2025 Delta Science Plan. The Delta Science Plan is a 5-year guidance document that identifies principles and approaches to better coordinate Delta science and connect science to policymakers so they can effectively take on the region's natural resource management challenges. Updates to the Delta Science Plan provide the opportunity to incorporate new ideas and actions to reflect current science and management needs of the Delta. Given the rise in extreme events and increased awareness of the need to better understand and manage the Delta as a social-ecological systemin recent years, the Delta Science Program proposes to orient the 2025 Delta Science Plan to address Grand Challenges to Delta Science.

The four Grand Challenges to shape the 2025 Delta Science Plan were determined through an analysis of visionary literature published since 2007, when the Delta Vision Blue Ribbon Task Force laid the foundation for the Delta Reform Act, relevant to the science of the Delta, its watershed, and the broader San Francisco Estuary. Grand Challenges must have met criteria defined by the National Research Council and were workshopped within the Delta Science Program in 2023. Grand Challenges speak to unanticipated future climate and regulatory conditions, decision making under deep uncertainty, collaborating and communicating with non-science audiences, and interweaving non-western science and community knowledge into decision-making.

This poster covers the progress made on the 2019 Delta Science Plan and discusses how the 2025 Delta Science Plan will be structured to address these Grand Challenges.

Keywords: Resource management, Science planning, Grand Challenges

Poster Topic: Planning and Permitting

Interagency Collaboration to Achieve Delta Plan Restoration Targets

Annie Merritt[1], Rachel Wiggington[2], Elizabeth Brusati[1], Dylan Chapple[1], Amanda Bohl[1]

[1]Delta Stewardship Council, Sacramento, CA
[2]Sacramento-San Joaquin Delta Conservancy, West Sacramento, CA

annie.merritt@deltacouncil.ca.gov, rachel.wiggington@deltaconservancy.ca.gov, elizabeth.brusati@deltacouncil.ca.gov, dylan.chapple@deltacouncil.ca.gov, amanda.bohl@deltacouncil.ca.gov

The Delta Plan Interagency Implementation Committee's (DPIIC) Restoration Subcommittee was established in 2022 in response to a recommendation in Chapter 4 of the Delta Plan to increase interagency collaboration to implement ecosystem restoration. The DPIIC Restoration Subcommittee envisions a Delta ecosystem that supports a mosaic of natural and human communities, is resilient to stressors, adapts to change, and is accessible for recreation. The Subcommittee aims to (1) provide forums for meaningful community participation in Delta restoration efforts, (2) increase interagency collaboration to streamline restoration implementation, (3) identify opportunities in restoration planning and long-term management efforts, and (4) increase transparency and coordination around existing, new, and needed restoration funding. To advance the first goal, a Delta Restoration Forums was held in February 2023, which engaged 146 in-person and virtual attendees from local, state, federal, and tribal governments, consulting groups, non-profit organizations, academia, and the Delta community. Attendees engaged in small group conversations to explore how future ecological restoration can best be implemented to support flourishing Delta ecosystems and human communities. Attendees highlighted the importance of outreach, engagement, and public education; called for streamlined funding, regulations, and permitting; noted the importance of recreational opportunities; emphasized the importance of projects addressing subsidence and providing multiple benefits; and challenged planners to balance short- and long-term goals when scoping projects. Feedback also suggested the Restoration Subcommittee focus the next forum on sharing content about current and planned restoration projects. The second forum was held in November and was attended by 67 people representing 43 organizations. Over 20 projects and programs were showcased across the Delta and Suisun Marsh. We will present outcomes from the first two forums, including lessons learned from participants.

Keywords: Restoration, community engagement, interagency collaboration

Poster Topic: Planning and Permitting

Resilient Roots: Unearthing the Benefits and Equity Dimensions of Restoration Projects Across the Bay-Delta

Xoco Shinbrot[1], Pascale Goertler[2], Eric Holmes[2], Bailey Morrison[3], Taylor Pantiga[4], Alexandra Thomsen[4], Kenji Tomari[5]

[1]Delta Stewardship Council, Sacramento, CA
[2]Department of Water Resources, Sacramento, CA
[3]UC Merced, Earth Observation and Remote Sensing, Merced, CA
[4]San Francisco Estuary Partnership, San Francisco, CA
[5]UC Davis Department of Geography, Davis, CA

xoco.shinbrot@deltacouncil.ca.gov, Pascale.Goertler@water.ca.gov, Eric.Holmes@water.ca.gov, bmorrison3@ucmerced.gov, taylor.pantiga@sfestuary.org, alexandra.thomsen@sfestuary.org, ktomari@ucdavis.edu

At their best, restoration projects offer vital habitat for wildlife while providing humans with cleaner air, water, and access to recreation. Socially vulnerable communities have historically had less access to restoration areas, a trend that may still persist. In part, this may be due to a focus on restoration benefits skewed towards environmental goals. In this context we ask: (1) What are the range of social-ecological benefits of restoration projects across the Bay Delta? (2) How do restoration projects fill social equity needs and gaps? To answer these questions, we expand the definition of the Bay Delta beyond the legal Delta to include the historic boundaries of the Delta, as well as the boundary of Operational Landscape Units along the Bay shoreline. We examine the distribution and stated benefits of Planning and Implementation restoration projects funded by: Proposition 1 Chapter 6, Wetlands Restoration for Greenhouse Gas Reduction, and San Francisco Bay Restoration Authority funding programs. Using text analyses of the proposals, we compare the social and environmental benefits by community type (disadvantaged or not) and compare them to social benefits identified by the Society for Ecological Restoration. Then we use CDC's Environmental Justice database to conduct a spatial cluster analysis to determine to what extent socially vulnerable communities are benefiting from restoration. The results may help decision makers (1) better target restoration sites to focus on those regions near socially vulnerable populations, and (2) identify and track what social and environmental benefits are provided or missing from restoration proposals. Initial analysis suggests there are a range of social benefits that restoration proposals do not focus on including aesthetic enjoyment, cultural enrichment, employment, or community well-being. Tracking who benefits, and what the range of benefits are, is a necessary first step for decision making on restoration projects to be more equitable.

Keywords: Restoration; Bay-Delta; Social Vulnerability

Poster Topic: Planning and Permitting

Collaborative Wetland Restoration Implementation in the Bay and Delta: A Comparative Case Study Approach

Kyra Gmoser-Daskalakis*

University of California Davis, Davis, CA

kgmoserd@ucdavis.edu

Regional governance structures in California increasingly promote wetland restoration as a multi-benefit environmental infrastructure solution to advance goals such as climate change adaptation, water resource management, public recreation access, and species protection. How do policy goals, targets, and authorities translate into completion of these projects on the ground, given complex relationships among public and private stakeholders? This poster summarizes the results of a comparative case study approach to examine the process of implementing wetland restoration in the San Francisco Bay and Sacramento San Joaquin Delta Estuary. Case studies of 12 completed and in-progress restoration projects using stakeholder interviews and document analysis identify common barriers and opportunities across projects and landscapes. Applying collaborative and adaptive governance frameworks to project processes reveals tradeoffs for different multi-benefits and temporal and spatial challenges over project lifetimes. Differences in needs, opportunities, and actors in the Bay and Delta reveal complications for estuary-level environmental policy and management. Understanding where conflicts and synergies emerge among actors in wetland restoration projects can help improve translation of restoration policy goals into on-the-ground outcomes for the Bay-Delta, and other tidal estuaries.

Keywords: collaborative governance, adaptive management, wetland restoration, implementation barriers, social science

Poster Topic: Planning and Permitting

The Lower Walnut Creek Restoration Project Two Years Post-construction

Stephanie Bishop

Environmental Science Associates, Petaluma, CA

sbishop@esassoc.com

This poster will present the results of the first two years of post-construction monitoring of the Lower Walnut Creek Restoration Project located along the southern shoreline of Suisun Bay at the mouth of Walnut Creek. The design targeted restoration of a complex degraded estuarine landscape, creating a diverse range of habitats and integrating pre-existing habitat areas with newly restored landscapes. The restoration capitalized on large areas of supratidal elevation lands and existing (degraded) landscape features to restore and expand tidal marsh habitat intergraded with a matrix of lowland terrestrial and seasonal wetland ecotone habitats. The Project anticipates gradual estuarine transgression and is designed to provide high ecological value and function through the 21st century. Project construction was completed in 2021 and site plantings in February 2022.

ESA is actively engaged in monitoring key ecosystem parameters pursuant to the project's Monitoring and Adaptive Management Plan. Monitoring provides successes and lessons learned that will be helpful to understand for future tidal wetland restoration projects. The first two years of monitoring results show the site performing as anticipated in most areas. The channels are on their way to becoming fully tidal, with channel and marsh development starting to adjust post-construction. Dissolved oxygen concentrations are mostly within suitable ranges to support aquatic life, however isolated and sustained periods of low dissolved oxygen were observed. The site has high vegetative cover as the project was designed and constructed to keep as much of the existing wetland vegetation in place as possible. Despite consistent management of weeds since construction, weeds are expected to remain a primary challenge at the site. There was a notable improvement in wetland condition in Year 1 compared to pre-construction with a significant increase in CRAM score. The site will continue to be monitored for 10 years.

Keywords: monitoring, tidal wetlands, restoration, Walnut Creek, marsh development

Poster Topic: Restoration - General

Large-scale, Low-cost Native Plant Propagation for Transition-zone Habitat Restoration in the San Francisco Bay

Alyssa Alfonso

Save The Bay, Oakland, CA

aalfonso@savesfbay.org

The San Franciso Estuary (SFE) is the largest estuary on the west coast of North America. The SFE is an important habitat for endangered species, millions of migratory birds, and nurseries for fish. Not only is it crucial for wildlife, 8 million people call the SFE home. With climate change and the rising lea-levels, shoreline communities, both human and nonhuman, are at risk of losing habitat. To combat this, Save the Bay utilizes nature-based solutions specifically large-scale, habitat restoration of tidal-wetland transition zones. Since the initiation of Save The Bay's habitat restoration program in 2001, restoration projects have scaled up in size and are utilizing new revegetation techniques and knowledge gained from previous large-scale sites, such as the Oro Loma Horizontal Levee Demonstration Project and R4 levee of the Ravenswood Project. The Ravenswood Project consists of two habitat transition zones, a nine-acre site along the R4 levee that was revegetated in fall/winter 2021 and a sixteen-acre levee along the All-American Canal that was revegetated in fall/winter 2023. The native plant assemblage used to revegetate both slopes of the Ravenswood project were locally collected rhizomatous, perennial native plant material and were grown into an on-site division bed nursery adjacent to the project site at Bedwell Bayfront Park. To maximize workforce efficiency, Save The Bay utilized farming equipment and partnered with San Jose Conservation Corp (SJCC). Clonal meadow species, the most extensive in the project assemblage, were primarily outplanted with mechanized, heavy equipment run by an experienced operator. SJCC were integral in maximizing the amount of manual work and increasing time efficiency in cutting up and staging sod on the slope. With promising vegetation monitoring results at R4 of The Ravenswood Project, similar success is expected at the All-American Canal as Save The Bay used scaled up and iterated revegetation techniques.

Keywords: Habitat, Restoration, Community, Resiliency, Levee, Farm, Large-scale, Wetland, Revegetation,

Poster Topic: Restoration - General

Changes in Tidal Range and Optimization of Sediment Capture in a South San Francisco Bay Tidal Marsh Restoration Project

Noah Hume[1], Michael MacWillliams[2], Kris May[3], Charles Andersen[4], Scott Dusterhoff[5], Judy Nam[6], Emily Zedler[6]

[1]Stillwater Sciences, Berkeley, CA
[2]Anchor QEA LLC, San Francisco, CA
[3]Pathways Climate Institute, San Francisco, CA
[4]Schaaf & Wheeler, Santa Clara, CA
[5]San Francisco Estuary Institute, Richmond, CA
[6]Valley Water, San Jose, CA

noah@stillwatersci.com, mmacwilliams@anchorqea.com, kris.may@pathwaysclimate.com, CAnderson@swsv.com, scottd@sfei.org, JNam@valleywater.org, EZedler@valleywater.org

Consistent with the South Bay Salt Pond Restoration Project goals of tidal habitat wetland restoration, enhanced public access, and flood management, the Calabazas and San Tomas Creek Marsh Connection Project was awarded grant funding from the San Francisco Bay Restoration Authority, California Dept. of Fish and Wildlife and USEPA to re-establish fluvial and tidal connections between riverine, creek, and estuarine habitats of southern San Francisco Bay, benefiting sediment transport, capture and tidal marsh re-establishment.

Balancing ecosystem goals with public use, flood protection and long-term creek maintenance requires estimates of marsh accretion rates as well as changes in tidal elevations under both existing conditions and future conditions including sea level rise. A combination of conceptual and numerical modeling was employed to develop and rank restoration alternatives drawing upon historical ecology and linkages with present day and future changes in tidal dynamics under future conditions.

Hydrodynamic modeling was used to optimize the numbers, sizes, and locations of breaches in former salt pond habitats, maximizing sediment capture from fluvial and estuarine sources. Initial modeling results showed suspended sediments from San Francisco Bay were the dominant source of simulated sediment accretion, with creeks providing a secondary source during rainfall runoff events. Changes in tidal prism accompanying reconnection of former tidal marsh habitat is anticipated to reduce local tidal maxima, improving coastal flood resiliency in the face of projected sea level rise.

Keywords: Climate, Hydrodynamic, Model, SBSPRP, Sediment, Tide, Tidal, Resiliency

Poster Topic: Restoration - General

Elk Slough Fish Passage and Flood Improvement Project

Doug Brown

Douglas Environmental, Sacramento, CA

browndoug@att.net

The Elk Slough Fish Passage and Flood Improvement Project proposes to restore fish passage to Elk Slough, a major distributary channel of the Sacramento–San Joaquin Delta. Elk Slough was historically maintained by direct flood flows from the Sacramento River that resulted in a well-defined channel bordered by steep natural levees supporting a dense riparian forest. The historic connection of Elk Slough to the Sacramento River was modified in the 1950s with the construction of the Sacramento River west levee and road crossing (South River Road) across the head of Elk Slough. The culvert is a barrier to fish passage and provides only limited exchange of flow between the river and slough. As a result, Elk Slough is currently functioning like a backwater of the Sacramento River. The proposed project includes replacing the existing levee and culvert at the head of Elk Slough with a bridge and constructing operable gates at the upstream and downstream ends of the slough to restore fish passage and improve flood protection. The proposed reconnection of Elk Slough presents an opportunity to restore access to a historical fish migration route, increase the rearing capacity of the lower Sacramento River, and contribute to the overall diversity of migration pathways and rearing habitats available to anadromous salmonids and other native fishes. This project also responds to broader species recovery and ecosystem restoration needs by increasing the diversity, connectivity, and quality of habitats supporting the productivity and persistence of Chinook salmon and other native fish populations.

Keywords: salmon, reconnection, restoration, flood protection, fish migration, passage, rearing, recovery

Poster Topic: Restoration - General

Showcase of Nature-positive, Multi-benefit Urban Creek Restoration

Juliet Lamont, Phillip Price

Creekcats Environmental Partners LLC, Berkeley, CA

jlamont@creekcats.com, pnprice@creekcats.com

Problem: Flooding, bank erosion, and lack of biodiversity are challenges along urban streams.

Approach: Private property owners contracted with the Restoration Design Group (RDG) to develop a nature-based restoration design along a heavily engineered stretch of Codornices Creek in Berkeley. The project demonstrates the multiple benefits that can be achieved through nature-positive strategies and techniques, even in dense urban settings.

Restoration included removal of artificial concrete box channels, retaining walls, and gabions and rip-rap, across three adjacent private property parcels on Codornices Creek, roughly 2 miles from the creek's outfall into S.F. Bay. The restoration site and project included approximately 300 linear feet of creek channel, and roughly 1 acre in restored bed, banks, and upslope regrading.

Bed and bank reconstruction employed a rock/boulder sub-structure, supported by diverse, native plantings, to restore a natural channel with functional sinuosity, a more gradual linear channel profile, flood overflow swales and retention features, provision of nature-based bank stabilization, and enhancement of biodiversity and habitat. This bed and bank structure was completed in November 2018, accompanied by planting of native willows, alders, dogwoods, and additional species appropriate for in-channel sediment retention and understory growth. Subsequent upslope plantings included an array of species targeted for pollinator attraction, bird habitat, and overall biodiversity enhancement.

Results: Annual monitoring of vegetative cover and tree canopy demonstrate that the project has exceeded annual targets. Over 50 species of birds have been observed on-site, including nesting pairs and fledglings. Site tours have been given to many local groups, including City of Berkeley representatives.

Conclusions: Urban settings are essential for a comprehensive mix of strategies and projects to provide regional climate resilience and biodiversity enhancement. While traditionally undervalued as important contributors to biodiversity and waterways restoration, they in fact provide habitat refuge for a multitude of species, along with educational benefits.

Keywords: creek, restoration, NBS, urban, biodiversity, nature-positive, climate, resilience, adaptation, education

Poster Topic: Restoration - General

Monitoring Waterbird Nesting Populations for the South Bay Salt Pond Restoration Project

Alex Hartman, Josh Ackerman, Mark Herzog

USGS Western Ecological Research Center, Dixon, CA

chartman@usgs.gov, jackerman@usgs.gov, mherzog@usgs.gov

South San Francisco Bay is an important breeding area for many waterbird species and supports large populations of nesting Forster's terns (*Sterna forsteri*), American avocets (*Recurvirostra americana*), and black-necked stilts (*Himantopus mexicanus*). Former salt evaporation ponds, now managed as wildlife habitat, provide critical foraging and island nesting habitat for waterbirds. The South Bay Salt Pond Restoration Project is in the process of restoring 50-90% of these former salt ponds into tidal marsh and tidal mudflat habitats. To offset the loss of pond habitat, and the historic nesting islands therein, new island construction in ponds that will not be restored is a major component of the Restoration Project. USGS has been monitoring waterbird nests in South San Francisco Bay for the past two decades and these data have been used to track the changes to waterbird nesting populations and ensuring populations persist as the South Bay Salt Pond Restoration Project progresses. Between 2005 and 2019, Forster's terns (-36%), American avocets (-53%), and black-necked stilts (-71%) all experienced declines below baseline pre-restoration values in overall nest abundance in South San Francisco Bay. In 2022, the most recent survey year, we observed a 186% increase in Forster's tern nest abundance, returning the population above baseline values. However, nest abundance of avocets and stilts were still well-below baseline values in 2022. Forster's tern colonization of newly constructed islands and mudflat habitat within two enhanced former salt ponds (now managed ponds) accounted for 86% of the entire Forster's tern nesting population in 2022, suggesting that it is possible to enhance the remaining managed ponds to improve waterbird nesting habitat.

Keywords: American Avocet, Black-necked Stilt, Forster's Tern, managed ponds, restoration

Poster Topic: Restoration - Species Impacts

Habitat Use by Breeding Waterbirds in Relation to Tidal Marsh Restoration in the San Francisco Bay Estuary

Carley Schacter[1], Alex Hartman[1], Mark Herzog[1], Sarah Peterson[1], Max Tarjan[2], Yiwei Wang[2], Cheryl Strong[3], Rachel Tertes[3], Nils Warnock[4], Josh Ackerman[1]

[1]USGS Western Ecological Research Center, Dixon, CA
[2]San Francisco Bay Bird Observatory, Milpitas, CA
[3]US Fish and Wildlife Service, Don Edwards San Francisco Bay National Wildlife Refuge, Fremont, CA
[4]Audubon Canyon Ranch, Stinson Beach, CA

crs164@humboldt.edu, chartman@usgs.gov, mherzog@usgs.gov, sepeterson@usgs.gov, max_tarjan@natureserve.org, ywang@sfbbo.org, cheryl_strong@fws.gov, rachel_tertes@fws.gov, nils.warnock@egret.org, jackerman@usgs.gov

The South Bay Salt Pond Restoration Project aims to restore many former salt production ponds, now managed for wildlife and water quality, to tidal marsh. However, because they support large densities of breeding waterbirds, reduction of pond habitat may influence breeding waterbird distribution and abundance. We investigated habitat use during the breeding season for American avocets, black-necked stilts, Forster's terns, and Caspian terns in south San Francisco Bay in 2019 after tidal marsh restoration and compared results to a 2001 survey (before restoration). In 2019, managed ponds (26% of currently available habitat) were selected by waterbirds engaged in breeding behaviors (> 39% of observations), foraging (> 42%), and roosting (> 73%). Waterbirds avoided tidal habitats (43% of available habitat), comprising < 17% of observations of breeding behavior, < 28% of foraging observations, and < 13% of roosting observations. Waterbird densities increased in managed ponds between 2001 and 2019, and decreased in active salt ponds, especially among feeding avocets (92% decrease) and stilts (100% decrease). Islands were important for waterbirds observed breeding and roosting (45% of avocet and 53% of tern observations). Avocets and stilts fed primarily on wet bare ground (65% and 58%, respectively), whereas feeding Forster's terns and Caspian terns used mostly open water (82% and 93%, respectively). Within ponds, avocets were associated with islands (131 m closer than expected). Stilts and Forster's terns were also associated with islands (68 m and 161 m closer than expected), except when feeding (1 m closer and 90 m farther than expected). Avocets and stilts were associated with pond levees (39 m and 41 m closer than expected), but Forster's terns were not (9 m closer than expected). Our results emphasize the importance of managed ponds for breeding and foraging waterbirds, especially the significance of creating island habitat for nesting and roosting.

Keywords: habitat use, managed ponds, micro-habitat, nesting islands, restoration, waterbirds

Poster Topic: Restoration - Species Impacts

Restoring Tidal Marsh Food Web Structure and Energy Pathways for Estuarine Fish Communities

Megan Pagliaro*[1], Susan De La Cruz[2], Isa Woo[2], Jake Sousa[3], Natalie Rich[1], Lenny Grimaldo[3,4], Albert Ruhi[1]

[1]UC Berkeley, Berkeley, CA
[2]USGS Western Ecological Research Center, Moffett Field, CA
[3]ICF, Sacramento, CA
[4]Department of Water Resources, Sacramento, CA

megan.pagliaro@berkeley.edu, sdelacruz@usgs.gov, iwoo@usgs.gov, Jake.Sousa@icf.com, nrrich@berkeley.edu, Lenny.grimaldo@water.ca.gov, albert.ruhi@berkeley.edu

Tidal marsh restoration performance is typically measured via habitat availability and recolonization of target species. However, functional metrics such as the transfer of energy from basal resources to fish can more effectively determine whether restoration of habitat structure translates into the recovery of robust food webs. We asked two questions. First, does tidal marsh restoration lead to the recovery of energy pathways that support diverse feeding strategies among estuarine fishes (measured by the distribution and volume of their isotopic niches)? Second, how does the food web structure vary between native and non-native fish? We sampled basal resources (fine particulate organic matter and phytoplankton; n=80) and fishes (n=807) in three paired reference and restored tidal marshes in the San Francisco Bay Delta in winter and summer 2020 and 2021. We quantified stable isotope ratios using δ^{13}C, δ^{15}N, and δ^{34}S for common fishes and basal resources at each site, and then calculated their isotopic niche volume (standard volume encompassing all the plotted isotope values), food-chain length, and relative influence of “brown” (detrital) versus “green” (algal) pathways. We found that two of the restored sites had smaller isotopic niche volumes compared to their reference pair (in support of our hypothesis), but the youngest restoring marsh had a larger niche volume than its reference, suggesting early succession may still be influencing the energy flows within that food web. Additionally, non-native fish generally occupied a larger niche volume compared to native fish, suggesting that the former consume a wider range of food sources. Notably, a majority of the native niche was also contained within the non-native niche. Our findings show that food web structure is not immediately recovered with tidal marsh restoration and highlight the need to incorporate the recovery of energy pathways as a key indicator of restoration success.

Keywords: wetlands, stable isotope, food-webs, niche volume, restoration, fish, trophic structure

Poster Topic: Restoration - Species Impacts

Larval Fish Diets as Indicators of Food Web Dynamics in Tidal Wetland Restoration

Anthony Donahue*, Erick Ortiz, Anne Slaughter, Wim Kimmerer, Michelle Jungbluth

Estuary & Ocean Science Center, San Francisco State University, Tiburon, CA

adonahue1@sfsu.edu, eortiz13@sfsu.edu, aslaught@sfsu.edu, kimmerer@sfsu.edu, mjungbluth@sfsu.edu

Fish populations in the San Francisco Estuary have been declining for decades due to multiple interacting factors, including a substantial reduction in tidal wetlands. Tidal wetlands are currently being restored in an effort to enhance fish populations by providing beneficial habitat and associated food web resources. Longfin smelt (LFS; *Spirinchus thaleichthys*) is one of the declining native fish populations and is a threatened species of concern. Zooplankton abundance in wetlands directly affects LFS populations, since larval LFS rely on zooplankton as their primary source of food. The aims of this study are to identify food web resources in close proximity to the restoring wetlands, compare them with ecological indicators in wetlands at different stages of restoration (early, intermediate, mature), and identify a set of zooplankton indicator species that are associated with beneficial habitat for LFS. High-throughput sequencing (HTS) will be utilized to identify the diversity of prey and indicator species in diets of larval fishes, specifically LFS, as well as Pacific herring (*Clupea pallasii*), and Prickly sculpin (*Cottus asper*), which utilize the wetlands as nursery grounds at the same time of year as LFS. HTS will identify the DNA of the prey consumed by the larval fishes, to identify the food web resources available to the larval fishes and the indicator species at each wetland restoration site. This study will provide necessary information to wetland restoration managers, such as the prey availability of specific species of zooplankton for larval fishes in their nursery grounds, an understanding of how these prey differ across wetlands at different stages of restoration, and key characteristics of wetlands that most support larval fish populations, which will ultimately benefit declining fish populations in the San Francisco Estuary.

Keywords: Food Webs, Larval Fish, Zooplankton, DNA Sequencing, Wetland Restoration

Poster Topic: Restoration - Species Impacts

Reconnecting Delta Food Webs: Evaluating the Influence of Tidal Marsh Restoration on Prey Availability and Diet of Native Fishes

Susan De La Cruz[1], Isa Woo[1], Stacy Moskal[1], Albert Ruhi[2], Megan Pagliaro[2], Jake Sousa[3], Lenny Grimaldo[4], Linda Standlee[5], Darcy Austin[5]

[1]US Geological Survey, San Francisco Bay Estuary Field Station, Moffett Field, CA
[2]University of California Berkeley, Berkeley, CA
[3]ICF Fish and Aquatic Sciences, Sacramento, CA
[4]California Department of Water Resources, Sacramento, CA
[5]State Water Contractors, Sacramento, CA

sdelacruz@usgs.gov, iwoo@usgs.gov, smoskal@usgs.gov, albert.ruhi@berkeley.edu, megan.pagliaro@berkeley.edu, Jake.Sousa@icf.com, lenny.grimaldo@water.ca.gov, LStandlee@swc.org, daustin@swc.org

In the upper San Francisco Estuary (USFE) species introductions, wetland loss, and watershed modifications have led to long-term declines in primary productivity and native fish populations. While expansive tidal wetland restoration is underway in the region, our knowledge on how pelagic, benthic, and terrestrial components of Bay-Delta wetland food webs interact is cursory. This data gap precludes systematic understanding of restoration benefits for native fishes such as delta smelt (*Hypomesus transpacificus),* longfin smelt (*Spirinchus thaleichthys*), and salmonids. The goal of our research is to elucidate the effects of tidal marsh restoration on food web structure and prey quality for native fishes. To accomplish this, we compared seasonal pelagic, benthic, and terrestrial prey abundance, fish diet and trophic structure, among six paired reference and restored wetlands. Our preliminary results indicate that early season (Feb) prey availability was limited at all wetlands compared with late season (May) and also varied based on location in the USFE, habitat type (wetland interior vs. exterior) and restoration age. Of 890 fish captured across all sites and processed for diet, 57% contained invertebrate prey from 8 broad taxa. Prey taxa with greatest relative importance across sites were copepods and mysids for pelagic fish species, nematodes for benthopelagic fish and amphipods for demersal fish. Percent similarity indices showed that proportions of prey items in fish from restored compared to reference sites were most similar for demersal fish (PSI 82) and least similar for pelagic fish (PSI 58). Currently we are integrating stomach content with stable isotope results from these fish to further understand linkages among prey availability, diet and food web complexity in restored compared to reference sites. Results from this on-going project will address key management questions on how restoration of tidal wetland structure translates into the recovery of food web processes and improved fish habitat.

Keywords: food webs, Delta, fish, invertebrates, wetland, prey resources

Poster Topic: Restoration - Species Impacts

Microorganisms as Indicators of Habitat Conditions in Restoring Wetlands

Erick Ortiz*[1], Anne Slaughter[1], Jason Hassrick[2], Wim Kimmerer[1], Michelle Jungbluth[1]

[1] Estuary & Ocean Science Center, San Francisco State University, Tiburon, CA
[2]ICF, Inc, Richmond, CA

eortiz13@sfsu.edu, aslaughter@sfsu.edu, Jason.Hassrick@icf.com, Kimmerer@sfsu.edu, mjungbluth@sfsu.edu

Wetlands are highly productive ecosystems that provide vital ecological services such as water purification, carbon sequestration, and biodiversity conservation. Unfortunately, wetland degradation has become a significant problem globally, including in the San Francisco Estuary (SFE), where 90% of wetlands have been lost; these losses create a pressing need for wetland restoration. Physical, chemical, and biological assessment tools are often used to monitor and conserve wetlands. However, microbial communities within these ecosystems have received little research attention. Despite their potential utility as indicators of water quality, microbial communities are frequently overlooked because diversity is high, the organisms are small and hard to identify, and sampling them is difficult. To address this issue, we are conducting a two-year study, using high-throughput DNA sequencing (HTS) to identify differences among SFE wetlands in the distribution and diversity of bacteria, archaea, and other plankton (ranging from pico to meso-sized). By characterizing the assemblages present in these wetlands, the study aims to determine which species are indicators of physical or chemical characteristics of the sampled wetlands. We will characterize bacteria, archaea, and phytoplankton using 16s rRNA HTS and zooplankton using 18s rRNA HTS to identify the organisms present and their relative abundance. We expect the microorganisms to differ between early-stage and mature wetlands with regard to the presence, absence, and relative abundance of species. The study aims to improve wetland restoration efforts by understanding microorganism diversity and distribution patterns and their links to important metrics of wetland restoration, with the goal of expanding fish habitat to increase populations.

Keywords: Microbial Ecology, Metabarcoding, Wetland Restoration, Indicator Species

Poster Topic: Restoration - Species Impacts

Investigating Ecosystem Functions of Restored Eelgrass Beds in San Francisco Bay

Natalie Rossi*, Katharyn Boyer

Estuary & Ocean Science Center, San Francisco State University, Tiburon, CA

nrossi@sfsu.edu, katboyer@sfsu.edu

Eelgrass (Zostera marina) beds are marine flowering plants found in shallow coastal zones and are in decline globally. In San Francisco (SF) Bay, they are known to provide many ecosystem services, including but not limited to sediment stabilization, carbon sequestration, habitat structure, and food web support. Due to the decline of this species, there has been an increased effort in SF Bay to restore eelgrass with the ultimate goal of returning these many valued functions, yet these functions have scarcely been evaluated. In this study we are assessing epifauna and mobile macrofauna community composition and abundance, nursery use, and trophic interactions (e.g., predation and herbivory assays) in two pairs of restored and reference sites: with each pair in two different bay regions. Both of the reference sites were chosen as the closest eelgrass beds to the restoration, although the proximity to reference sites differs. Through repeated monthly measures from May through August 2023, we are assessing the similarity of restored beds and natural beds as well as whether the setting matters to the degree of equivalency. In addition, we are analyzing a long-term data set (2016-2022) for eelgrass and epifauna and exploring whether a trajectory in epifaunal community development is detectable over time amidst a known background of interannual variability in abiotic conditions. Early results indicate that trophic interactions, epifaunal and mobile macrofaunal communities are more strongly influenced by site and localized conditions rather than restored versus natural eelgrass. Further, the more distant natural and restored pair showed less similarity in functional attributes. These results contribute to our understanding of the functions of restored eelgrass beds and also point to the difficulty in assessing convergence in habitat function when there are no nearby natural beds to serve as a reference.

Keywords: eelgrass, Zostera marina, restoration, ecosystem function

Poster Topic: Restoration - Species Impacts

Effects of Eelgrass and Reef Restoration on Blue Carbon Storage in San Francisco Bay

Tessa Filipczyk*, Margot Buchbinder, Katharyn Boyer

Estuary & Ocean Science Center, San Francisco State University, Tiburon, CA

tfilipczyk@sfsu.edu, mbuchbin@sfsu.edu, katboyer@sfsu.edu

Blue carbon ecosystems are of special interest for management and restoration efforts as global CO_2 emissions continue to rise, potentially adding the offset of greenhouse gas emissions to the ecosystem services for which these systems are valued. As such, it is imperative that we understand the efficacy and success of restoration projects in contributing to carbon storage. Here we present early results of a carbon stock assessment in San Francisco Bay to determine to what extent restoring eelgrass, *Zostera marina*, with and without reef structures installed as living shorelines, affects carbon storage. We quantified total organic material (TOM), inorganic carbon content, and grain size in three treatments: bare sediment, eelgrass shoreward of reef balls, and eelgrass with no reef. We expected to see a higher percentage of organic material on average in restored eelgrass and especially when shoreward of reef structures (due to slowing of water and reef-contributions of organic matter) when compared to bare sediment. In addition, we expected the presence of eelgrass to influence grain size. Early results show higher percentages of TOM in restored eelgrass shoreward of reef structures, with a peak in organic material between 4- and 8-centimeters depth. We also observed higher silt/clay percentages in the bare sediment treatment when compared to the eelgrass treatments, which exhibited higher percentages of sand, especially with reef presence. Ongoing work to assess organic and inorganic carbon will help to complete our understanding of these patterns, as will stable isotope analysis to ascertain carbon sources. Further, we are sampling from additional restored eelgrass beds in comparison to natural ones and bare sediment across San Francisco Bay. This research will provide some of the first blue carbon measurements in restored eelgrass beds and add to our understanding of the contributions that restoration projects make across a range of ecosystem services.

Keywords: Blue carbon, eelgrass, restoration, nature-based solutions, living shorelines

Poster Topic: Restoration - Species Impacts

Investigating Dynamic Landform Features that Comprise Wetland Fish Habitat in the California Delta

Alejandro Ramos Hurtado*, David Ayers, Bryson Zheng, Jesse Schroeder, Andrew Rypel

UC Davis, Davis, CA

aramoshurtado@ucdavis.edu, Deayers@ucdavis.edu, Bezheng@ucdavis.edu, jrschroeder@ucdavis.edu, rypel@ucdavis.edu

Large-scale restoration is currently underway in the San Francisco Estuary and seeks to increase shallow nursery habitat for several imperiled fish species. These projects cost millions of dollars but highly dynamic tides obscure efforts to measure habitat restoration efficacy. For example, the spatial extent of wetlands changes constantly which has constrained efforts to understand the influence of wetland terrain and shape on functional fish habitat.
We seek to address this knowledge gap by quantifying how wetland terrain and shape changes across high-frequency units of space and time. Previous studies have demonstrated that restored wetlands differ in terrain and shape from established natural wetlands. Moreover, researchers have demonstrated a link between terrain metrics, food abundance, and predation risk, subsequently influencing rearing functions for fishes. Our efforts build on these findings and seek to understand how indices of roughness, slope, elevation, and drainage density change over tidal timescales.
Preliminary results demonstrate that bathymetric profiles can vary widely between and within habitat restoration sites. For example, both of our adjacent study sites underwent rapid and non-linear changes in terrain features although these changes occurred in different areas within the tidal range. This information can help illustrate how dominant terrain features, and thus fish habitat conditions, at a given restoration site will likely shift under anticipated sea level rise.

Keywords: Habitat, Restoration, Estuary, Marsh, Topography, Tides, Wetland, Fish, Delta, Bathymetry

Poster Topic: Restoration - Species Impacts

Tidal Marsh Restoration Benefits of Dredged Sediment Reuse in North San Francisco Bay

Ryan Dougherty, Luisa Valiela, Jennifer Siu

U.S. Environmental Protection Agency, San Francisco, CA

dougherty.ryan@epa.gov, valiela.luisa@epa.gov, siu.jennifer@epa.gov

Salt, brackish, and freshwater wetlands once formed a broad ring along the San Francisco Bay shoreline, but over the past 150 years as Europeans and Americans settled in the area, they diked off and filled in nearly 80% of these historic marshes. Tidal marshes were reduced to 10% of their historic acreage. Federal, state, and local agencies as well as a broad array of stakeholders in the restoration community have partnered in a region-wide effort to restore 100,000 acres of tidal wetlands in San Francisco Bay by 2100. Marsh restoration requires substantial amounts of sediment in the Bay Area because of land subsidence, and projections for natural sediment availability show that the Bay would require more sediment than what is available through natural accretion. This makes using dredged material to augment sediment supply in wetlands imperative if we want tidal wetlands to persist in the face of sea level rise. Therefore, we analyzed tidal marsh restoration outcomes from projects in San Pablo Bay that have beneficially reused dredged sediment and restoration projects that did not reuse dredged sediment to assess the speed and efficacy of using supplemental sediment in comparison to passive, natural sediment accretion. We found that the use of dredged material effectively accelerated mudflat development while allowing for development of an interior channel system similar in extent to natural reference marshes. In some cases, vegetation cover established at a higher rate at the beneficial use sites than natural accretion sites. In smaller natural accretion sites, with good connection to bay tidal action, sediment accreted at a rate similar to beneficial reuse sites. With some San Francisco Bay climate projections predicting a decreasing sediment supply to the Bay, the benefits of reusing dredged material will increase.

Keywords: Tidal Marsh, Beneficial Reuse, Dredged Sediment, Subsidence, Accretion

Poster Topic: Sediment - Beneficial Reuse

Evaluating Wetland Restorations with Beneficial Reuse of Dredged Material

Lyndsay Rankin, McKenna Bristow, Desmond Mackell, Kevin Buffington, Karen Thorne

USGS Western Ecological Research Center, Davis, CA

lrankin@usgs.gov, mbristow@usgs.gov, dmackell@usgs.gov, kbuffington@usgs.gov, kthorne@usgs.gov

The San Francisco Bay estuary (SFBE) has experienced over 85% loss of tidal wetlands due to land conversion into agricultural, urban infrastructure, and salt harvesting. Fortunately, expansive tidal wetland restorations are in progress and planned for the SFBE. Many restoration sites are diked baylands positioned below mean tide levels with modified hydrology, salinity levels, and sediment sources. These conditions impact the wetland's ability to accumulate sediment and keep pace with sea level rise. Beneficial reuse of dredged material has been used to improve restoration outcomes by building wetland elevations to accelerate habitat development. We compared the physical characteristics of San Pablo tidal wetlands with different restoration histories including those restored using beneficial reuse (Hamilton Wetland, Sonoma Baylands), those restored through natural tidal sediment accretion (Tolay, Carl's Marsh), and old tidal wetlands (Black John Marsh, Centennial Strip Marsh). Elevation and bathymetry surveys were used to compare biogeomorphic features by restoration type and age. Soil cores were used to identify restoration horizons and calculate post-restoration deposition rates. We examined the influence of dredge reuse on accretion rates and habitat structure. By identifying differences between natural accretion and beneficial reuse restorations, we can provide valuable information on tidal wetland restoration designs across the SFBE.

Keywords: wetlands, restoration, dredge material, elevation, bathymetry, accretion, soil cores, sediment

Poster Topic: Sediment - Beneficial Reuse

Montezuma Wetlands Project: Beneficial Sediment Reuse for Tidal Marsh Restoration

Cassie Pinnell[1,2], Jim Levine[2], Doug Lipton[3], Roger Leventhal[4]

[1]Vollmar Natural Lands Consulting, Arcata, CA
[2]Montezuma Wetlands, LLC, Emeryville, CA
[3]Lipton Environmental Group, Healdsburg, CA
[4]Engineer, Petaluma, CA

cassie@montezumallc.com, jim.levine@upstream.us.com, doug@healdsburgshed.com, roger.leventhal@gmail.com

The Montezuma Wetlands Project is a multi-phase restoration project that uses dredged sediment to raise elevations in diked, subsided baylands to restore ~2,000 acres of tidal wetlands. These include sediments not suitable for unconfined aquatic disposal, which are buried and isolated in an anoxic environment under at least 3 feet of cleaner sediments. The project owns the highest rate sediment offloading system west of the Mississippi and has operated successfully since 2003 by placing over 10 million cubic yards. The project is on target to accomplish its restoration goals in support of the Long-Term Management Strategy (LTMS), established by a joint effort of the Corps and other federal, state and regional agencies to maximize the safe beneficial reuse of sediment dredged from the SF Estuary. Montezuma restored tidal action to its first phase of over 500 acres in October 2020, and has been monitoring development of the new marsh system. Post-breach monitoring data includes fish, bird and special-status wildlife use, vegetation development, water quality, and tidal channel formation. Three years of monitoring indicate the breach was successful, with encouraging physical (tidal flows matching with target site elevations), chemical (water quality), and biological (wildlife use) results. Ongoing monitoring will provide important data on early marsh development and the ability of plants and wildlife to colonize projects using dredged sediment. Pre-breach data includes detailed elevation and habitat surveys and 20 years of biological and chemistry sampling results, which documented safe handling of the sediments. The extensive data collected has allowed Montezuma to adaptively manage and improve its restoration methods to increase resiliency for sea level rise and changing needs and conditions. By working in collaboration with regulatory agencies, project partners, and the Technical Review Team, Montezuma has pioneered many new scientific and engineering approaches and methods for large-scale tidal marsh restoration.

Keywords: sediment, beneficial reuse, tidal marsh

Poster Topic: Sediment - Beneficial Reuse

Sediment to Wetlands Adaptation Project: Workshop Findings and Roadmap Preview

Maya McInerney, Brenda Goeden, Erik Buehmann

Bay Conservation and Development Commission (BCDC), San Francisco, CA

maya.mcinerney@bcdc.ca.gov, brenda.goeden@bcdc.ca.gov, Erik.buehmann@bcdc.ca.gov

Wetlands of the San Francisco Bay need a significant amount of supplemental sediment to meet the region's restoration goals and keep pace with sea level rise over time. The Bay Conservation and Development Commission is working on a Sediment for Wetland Adaptation Project, with the goal of increasing beneficial reuse of sediment and soil for wetland habitat restoration, resilience, and sea level rise adaptation in the San Fransisco Bay Area. This grant-funded project is being conducted as a coordinated effort between the Bay Conservation and Development Commission, San Francisco Estuary Institute, San Francisco Bay Joint Venture, U.S. Environmental Protection Agency, California State Coastal Conservancy, and San Francisco Bay Regional Water Quality Control Board. The project involves development of a sediment to wetlands implementation roadmap; increasing coordination and collaboration among stakeholders; improving sediment management policies; and developing a financing and funding strategy for beneficial reuse of sediment and soils in the region. The current focus of the project is on development of the roadmap, which addresses roadblocks and provides potential solutions refined through a collaborative sediment management stakeholder workshop held in January and February of 2024. The poster provides key lessons from the workshop, which will be the basis of a roadmap to increased beneficial reuse in the region.

Keywords: Sediment, Wetlands, Adaptation, Policies, Workshop, Roadmap, SWAP, Dredging, Habitat, Resilience

Poster Topic: Sediment - Beneficial Reuse

Regional Monitoring Program Survey of Contaminants in Shallow and Intertidal Bay Margin Sediment

Donald Yee[1], Adam Wong[1], Marco Sigala[2], Sean Campbell[3], Amy Goodall[4], Tony Rattonetti[5]

[1]San Francisco Estuary Institute, Richmond, CA
[2]Marine Pollution Studies Lab, Moss Landing, CA
[3]SGS-Axys, Sidney, BC, WA
[4]Brooks Applied Labs, Seattle, WA
[5]SFPUC Southeast Lab, San Francisco, CA

donald@sfei.org, adamw@sfei.org, marco.sigala@sjsu.edu, sean.campbell@sgs.com, amy@brooksapplied.com, trattonetti@sfwater.org

Sediment in shallow (<1 ft deep at mean lower low water) and intertidal "margin" areas were historically not sampled by the Regional Monitoring Program for Water Quality in San Francisco Bay (RMP). Pilot surveys by the RMP in Central (2015), South (2017) and North Bay (2020) margins were conducted to fill this information gap. The results generally support a conceptual model of many contaminants originating from near-shore sources and pathways. In Central Bay, with the oldest and most industrial and urban development, sediment concentrations of contaminants such as PCBs in margins were significantly higher than in the deep Bay. For South Bay, margins were a greater percentage of the overall surface area and were more proximate to their adjacent deepest waters, so PCB concentrations were more similar. In contrast, North Bay margins sediment had lower PCBs than in nearby deep-water. In addition to typically higher concentrations in Central Bay margins, within each region, the highest concentrations were found near industrialized areas, often more enclosed areas with less water exchange and wave energy to disperse deposited contaminants. Although contaminants persisting in these areas indicate little or no recovery without active management, they also suggest opportunities to act on relatively localized scales to promote recovery.

These RMP pilot studies provide an initial ambient survey of contaminant concentrations in margin areas of all the Bay segments, providing context against which contamination at specific sites can be compared. This baseline dataset also is useful in setting expectations and tracking improvements in watershed loads and their near-field receiving waters, and for informing sediment guidelines for the re-use of dredged sediment.

Keywords: contaminants, sediment, intertidal, mudflat

Poster Topic: Sediment - Beneficial Reuse

Strategic Sediment Pulse Delivery Pilot Project in Marin County

Roger Leventhal[1], Julie Beagle[2], Tiffany Cheng[2], Jade Ishii[2], Jared McKnight[3]

[1]Marin County Public Works, San Rafael, CA
[2]U.S. Army Corps of Engineers San Francisco District, San Francisco, CA
[3]U.S. Army Engineer Research and Development Center, Vicksburg, MS

RLeventhal@marincounty.org, Julie.R.Beagle@usace.army.mil, Tiffany.K.Cheng@usace.army.mil, jade.ishii@usace.army.mil, charles.j.mcknight@erdc.dren.mil

USACE San Francisco District and Marin County Department of Public Works (DPW) are investigating a potential dredging approach measure called Strategic Sediment Pulse Delivery (SSPD) to support coastal/fluvial flood risk management in tidal flood control channels in Marin County, CA. This study focuses on tidal flood control channels that are infrequently being dredged under current conditions and are in essence "mud locked". A "design with nature" engineering approach, SSPD entails the use of hydrodynamic dredge methods to disturb and entrain sediments from the channel bottom during naturally elevated turbid conditions (e.g. prior to a storm event) and allowing the natural tidal currents and waves to redistribute sediments downstream to the Bay. Recent research in San Francisco Bay shows that tidal marsh accretion is closely linked with storm activity. This approach is proposed as a potential lower cost, lower GHG and less polluting alternative to traditional dredging methods under non-turbid conditions and mechanical piping and transport of sediment in barges for disposal. In addition to reducing flood risk around tidal channels, this type of measure could also re-distribute sediment beneficially to local marsh and mudflat systems post-storm. The team will evaluate the efficacy of SSPD for the tandem goals of flood risk reduction and regional marsh/mudflat resiliency using a regional Adaptive Hydraulics (AdH) model developed by USACE Engineer Research & Development Center (ERDC) at the pilot site, Gallinas Creek, by San Pablo Bay. Modeling results and additional analyses by the team will inform the potential ecological and biological impacts of this technique on the tidal channel bottom, as compared to traditional flood risk management currently performed, and support quantification of the benefits of keeping dredged sediment in the San Francisco Bay system. Model development and calibration are ongoing through Winter 2023/2024 and modeling results are anticipated by Spring 2024.

Keywords: Sediment, hydrodynamic dredge, beneficial re-use, marsh resiliency

Poster Topic: Sediment - General

Updated Curves of Tidal Channel Regime Equations for Central and North SF Bay Marshes

Roger Leventhal[1], Laurel Collins[2]

[1]Marin County DPW Flood Control, San Rafael, CA
[2]Consulting Geomorphologist, Bend, OR

roger.leventhal@gmail.com, laurelgene@comcast.net

One of the most important tools for wetlands restoration designers are tidal channel regime equations and associated curves of tidal hydraulic geometry. These curves of stable tidal channel dimensions (width, depth and area) as a function of connected marsh area, a surrogate for tidal prism, allow engineers and scientists to design tidal channel networks critical for the physical and ecological success for restored tidal marsh systems. The current dilemma in marsh design is that minimal data exists on stable channels because most are still adjusting to legacy and modern land use impacts. This project presents an empirical analysis with hundreds of hydraulic geometry measurements of historical marshes mapped in the 1800s (assumed stable) and compares them to their modern counterpart. This provides wetlands engineers a pragmatic tool to design channel system as well as understand the trajectory of tidal channels due to land use decisions such as diking of marshlands.

We built upon the work of PWA 2002 to significantly expand the database of sites and to stratify the data by marsh and separately analyze historic from modern tidal marshes. The data is analyzed and plotted on a series of approximately 30 design curves. The findings show that in general, historical width to depth ratios were smaller in the historic marshes versus modern and the smallest ratios in modern marshes are in the least disturbed channels. These design metrics are important to building tidal channels that are in equilibrium with the available tidal prism and thus less prone to erosion or siltation.

Marin County Flood Control District uses these nature-based curves as a dredge template called “geomorphic dredge design” to provide more self-maintaining tidal channels that should have less negative environmental impacts than traditional engineering templates that over-deepen and/or over-widen channels that necessitate repeated dredging to maintain design capacity.

Keywords: Dredging, design with nature, tidal channels, flood risk management, resiliency

Poster Topic: Sediment - General

Modeling Sediment and Contaminant Transport in San Leandro Bay

Samuel McWilliams[1], Jay Davis[2], Craig Jones[1], Don Yee[2], Allie King[2]

[1]Integral Consulting Inc., San Francisco, CA
[2]San Francisco Estuary Institute & The Aquatic Science Center, Richmond, CA

smcwilliams@integral-corp.com, jay@sfei.org, cjones@integral-corp.com, don@sfei.org, alliek@sfei.org

Historically, sediment entering San Leandro Bay (SLB) has contained contaminants of concern due to a variety of activities within the surrounding watersheds. The upland material mixes with sediment within SLB and the wider San Francisco Bay, settling in subtidal areas as well as on intertidal wetlands. Biotic exposure to these contaminants in SLB is governed, in part by the rate of material exported from the watershed depositing on the older contaminated sediment. The San Francisco Estuary Institute (SFEI) and Integral Consulting Inc. have completed a study to evaluate the sediment transport patterns within SLB by utilizing a combination of measured data and numerical models to evaluate recovery rates and site response over multiple timescales.

The team applied sediment concentration and discharge rate results of SFEI's Watershed Dynamic Model (WDM) to introduce sediment to a hydrodynamic and sediment transport model of SLB. The hydrodynamic and sediment model is a modified version of the publicly available DFlow-FM model representing all of San Francisco Bay, previously developed by Deltares Inc. Grid and bathymetry refinements in SLB ensured the model had an appropriate resolution to capture intertidal dynamics in the prominent mudflats and marshes as well as the creek and channels where the upland sediment is introduced to the system. Representative sediment characteristics were applied based upon field measurements and literature values.

Model results were evaluated by comparing deposition patterns with observed and historic sedimentation rates. The model predicts the distribution of sediment from each of the input locations. Future model evaluations will address contaminant management questions for San Leandro Bay.

Keywords: San Leandro Bay, sediment, contaminants, hydrodynamics, numerical modeling, watershed modeling

Poster Topic: Sediment - General

Is Suspended-sediment Concentration a Good Predictor for Marsh Accretion?

Samantha McGill[1], Jessica Lacy[1], McKenna Bristow[2], Karen Thorne[2]

[1]USGS Pacific Coastal and Marine Science Center, Santa Cruz, CA
[2]USGS Western Ecological Research Center, Davis, CA

scmcgill@usgs.gov, jlacy@usgs.gov, mbristow@usgs.gov, kthorne@usgs.gov

Sediment supply is a critical determinant in whether existing and restored marshes will accrete and, thus, maintain elevation as sea level rises. The rate of mineral sediment deposition on marshes is thought to be directly related to inundation time and the suspended-sediment concentration (SSC) in adjacent waters. In San Francisco Bay, it is also likely influenced by several other factors, including wave exposure, proximity to sediment supply from the Sacramento-San Joaquin Delta and other watersheds, vegetation cover, and marsh edge type. We are investigating the relationship between SSC and deposition at a range of elevations in two marshes in different settings in northern San Francisco Bay, to test the hypothesis that SSC is a good predictor for marsh accretion, prognosticating resilience and restoration success. Corte Madera Marsh has a scarped (0.5 m) edge and is in a semi-sheltered embayment. The second site, San Pablo Bay National Wildlife Refuge marsh, has a gently sloped edge and is located closer to the Delta and near the Petaluma River outflow. From April 2022 through July 2023, we collected deposition data using sediment pads deployed in transects extending from the bay edge towards the interior marsh at both sites. For each site, we deployed instrumentation in the intertidal and subtidal shallows to measure waves and tidal currents, SSC, and other hydrographic data. SSC and wave energy were significantly greater in San Pablo Bay than Corte Madera Bay. Our presentation will address whether temporal variation in deposition can be predicted from temporal variation in SSC in the shallows and explore how this relationship varies between sites. We will also present the influence of the wet 2022/2023 winter on deposition during and after storm events. These results will aid restoration planning, management of marshes, and prediction of marsh resilience and vulnerability to sea level rise.

Keywords: Sediment, Marsh accretion, Suspended Sediment

Poster Topic: Sediment - General

Monitoring Suspended Sediment Flux from Fluvial and Estuarine Sources in Tidal Slough Habitats of South San Francisco Bay

Ian Pryor, Noah Hume, Joseph Verdian

Stillwater Sciences, Berkeley, CA

ian@stillwatersci.com, noah@stillwatersci.com, jverdian@stillwatersci.com

Consistent with the South Bay Salt Pond Restoration Project goals of tidal habitat wetland restoration, enhanced public access, and flood management, the Calabazas and San Tomas Creek Marsh Connection Project was awarded grant funding from the San Francisco Bay Restoration Authority, California Dept. of Fish and Wildlife and USEPA to re-establish fluvial and tidal connections between riverine, creek, and estuarine habitats of southern San Francisco Bay, benefiting sediment transport, capture and tidal marsh re-establishment.

To provide validation data for hydrodynamic modeling of restoration alternatives as well as a baseline for post-project comparisons of sediment transport and depositions, pre-project monitoring of suspended sediment transport across tidal cycles and during seasonal runoff events is being conducted as part of Calabazas and San Tomas Creek Marsh Connection Project. Continuous acoustic doppler profiling and turbidity monitoring in tidal slough habitats, coupled with suspended sediment sampling from the water column provides estimates of bayward and landward sediment flux on tidal and seasonal scales.

In addition to improving calibration and validation of hydrodynamic and sediment transport models, the results allow improved estimates of sedimentation rates and tidal marsh accretion in the face of projected sea level rise.

Keywords: ADCP, Flux, Methods, Restoration, SBSPRP, Sediment, Tide, Tidal, Turbidity

Poster Topic: Sediment - General

Sources and Spatial Patterns of Deposited and Incorporated Blue Carbon Across a Marsh Surface

McKenna Bristow[1], Scott Jones[2], Kevin Buffington[1], Jessica Lacy[3], Karen Thorne[1]

[1]U.S. Geological Survey - Western Ecological Research Center, Davis, CA
[2]University of North Florida, Jacksonville, FL
[3]U.S. Geological Survey - Pacific Coastal and Marine Science Center, Santa Cruz, CA

mbristow@usgs.gov, scott.jones@unf.edu, kbuffington@usgs.gov, jlacy@usgs.gov, kthorne@usgs.gov

Tidal salt marshes are important carbon sinks, and are threatened by climate change, sea level rise and habitat loss. Understanding carbon at fine spatial scales can help inform management decisions as these threats loom. Whale's Tail marsh is a high pickleweed-dominated marsh that is exposed to heavy wind-wave action, resulting in a deep scarped edge facing South San Francisco Bay, CA. To investigate how blue carbon is distributed and incorporated across the marsh surface, we measured sediment deposition ($g/m^2/day$) along transects from different sediment sources including the bay edge, tidal channel, and interior channel from 0 m to 72 m from source, then analyzed mineral and organic deposition fractions. We also collected shallow cores along each transect to investigate incorporated vs deposited carbon. We identified potential carbon sources for this marsh, including standing biomass, imported suspended particulate matter from the channels and bay, and resuspension of the scarped marsh edge. We analyzed deposited and incorporated sediment samples for ^{15}N and ^{13}C ratios to determine carbon sources. Our results help inform where blue carbon comes from, how it is spatially distributed across a marsh surface relative to covariates such as inundation and vegetation, and how and when it is incorporated into the marsh soil.

Keywords: blue carbon, salt marsh, sediment, isotopes

Poster Topic: Sediment - General

Mining the Sand Transport System, What Have We Learned?

Brenda Goeden[1], Lester McKee[2], Scott Dusterhoff[2], Edwin Elias[3], Michael MacWilliams[4], Aaron Bevers[4], Bruce Jaffee[5], Theresa Fregoso[5], Zach Sickmann[6], Matthew Malkowski[6]

[1]San Francisco Bay Conservation and Development Commission (BCDC), San Francisco, CA
[2]San Francisco Estuary Institute, Richmond, CA
[3]Deltares Netherlands, Delft, Netherlands, NE
[4]Anchor QEA, San Francisco, CA
[5]US Geological Survey, Pacific Coastal and Marine Science Center, Santa Cruz, CA
[6]University of Texas at Austin, Austin, TX

brenda.goeden@bcdc.ca.gov, lester@sfei.org, scottd@sfei.org, Edwin.elias@deltares.nl, mmacwilliams@anchorqea.com, abevers@anchorqea.com, bjaffee@usgs.gov, tfregoso@usgs.gov, ztsickmann@gmail.com, matthew.malkowski@gmail.com

Sand mining in San Francisco Bay has been ongoing for decades, supplying the local communities with construction aggregate for building, roads, and infrastructure. However, the physical effects of mining on the Bay sediment system were not well understood and had previously not been investigated. In order to better understand impacts to the sand transport system, budget, Bay bathymetry, the San Francisco Bay Conservation and Development Commission required funding to support scientific studies as part of its permitting process in 2015. Since that time, technical advisory committee, an independent science panel, and researchers have worked to address management questions around mining activities. In the first of their kind studies, several researchers including SFEI, Deltares, Anchor QEA, UT Austin, and USGS have dove into the world of sand in San Francisco Bay. This poster will provide insights on these studies, their findings, and new techniques that have opened up the world of deep-water sand shoals. Studies include a sand budget, changes to Bay bathymetry, sand original, and transport pathways.

Keywords: sand, mining, sediment transport, budget, bathymetric change, natural resource use,

Poster Topic: Sediment - General

San Francisco Bay Sand and Mud Budget

Lester McKee, Scott Dusterhoff, Jeremy Lowe

San Francisco Estuary Institute, Richmond, CA

scottd@sfei.org, jeremyl@sfei.org, lester@sfei.org

A sediment budget was prepared for San Francisco Bay that explicitly defined sand and mud components separately. Inflow terms included the mass loads from the Sacramento and San Joaquin Rivers draining the Central Valley, the small local tributaries that drain the nine counties that surround the Bay, and sand inflow from the Pacific Ocean via littoral processes. Outflow terms included sediment mass associated with sand mining, navigational dredging, wetland deposition due to sea level rise (SLR), and sediment mass removed from the tidal portions of flood control channels on the edge of the Bay. The change in bathymetry was the only term considered for change and storage. The sand and mud budgets were resolved for each subembayment and for the Bay as a whole ensuring no missing mass for the period 2001-2020. At the scale of the whole Bay, net outflows of total sediment (4.0 Mt/y) exceeded net inflows (2.0 Mt/y), the balance being net bed losses (2.0 Mt/y). Of the annual average inflows, 0.45 Mt/y (23%) was sand. Overall, 67% of the net bed erosion was sand, despite the Bay generally being a muddy system. Sand mining and navigational dredging accounted for 30% and 24% respectively of the outflows in the total sediment budget. The Bay supplied the Pacific Ocean with 1.7 Mt/y of total sediment; 0.26 Mt/y (15%) was sand. This budget information, along with the details of sand and mud at subembayment scales, provides useful information for a variety of management decisions and could be used as the basis for the budgets of other sediment associated contaminants.

Keywords: Sediment budget, sand, mud

Poster Topic: Sediment - General

San Francisco Bay - Climate Refuge for Seabirds?

Maggie Lee Post, Julie Thayer

Farallon Institute, Petaluma, CA

mpost@faralloninstitute.org, jthayer@faralloninstitute.org

Seabird breeding populations are subject to multiple environmental and anthropogenic stressors, and may operate at or near their maximum capacity in order to survive and breed. Unpredictability and variability of ocean conditions are expected to increase with climate change, making seabirds increasingly vulnerable. The speed of climate change is predicted to exceed seabirds' response capabilities (e.g., shifts in diet, location, etc.). However, cormorants and other seabirds have moved into the Central Bay in recent decades and have excelled, demonstrating higher reproductive success and population growth than regional counterparts along the coast and offshore. This suggests that estuarine environments may offer more diverse and reliable foraging opportunities than offshore colonies, translating into climate refugia for breeding seabirds in the face of increasing climate extremes. We present comparative analyses of reproductive success, population growth, and diet from long-term datasets since the 1990s on Brandt's cormorants on Alcatraz Island versus outside the Bay, indicating greater success inside the Bay. As estuarine colonies may be climate refugia for seabirds, protection of these environments is increasingly important. We cannot control climate change, but we can mitigate growing human-caused stressors to bays and estuaries, such as human disturbance to wildlife and loss of habitat in rapidly developing coastal areas.

Keywords: Seabirds, Resilience, Long-term datasets, Forage fish

Poster Topic: Species and Communities - Birds

Influence of Drought on Long-term Waterbird Trends in the Napa-Sonoma Marshes Wildlife Area

David Nelson, Tanya Graham, Laurie Hall, Susan De la Cruz

US Geological Survey, San Francisco Bay Estuary Field Office, Moffett Field, CA

davidnelson@usgs.gov, tgraham@usgs.gov, Lahall@usgs.gov, sdelacruz@usgs.gov

Across the state of California, periods of prolonged drought continue to stress our water resources and the organisms that depend on them. With drought events expected to increase in frequency and duration in the coming years, concern grows for wildlife such as migratory waterbirds that rely on wetland habitat. The Napa-Sonoma Marshes Wildlife Area (NSMWA), north of San Pablo Bay, provides waterbirds with crucial wintering and stopover habitat. As seasonal freshwater wetlands continue to be afflicted by drought conditions, the managed and tidally influenced salt ponds of NSMWA may play an increasingly important role for migratory waterbirds. From 1999 to the present, the USGS San Francisco Bay Estuary Field Station has conducted monthly waterbird surveys in the NSMWA salt ponds to capture long-term trends in waterbird abundance and distribution. We leveraged these long-term waterbird monitoring data to examine how waterbird density in NSMWA is related to drought. We compared annual California statewide runoff with 24 years of monthly waterbird abundance data to help answer this question. We focused our analysis on dabbling ducks, diving ducks, large and small shorebirds as these guilds represent over 95% of the average winter abundances in NSMWA. Preliminary results suggest a potential relationship between decreased California statewide runoff and increased density of waterbirds in NSMWA, particularly dabbling and diving ducks. During drought years, decreased availability of wetland habitat in the Sacramento/San Joaquin Valley and Delta may drive birds to estuarine habitat. Conversely, wet years may draw birds away from the NSMWA and inland toward temporary flooded areas, such as agricultural fields, and floodplains. These preliminary results suggest additional waterbird distribution and abundance modeling may provide information to help managers make habitat management decisions during drought years. Insights provided by these analyses can help us understand the role of estuarine systems for waterbird resilience to climate change.

Keywords: drought, waterbird, waterfowl, shorebird, wetland, restoration, climate, salt pond, runoff

Poster Topic: Species and Communities - Birds

Utilizing Aerial Drones to Survey Waterfowl Broods to Inform Management

Desmond Mackell[1], Michael Casazza[1], Cory Overton[1], Kevin Buffington[2], Chase Freeman[2], Joshua Ackerman[1], Karen Thorne[2]

[1]U.S. Geological Survey, Western Ecological Research Center, Dixon Field Station, Dixon, CA
[2]U.S. Geological Survey, Western Ecological Research Center, Davis Field Station, Davis, CA

dmackell@usgs.gov, mike_casazza@usgs.gov, coverton@usgs.gov, kbuffington@usgs.gov, cmfreeman24@gmail.com, jackerman@usgs.gov, kthorne@usgs.gov

Effective waterfowl management relies on the collection of relevant demographic data to inform land management decisions; however, some types of data are difficult to obtain. For waterfowl, brood surveys are difficult to conduct because wetland habitats often obscure ducklings from being visually assessed. Unoccupied Aerial Systems (UAS) have been used to monitor wildlife and may be a useful tool for monitoring waterfowl broods at fine spatial scales while providing timely results to local managers. We equipped a 3DR solo platform UAS with a thermal imaging camera to test the viability of this tool to count waterfowl broods in brackish wetlands within Suisun Marsh, California. We surveyed 17 wetland units encompassing 332 ha of flooded area on seven waterfowl hunting clubs during the waterfowl breeding season. Additionally, using a combination of multispectral imagery collected from the UAS flights and LiDAR data from the previous year, we mapped habitat composition within each unit to relate to brood observation counts. From June 3-7, 2019, we identified 113 individual broods comprised of 827 ducklings. We found a positive relationship between the number of broods observed and the proportion of the unit that was flooded. We also found a positive relationship between the number of broods observed and the area of effective habitat, a metric of flooded habitat within a defined distance to flooded vegetation. Brood surveys could compliment the California Department of Fish and Wildlife's traditional Breeding Population Survey and provide local managers with fine scale and timely information regarding shifts in brood abundance in the region. This emerging technology can assist in real-time decision making for California waterfowl populations.

Keywords: Waterfowl, Brood, Drone, Unoccupied Aerial System, Wildlife Survey, Wetland Management

Poster Topic: Species and Communities - Birds

Abundance and Distribution of Non-breeding Shorebirds in San Francisco Bay

Mark Dettling, Blake Barbaree, Catherine Hickey, Matthew Reiter

Point Blue Conservation Science, Petaluma, CA

mdettling@pointblue.org, bbarbaree@pointblue.org, chickey@pointblue.org, mreiter@pointblue.org

Recent analyses suggest that migratory shorebirds have declined significantly across flyways in the Western Hemisphere. Along the Pacific Flyway there is also increasing evidence of shorebird population declines. San Francisco Bay is a designated site of Hemispheric Importance for shorebirds as part of the Western Hemisphere Shorebird Reserve Network and shorebird populations are considered an indicator of the health of intertidal habitats in the 2015 State of the Estuary Report. Since 2010, we have coordinated the largest annual community science driven survey of non-breeding shorebirds between November 15 and December 15 across three regions of San Francisco Bay. We used data from these surveys in 2011-2013 to show declining trends in medium and large sized shorebirds when compared to baseline data from 2006-2008. We have now quantified trends in shorebird abundance between 2011 and 2022 for 6 relatively common species (Black-bellied Plover, American Avocet, Black-necked Stilt, Marbled Godwit, Dunlin, and Western Sandpiper) representing a variety of body-sizes, life-history strategies, and habitat use. Initial results suggest variability in trends across species and regions of the Bay. These results and can help to target conservation efforts in San Francisco Bay and to guide efforts to update monitoring to account for the changing distribution of habitats.

Keywords: shorebirds, monitoring, trends, San Francisco Bay, habitat

Poster Topic: Species and Communities - Birds

Canvasback Winter Habitat Use in the San Francisco Bay Delta

Susan De La Cruz, Laurie Hall, Stacy Moskal, Mason Hill, Aliya McCarthy

USGS Western Ecological Research Center, Moffett Field, CA

sdelacruz@usgs.gov, lahall@usgs.gov, smoskal@usgs.gov, mhill@ducks.org, amccarthy@OSU.edu

The San Francisco Bay Delta and Central Valley of California are integral wintering areas for several waterfowl species, including more than 50% of canvasback (*Aythya valisineria*) in the Pacific Flyway. Little is known about wintering habitat use of diving ducks in California, but this information is critical given on-going and projected habitat changes in the region. We evaluated winter use of wetland habitats in California by canvasback to identify management regimes that may benefit the species. We collected 26,247 locations during the winters of 2017, 2018, and 2019 from 49 adult canvasbacks fitted with GPS-GSM tracking devices. We examined habitat use with an ensemble modeling approach comprised of generalized additive models, random forests, and boosted regression trees. Our results suggested that habitat use differed among years; for example, in the wetter winter of 2017 canvasback had limited use of estuarine habitats (particularly in the Suisun region), with individuals moving inland to the Central Valley in early winter, potentially due to historic freshwater availability. In contrast, canvasback used several types of estuarine habitats in the drier winter of 2018, including shallow shoals, tidal marshes, managed marshes, and static deep-water ponds. Then, they transitioned inland towards freshwater habitats during spring months. Given cyclical drought conditions, planned tidal wetland restoration, and diminishing freshwater flows to the San Francisco Bay Delta, information on winter habitat use of diving ducks in California can improve our understanding of how projected habitat changes may influence these species in the future.

Keywords: Canvasback, Diving duck, Resource selection, Habitat use, Telemetry, Restoration, Drought

Poster Topic: Species and Communities - Birds

Space Use Characteristics of Translocated and Resident Ridgway's Rail (*Rallus Obsoletus)* Evaluated Using High Frequency GPS Relocation with Comparisons to Traditional Low Frequency Radio-telemetry

Cory Overton, Michael Casazza

U. S. Geological Survey, Western Ecological Research Center, Dixon Field Station, Dixon, CA

coverton@usgs.gov, mike_casazza@usgs.gov

Problem Statement: Movements of animals through their environment provide substantial information about species ecology. Relocation frequency within habitats provides information about their perceived value and can inform conservation and habitat enhancement actions. Space use information may also illustrate important life history events, such as nesting, and movement patterns may illustrate factors associated with mortality risks. Herein, we address how the methodology to obtain animal locations affects the interpretation of biological phenomena.

Approach: Beginning in 2019, we collected 46,850 locations on 19 individual Ridgway's rail (*Rallus obsoletus*) at three marshes in San Francisco Bay at intervals as frequent as every half hour. We used these data to describe movement patterns for both resident rails and rails translocated between the three marshes to improve genetic exchange and evaluate translocation as a species management tool. We contrasted space use and movement characteristics of GPS-marked individuals with 109 individuals tracked as part of a 2007-2015 radio-telemetry project (n=15,426 locations).

Results: Comparatively similar movement and space use patterns were estimated when comparing radiotelemetry and GPS telemetry data that was subset to the same time intervals. GPS data collected at more rapid time intervals produces substantially different space use and movement characteristics.

Conclusions: GPS tracking Ridgway's Rail can be implemented effectively to better understand the species' resource needs, social structure in populations, behavior, and life history events and to infer causes and mechanisms of mortality. High resolution GPS data can provide detailed insights into species biology (i.e. nesting sites) that was previously difficult to determine using VHF tracking methodologies.

Keywords: movement, telemetry, habitat use, tides, survival, telemetry, Ridgway's Rail

Poster Topic: Species and Communities - Birds

Terns Eating Chinook Salmon: Using Geochemistry to Characterize the Origins of Tern Prey

Sami Araya[1], Levi Lewis[1], Malte Willmes[1], Meredith Elliot[2], Robert Lusardi[1]

[1]UC Davis, Davis, CA
[2]Point Blue Conservation Science, Bolinas, CA

sjaraya@ucdavis.edu, lewissci@gmail.com, mwillmes@ucdavis.edu, melliott@pointblue.org, ralusardi@ucdavis.edu

Wild Chinook Salmon (*Oncorhynchus tshawytscha*) in California have experienced sharp declines in population size due to an array of anthropogenic pressures. Chinook Salmon smolts (juveniles that are migrating to the ocean) are prey for numerous native species in California, including the endangered California Least Tern (*Sterna antillarum browni*). A large breeding colony of California Least Terns occurs in the San Francisco Estuary at Alameda Point each summer and coincides with smolt outmigration. However, interactions between this endangered avian piscivore and managed salmon stocks are poorly understood. From 2007 to 2018, Point Blue Conservation Science collected and maintained an archive of juvenile Chinook Salmon that were dropped by foraging Least Tern parents returning to the colony to feed their chicks. Here, we used otolith geochemistry to analyze the ratio of Strontium stable isotopes (^{87}Sr:^{86}Sr) in conjunction with extracted coded wire tags (CWTs) to determine the types (hatchery or wild), natal origins, and run timings of these dropped smolts. Our results call attention to a relatively understudied trophic pathway involving juvenile salmon and an endangered coastal avian piscivore. Detailing such interactions among managed species, and across years with different environmental conditions, can help improve future management strategies and, ultimately, the recovery of listed species.

Keywords: Chinook Salmon, California Least Tern, Otoliths, Alameda, Natal Origins, Hatcheries

Poster Topic: Species and Communities - Birds

Quantifying the White and Green Sturgeon Die-off Resulting from the 2022 San Francisco Bay Area Harmful Algal Bloom (HAB) Event

Dylan Stompe, Analicia Ortega, Jim Hobbs

California Department of Fish and Wildlife, Fairfield, CA

dylan.stompe@wildlife.ca.gov, analicia.ortega@wildlife.ca.gov, james.hobbs@wildlife.ca.gov

Harmful algal blooms (HABs) occur when colonies of algae overpopulate, often due to increased nutrient loading, residence time, and/or a combination of three. Some hamful algae produce toxins, causing adverse effects for humans, fish, shellfish, marine mammals, and birds. In addition, the decomposition of algae that follows a HAB event can cause a depletion of dissolved oxygen. In July through August of 2022, a HAB caused by the algae *Heterosigma akashiwo* occurred in the San Francisco Estuary, causing a historic fish kill event. As a result of this event, numerous white sturgeon (*Acipenser transmontanus*) and southern distinct population segment (sDPS) green sturgeon (*Acipenser medirostris*) were killed. To quantify the impact of the HAB on sturgeon species, reports of white and green sturgeon carcasses were aggregated from citizen science sources including iNaturalist and the San Francisco Estuary Institute, as well as from shoreline and open water surveys conducted by Cramer Fish Sciences and the California Department of Fish and Wildlife. To control for potential misidentification and multiple reports of the same carcass, records and associated images were manually analyzed. From these data, a total of 864 sturgeon carcasses, including at least 195 white sturgeon and 17 green sturgeon, were identified. These numbers represent minimums, since sturgeon carcasses may sink before they wash up on shore and large sections of shoreline were not surveyed. Given the potential that many more sturgeon likely died in the 2022 HAB than were recorded, this event may represent a population scale impact for both white sturgeon (a state species of special concern) and sDPS green sturgeon (ESA Threatened). These events may also increase in frequency and severity due to climate change and water management, as associated changes in water temperature and flow create conditions suitable for HABs.

Keywords: sturgeon, HAB, 2022, Herosigma akashiwo, fish, kill, community science, iNaturalist

Poster Topic: Species and Communities - Fish

Long-term Patterns in Splittail Abundance: Is a Trend Hidden in Their Inherent Recruitment Variability?

Anna Merrens, Savannah Valdez, Geoffrey Steinhart

United States Fish and Wildlife Service, Lodi, CA

anna_merrens@fws.gov, savannah_valdez@fws.gov, geoffrey_steinhart@fws.gov

Splittail (*Pogonichthys macrolepidotus*) are endemic cyprinids of the San Francisco Estuary dependent on flooded seasonal wetlands for successful spawning. Populations are equipped to survive drought years due to their long-life span and high fecundity, but habitat loss, contaminants, and extended drought periods could still threaten Splittail survival. Indeed, Splittail were listed as threatened by the United States Fish and Wildlife Service (USFWS) between 1999-2003 and remain a Species of Special Concern in the state of California. California's Central Valley experiences an increasingly variable Mediterranean climate, making it difficult to understand if Splittail long-term abundance and recruitment are stable considering the known variability in flooded wetland area. We analyzed catch of age-0 Splittail from beach seine data collected by the USFWS Delta Juvenile Fish Monitoring Program between 1999-2023 to investigate temporal trends as they relate to variation in precipitation; twenty-five years of seining (nearly 33,000 individual hauls), across 36 sites yielded over 143,000 Splittail. We hypothesized that catch of age-0 Splittail would be significantly higher in wet years than dry years, but that overall catch per unit effort (CPUE) has decreased since 1999 after adjusting for precipitation variability. Using CPUE, we determined Splittail abundance has remained relatively stable after accounting for variability in annual precipitation and runoff patterns. Results support previous work demonstrating that wetter years yield higher CPUE than drier years; however, there was not a significant decline in Splittail CPUE when correcting for water-year variability. Our results suggest a relatively stable Splittail population, future studies should apply climate models' predictions to better understand Splittail vulnerability.

Keywords: Drought, Water-Year, Fish, Climate, Population, Monitoring, Cyprinid, Long-Term, Splittail

Poster Topic: Species and Communities - Fish

Age-0 Pacific Herring Population Stability Across the San Francisco Estuary

Denise Colombano[1], Nina Pak[2], Thomas Greiner[3], James Hobbs[3], Stephanie Carlson[2], Albert Ruhi[2]

[1]Delta Stewardship Council, Sacramento, CA
[2]University of California, Berkeley, Berkeley, CA
[3]California Department of Fish and Wildlife, Santa Rosa, CA

denise.colombano@deltacouncil.ca.gov, nina.pak@berkeley.edu, tom.greiner@wildlife.ca.gov, james.hobbs@wildlife.ca.gov, smcarlson@berkeley.edu, albert.ruhi@berkeley.edu

Pacific herring (*Clupea pallasii*) is an ecologically and commercially valuable forage fish in the North Pacific Ocean. However, knowledge gaps exist around the abiotic and biotic drivers behind its variable population dynamics—as well as on the ability of the species to show spatially structured trends that stabilize population portfolios in the face of environmental change. Here we examined how historical hydroclimatic variability in the San Francisco Estuary (California) has driven age-0 Pacific herring population dynamics over 35 years. First, we used wavelet analyses to examine spatiotemporal variation and synchrony in the environment, focusing on two key variables: salinity and temperature. Next, we fitted multivariate autoregressive state-space models to environmental and abundance time series to test for spatial structure and to parse out abiotic (salinity and temperature) from biotic influences (spawning and density dependence). Finally, we examined the stabilizing effects of spatially asynchronous population fluctuations (i.e., portfolio effects) across the estuary. Our results showed that temperature, but not salinity, fluctuated synchronously across regions on seasonal and decadal timescales. The top-ranked model showed strong evidence of regional population structure and regional variation in population responses to the environment. As expected, age-0 herring were generally associated with cooler, saltier conditions in spring. Density dependence was strong in all regions, suggesting that local factors influencing rearing conditions limited juvenile population growth across the estuary. Additionally, age-0 abundance fluctuations were on average 15% more stable across the estuary than in individual regions, demonstrating that portfolio effects arising from population asynchrony have helped to stabilize recruitment across the estuary over the past four decades. We contend that ecosystem-based fishery management strategies to restore eelgrass and tidal marsh rearing habitats could increase the carrying capacity of the estuary, further stabilizing the herring population and reducing the risk of fishery closures.

Keywords: Ecosystem-based fisheries management, climate change, habitat restoration, eelgrass, pelagic fish

Poster Topic: Species and Communities - Fish

Otolith-based Insights Regarding the Growth, Phenology, Life History, Fitness, and Conservation of Delta Smelt in the San Francisco Estuary

Alex Lama, Christian Denney, Brian Alper, Leticia Cavole, James Hobbs, Bruce Hammock, Swee Teh, Levi Lewis

UC Davis, Davis, CA

awlama@ucdavis.edu, ctdenney@ucdavis.edu, baalper@ucdavis.edu, lcavole@ucdavis.edu, hobbsja@gmail.com, bghammock@ucdavis.edu, sjteh@ucdavis.edu, lslewis.sci@gmail.com

Conservation and management efforts have largely failed to protect Delta Smelt. As we search for answers, we have turned to novel approaches that utilize otoliths (calcified ear stones) to shed light on complex patterns in the age, growth, phenology, life history, genetics, fecundity, and overall fitness of the remnant wild population. We are also developing otolith-based tools to track patterns in movements and survival of hatchery-produced Delta Smelt that have been released into the environment. In aggregate, our results highlight how numerous demographic parameters of Delta Smelt fluctuate in relation to the local environment and regional climate, with warmer conditions corresponding with decreased growth, earlier reproduction, and reduced freshwater residency. Furthermore, results suggest that existing models and conservation strategies may be mismatched with optimal Delta Smelt life histories. While more studies are always needed, sufficient data likely exist to develop new conservation approaches that may help protect and restore California's most critically endangered Delta endemic.

Keywords: Delta Smelt, Conservation, Otolith, Life history

Poster Topic: Species and Communities - Fish

Otolith-based Age, Growth, and Life History of Adult Longfin Smelt

Brian Alper, Alex Lama, Sami Araya, Alec Scott, Nikolas Floros, James Hobbs, Levi Lewis

UC Davis, Davis, CA

baalper@ucdavis.edu, awlama@ucdavis.edu, sjaraya@ucdavis.edu, arsco@ucdavis.edu, njfloros@ucdavis.edu, hobbsja@gmail.com, lslewis@ucdavis.edu

In recent decades, the distinct San Francisco population of Longfin Smelt (*Spirinchus thaleichthys*) has been in rapid decline, raising concerns regarding local extinction risk. Accurate age and growth data are needed, therefore, to inform population models and support the development of effective conservation strategies. At UC Davis, we are developing and testing methods to quantify annual age and growth of Longfin Smelt using seasonally produced transparent and opaque bands ("annuli") in otoliths. Fish were selected from archived samples (from UC Davis and CDFW) based on numerous criteria including fork length, water year, and sampling location. Otoliths were then sectioned and polished in the transverse plane to expose annual increments for reconstructing age, growth, and life history information using image analysis and strontium isotope geochemical analysis (MC-LA-ICP-MS) to produce growth and life history chronologies for each individual. Thus far, we have generated age and growth estimates and geochemical profiles for more than 500 Longfin Smelt collected over the past 2 decades. Results will provide much-needed new information regarding variation in the age structure, growth rates, and life-histories for this imperiled native estuarine fish.

Keywords: Longfin Smelt, Otolith, Age and Life History

Poster Topic: Species and Communities - Fish

Collaborative Development of Fish Monitoring Recommendations for the Wetlands Regional Monitoring Program in San Francisco Estuary

Alison Weber-Stover[1], Lu Wang[2], Levi Lewis[3], Zachary Duckworth[4], Elizabeth Campbell[5], Jeff McLain[6], Christina Toms[7], Stephen Randall[7]

[1]NOAA Fisheries, Santa Rosa, CA
[2]USEPA, San Francisco, CA
[3]University of California at Davis, Davis, CA
[4]Ocean Associates, Arlington, VA
[5]U.S. Army Corps of Engineers, San Francisco, CA
[6]USFWS, Lodi, CA
[7]San Francisco Bay Water Board, Oakland, CA

alison.weber-stover@noaa.gov, winluwang@gmail.com, lewis.sci@gmail.com, zduck75@gmail.com, Elizabeth.A.Campbell@usace.army.mil, jeffrey_mclain@fws.gov, Christina.Toms@waterboards.ca.gov, Stephen.Randall@waterboards.ca.gov

The densely populated and highly modified San Francisco Estuary supports an astonishing mosaic of wetland habitats and species. However, 95% of the historic tidal marsh habitats have been lost or degraded, resulting in impaired ecological functions that impact humans and wildlife.
In the face of a rapidly changing climate, there is an urgent need to accelerate the pace of restoration to restore and preserve these valuable habitats and associated ecological services. Long-term, standardized monitoring is needed to better understand spatial and temporal dynamics of aquatic species in wetland habitats of San Francisco Estuary and quantify restoration outcomes. The Wetlands Regional Monitoring Program (WRMP) is a collaborative effort to enhance wetland restoration efforts throughout the San Francisco Bay by establishing regional-scale monitoring to better inform science-based management and restoration actions. The Fish and Fish Habitat (FFH) Workgroup of the WRMP, consisting of federal and state agencies, nonprofits, and universities, has established and completed a process for developing monitoring recommendations to inform the fisheries-related management questions of the WRMP Plan. Key steps included (a) identifying FFH-specific monitoring goals, (b) reviewing and summarizing prior monitoring efforts, and (c) collaboratively evaluating and ranking a comprehensive suite of monitoring options. The final recommendations included a suite of gears and approaches that were optimized to provide standardized long-term data on the broadest diversity of wetland fishes and associated habitats throughout the lower San Francisco Estuary.

Keywords: estuary fish monitoring WRMP collaboration

Poster Topic: Species and Communities - Fish

A Comparison of eDNA Sampling Methods in an Estuarine Environment to Assess the Effects of Beneficial Dredge Reuse on Presence of Longfin Smelt (*Spirinchus thaleichthys*) and Fish Community Composition

Lizabeth Bowen[1], Shannon Waters[1], Lyndsay Rankin[1], Karen Thorne[1], Daphne Gille[2], Susan De la Cruz[1], Isa Woo[1], Levi Lewis[3], Katie Karpenko[4], Cheryl Dean[4], Gregg Schumer[4]

[1]USGS, Davis, CA
[2]California Department of Water Resources, Sacramento, CA
[3]UC Davis, Davis, CA
[4]Cramer Fish Sciences, West Sacramento, CA

lbowen@usgs.gov, swaters@usgs.gov, lrankin@usgs.gov, kthorne@usgs.gov, Daphne.Gille@water.ca.gov, sdelacruz@usgs.gov, iwoo@usgs.gov, lewis.sci@gmail.com, katie.karpenko@fishsciences.net, cheryl.dean@fishsciences.net, greggs@fishsciences.net

The loss of tidal wetlands in the San Francisco Bay estuary have led to declines in native fish presence. Restoration of tidal wetlands in this area has intensified, with a primary goal being increased numbers of native fishes. We compared presence of longfin smelt in naturally accreted and beneficial dredge reuse wetlands as a measure of successful restoration. We used eDNA analyses as our metric for fish presence and fish community composition, employing two different water sampling methods for comparison (standard and high-volume). Longfin smelt were present in multiple sites, but at numbers too low for accurate comparisons across sites. Community composition varied based on water sampling method, but presence/absence of longfin smelt was consistent across sampling methods. As this represents a pilot study, further refinement of methodology is necessary, but use of high-volume water sampling methods is promising.

Keywords: environmental DNA, estuaries, community composition, high-volume sampling

Poster Topic: Species and Communities - Fish

The Influence of Abiotic and Biotic Factors on the Abundance of Delta and Longfin Smelts

Gonzalo Castillo[1], Steven Slater[2], Brian Mahardja[3]

[1]U.S. Fish and Wildlife Service, Lodi, CA
[2]California Department of Fish and Wildlife, Stockton, CA
[3]U.S. Bureau of Reclamation, Sacramento, CA

gonzalo_castillo@fws.gov, Steve.Slater@wildlife.ca.gov, bmahardja@usbr.gov

Understanding how abiotic and biotic factors influence the abundance of fishes are central research and management questions, particularly for listed species such as Delta Smelt and Longfin Smelt in the highly modified upper San Francisco Estuary (USFE). Our goal was to evaluate which habitat components could best explain the abundance patterns during the early life stages of these two declining species in open water habitats of the USFE. Fish, zooplankton and water quality data were obtained from the California Department of Fish and Wildlife 20-mm Survey conducted from spring to early summer 1995–2017. Potential explanatory environmental variables for catch per unit volume (CPUV, log-transformed) of both fish species were evaluated using nonparametric multiplicative regression. Environmental variables considered included abiotic factors (surface water temperature and salinity, Secchi and bottom depths), and biomass per unit volume (BPUV; log-transformed) of potential zooplankton prey (adults of *Pseudodiaptomus* spp., *Limnoithona* spp., *Tortanus* spp. *Eurytemora* spp.; *Acartia* spp., *Daphnia* spp.; copepodids of calanoids and cyclopoids; copepod nauplii, and rotifers). Preliminary results showed both water quality and zooplankton taxa, known to be common prey for both smelt species, had the greatest influence on fish abundance. Secchi-depth, and BPUV of *Pseudodiaptomus* spp. and *Tortanus* spp., accounted for ca. 35% the Delta Smelt CPUV. For Longfin Smelt, ca. 48% of the variation in their CPUV was explained by water temperature and BPUV of *Limnoithona* spp. and *Eurytemora* spp. Delta Smelt reached highest CPUV at Secchi depths < 40 cm, coinciding with high BPUV of *Pseudodiaptomus* spp. and intermediate-low BPUV of *Tortanus* spp. Highest CPUV of Longfin Smelt coincided with temperatures < 17 ^{o}C, and high BPUV of *Limnoithona* spp. and *Eurytemora* spp. These preliminary results support the need to concurrently consider the water quality conditions and the prey-base requirements to enhance the populations of both smelt species.

Keywords: habitat, delta smelt, longfin smelt, zooplankton, prey, temperature, Secchi depth

Poster Topic: Species and Communities - Fish

Improving Our Understanding of Longfin Smelt (*Spirinchus thaleichthys*) Maturation and Fecundity

Nikolas Floros, Sami Araya, Tien-Chieh Hung, Nann Fangue, James Hobbs, Richard Connon, Levi Lewis

UC Davis, Davis, CA

njfloros@ucdavis.edu, sjaraya@ucdavis.edu, thung@ucdavis.edu, nafangue@ucdavis.edu, jahobbs@ucdavis.edu, reconnon@ucdavis.edu, lslewis@ucdavis.edu

The genetically distinct population of Longfin Smelt (*Spirinchus thaleichthys*) in the San Francisco Estuary (SFE) has experienced significant population declines in recent decades, resulting in an increased risk of extinction. The effectiveness of conservation strategies for this species hinges on the development of robust population models, which rely on accurate parameter estimates for age-at-maturity, size-at-maturity, and size-specific fecundity. Here, we have developed a non-destructive method to assess gonad tissues using image analysis, and we are applying these methods to assess ontogenetic, temporal, and spatial patterns in maturation and fecundity of wild Longfin Smelt collected across the SFE over the last two decades. Across the SFE the mean sex ratio was 3:1 females:males. Individuals with the highest condition K index were caught in the Alviso marsh complex in the south of SF Bay or in the Petaluma and Napa river marshes in the North of SF Bay A distinct increase in the Gonadosomatic Index (GSI) of fish above >60 mm standard length (SL) was observed, and in extreme cases, gonads made up as much as 33% of a fish's total mass. Gonads began to ripen in fish above 60 mm SL, with 33% of fish over 70 mm SL containing gonads with fully mature oocytes. Longfin Smelt oocytes generally exhibited synchronous development, but the presence of some mixed-stage ovaries indicated multiple sequential spawning events within a given season. Females with maturing or mature ovaries were 65–106 mm standard length and contained 787–10,024 oocytes, with the average female being 75 mm and carrying 4,500 oocytes. Results are currently being combined with otolith-based analyses to assess patterns in age-at-maturation.

Keywords: Longfin; Threatened; Fecundity; Maturation; Alviso; Petaluma; Napa; Marsh; Restored Ponds

Poster Topic: Species and Communities - Fish

Utilizing New Technology to Address the Vessel Traffic Gap in Conventional Whale-ship Strike Risk Assessments

Pilar Rodriguez[1], Rebekah Lane[1], Samantha King[2], Julia O'Hern[1], Kathi George[1], William Keener[1], Marc Webber[1]

[1]The Marine Mammal Center, Sausalito, CA
[2]ProtectedSeas, Palo Alto, CA

pnrodriguez24@gmail.com, laneb@tmmc.org, samantha@protectedseas.net, ohernj@tmmc.org, georgek@tmmc.org, keenerb@tmmc.org, webberm@tmmc.org

Methodologies for creating whale-ship strike risk assessments involve two components: whale distribution data and vessel traffic data. For the latter, data are typically received from vessels transmitting Automatic Identification Systems (AIS). However, federal law only requires commercial vessels 65 feet and longer and vessels certificated to carry more than 150 passengers to transmit AIS. While AIS data are readily available for use, it is not representative of overall vessel traffic. This is important in urban areas such as San Francisco Bay, where gray and humpback whales feed in areas of high-density vessel traffic. The objectives of this study were to investigate the data gap created when only using AIS data, and seasonal differences and speed variability in non-AIS transmitting vessel traffic. To address this gap, a Marine Monitor system containing a radar sensor and camera was positioned on Point Bonita, overlooking the Golden Gate Strait, to collect both AIS and non-AIS vessel data. Using a random sample of days from September 2021 to August 2022, vessel tracks detected by radar were manually tagged according to their vessel type and both radar and AIS data were analyzed. Results show that 80.7% of all tracks in the Golden Gate Strait during the study period consisted of non-AIS transmitting vessel tracks. When looking at radar track composition and seasonality, small recreational vessels had the greatest average number of tracks per day and traffic differed seasonally. These findings demonstrate that using only AIS data to create ship-strike risk assessments creates an incomplete vessel traffic map, which can result in underestimating risk to whales. Results also highlight the importance of developing strategies and campaigns that educate small recreational boaters on how to safely navigate in an urbanized waterway utilized by large whales.

Keywords: ship-strike, cetaceans, novel technology, AIS, risk-assessment, marine monitor, vessel traffic

Poster Topic: Species and Communities - Sensitive Species

Novel Photo-identification of Gray Whales (*Eschrichtius robustus*) in San Francisco Bay

Josephine Slaathaug, Bekah Lane, William Keener, Marc Webber, Julia O'Hern, Kathi George

The Marine Mammal Center, Sausalito, CA

j.m.slaathaug@gmail.com, laneb@tmmc.org, keenerb@tmmc.org, webberm@tmmc.org, ohernj@tmmc.org, georgek@tmmc.org

Gray whales (*Eschrichtius robustus*) are a poorly understood part of the San Francisco Bay ecosystem due to their irregular presence. Typically, they migrate 10,000 km from their breeding grounds in Mexico to their feeding grounds in the Arctic, traveling along the California coast from December to May. In 2018, we noted a marked increase in gray whale sightings inside San Francisco Bay, coinciding with an unusual mortality event that led to a population decline of 46% since 2016. Regular boat-based survey efforts were initiated in 2023 to better understand the ecology of gray whales in the area. To quantify the number of individuals utilizing the Bay from 2018-2023, the first photo-identification catalog of gray whales in San Francisco Bay was compiled. Images of unique markings obtained during 303 whale sightings resulted in a dataset of ~87 individuals, with ~71 individuals identified by the right-side (standard for the species). Of the total 87 individuals, 31 (35%) were only sighted once and 55 (63%) were seen ≥ 3 times. Four individuals were resighted inter-annually. In several instances, whales were observed creating mud plumes during apparent benthic feeding behavior. These whales were sighted in areas of high-density vessel traffic, and one individual was resighted multiple times during the February-June 2023 season suffered two vessel strike injuries, the second being fatal. This photo-identification catalog provides a first look into the identity of gray whales in this urbanized estuary habitat, creating a foundation for further investigation and comparison of individual identity, health, and behavior. Understanding whether San Francisco Bay gray whales constitute a local feeding group or an extension of the Pacific Coast Feeding Group, a subset of gray whales known to forage from northern California (41°N) to British Columbia, will be a focus of future research and has important implications for conservation.

Keywords: photo-identification, gray whales, cetaceans, site fidelity, occurrence, phenomenon, climate change

Poster Topic: Species and Communities - Sensitive Species

A Prickly Pappose Tarplant Success Story: Disturbance in the Delta

Karley Rodriguez, Carina Bilodeau, Emily Applequist, Megan Keever

Stillwater Sciences, Berkeley, CA

karley@stillwatersci.com, cbilodeau@stillwatersci.com, eapplequist@stillwatersci.com, megan@stillwatersci.com

Centromadia parryi subsp. *parryi* (pappose tarplant) is a special-status annual herb in the Asteraceae family that is endemic to California with a California Rare Plant Rank of 1B.2. It occurs in coastal salt marshes and alkaline grasslands, predominantly within the San Francisco Bay Delta, Sacramento Valley, and inner North Coast ranges. Botanical surveys prior to construction of the Arnold Slough Tidal Habitat Restoration Project documented over 6,000 individuals within 100 acres of high marsh alkali grassland. Prior to project implementation, over 4,800 seeds were salvaged then seeded across the site following construction. Seeded locations varied in elevation above existing tidal datums to assess potential impacts of the increased tidal range expected following restoration, disturbance level to assess impacts of construction, and seed preparation and sowing methodology to assess germination requirements. Two years of monitoring the existing population and seeded locations suggests that microtopography and water availability may be more important than relative elevation for this species, with higher germination documented in swales and vernally wet areas. Compared to the pre-construction census, areas seeded following construction disturbance increased five times that documented at reference populations during the same time period, suggesting that disturbance supports population growth for pappose tarplant. Finally, application of locally sourced mulch (i.e., shredded salt grass and pappose tarplant vegetative material) at the time of seeding did not appear to affect germination success. Overall, results indicate that with careful planning and a healthy dose of disturbance, re-seeding suitable habitat after restoration-related construction activities can result in population increases for pappose tarplant.

Keywords: Centromadia, special-status plant, restoration, tidal, disturbance, Delta, alkaline grassland

Poster Topic: Species and Communities - Sensitive Species

From Protocols to Population Estimate: How a Standardized Protocol and Multi-partner Database Led to More Efficient Tracking of an Endangered Species

Megan Elrod, Julian Wood, Leo Salas, Nadav Nur

Point Blue Conservation Science, Petaluma, CA

melrod@pointblue.org, jwood@pointblue.org, lsalas@pointblue.org, NNur@pointblue.org

The California Ridgway's Rail (*Rallus obsoletus obsoletus*) is a federally listed endangered species that depends on tidal salt marsh habitat in the San Francisco Estuary. With over a billion dollars spent on rail recovery efforts, it is critical that monitoring data from multiple institutions is used efficiently to assess rail response to management actions and track population recovery. Coordinating rail survey efforts began in 2005 and culminated in 2017 with a site-specific protocol developed and implemented by USFWS, Point Blue Conservation Science, CDFW, and the Coastal Conservancy's Invasive Spartina Project. Data were entered into a centralized database hosted by the Avian Knowledge Network. The standardized protocol and shared database reduced previous issues found when compiling and analyzing data aggregated from different sources. Using this multi-partner dataset, we estimated the rail's rangewide population size by applying a statistically robust modeling approach. This modeling effort was similar to the previous estimate conducted in 2012, and included accounting for imperfect detection, estimating point-densities of detected and undetected individuals, and a landscape model incorporating 13 key predictor variables fitted into a boosted regression tree model characterizing the tidal marsh habitat. Rail densities in 2020 were only slightly higher than 2019 and 2021 therefore the three years were averaged to produce a single population estimate. We will continue to leverage this rich dataset with our partnership, to investigate rail response to landscape change and management actions and to track the population's progress toward recovery.

Keywords: endangered species, restoration, tidal marsh, Ridgway's Rail, wildlife, partnership, monitoring

Poster Topic: Species and Communities - Sensitive Species

California Freshwater Shrimp (*Syncaris pacifica*) Distribution in Lagunitas Creek Watershed, Marin County

Jonathan Koehler

Marin Water, Corte Madera, CA

jkoehler@marinwater.org

The California freshwater shrimp (*Syncaris pacifica*) is a state- and federally listed endangered species occurring only in a handful of streams in Marin, Sonoma, and Napa Counties. In fall 2023, Marin Water conducted presence/absence surveys for this species throughout the Lagunitas Creek watershed in Marin County. A combination of wading and kayaking was used to access stream segments with potential freshwater shrimp habitat in mainstem Lagunitas Creek from Kent Lake (Peters Dam) to the tidal estuary of Tomales Bay. Surveys were also conducted in several tributary streams, including San Geronimo Creek, Devil's Gulch, Cheda Creek, McIsaac Creek, and Nicasio Creek. A total of 163 habitat units encompassing 12.6 stream kilometers was sampled. Sampling was conducted via dipnet focusing on habitats with slow-moving water, undercut banks, overhanging riparian vegetation, and emergent and aquatic vegetation. This study was intended to determine the current distribution of freshwater shrimp within the watershed, specifically the upstream and downstream limits in mainstem Lagunitas Creek, and relative abundance (not present, low abundance, high abundance).
California freshwater shrimp were found in relatively high abundances throughout most of mainstem Lagunitas Creek. Multiple life-stages were present, including ovigerous (egg-bearing) and non-ovigerous females, juveniles, and young-of-year. The upstream-most occurrence of freshwater shrimp in Lagunitas Creek was approximately 0.8 km downstream of Peters Dam; the downstream-most occurrence was at the Highway 1 bridge in Pt. Reyes Station. Moderate abundances of freshwater shrimp were found in Nicasio Creek with the upstream-most observation approximately 0.7 km downstream of Seeger Dam on Nicasio Reservoir. California freshwater shrimp were not found in San Geronimo Creek, Devil's Gulch, Cheda Creek, and McIsaac Creek. Marin Water plans to repeat presence/absence surveys for freshwater shrimp on a recurring basis in the future to monitor species distribution and relative abundance within the Lagunitas Creek watershed.

Keywords: shrimp, syncaris, pacifica, lagunitas, marin, invertebrate, endangered

Poster Topic: Species and Communities - Sensitive Species

Above Average Rainfall During Spring 2023 Led to a Rare Diatom Bloom in San Pablo Bay

Ella Jones*, Morgan Illman, Alexander Parker

CSU Maritime Academy, Vallejo, CA

Ejones79@csum.edu, MIllman63@csum.edu, aparker@csum.edu

The northern San Francisco Estuary is characterized by low phytoplankton biomass and rare spring bloom events. The lack of phytoplankton is the result of benthic grazing while infrequent water column stratification, combined with strong tidal mixing and high turbidity, result in poor conditions for phytoplankton growth. It is speculated that low productivity conditions have negatively impacted the pelagic food web. The San Pablo Bay, which connects Central Bay with Suisun Bay, is poorly studied relative to these other embayments. During spring 2023, students at the California State University Maritime Academy characterized physical, chemical, and biological conditions in San Pablo Bay weekly between late February and mid-April using the *R/V Questuary*. During this time, northern California experienced above average precipitation from a large number of atmospheric rivers. This set up conditions favorable for salinity stratification. The team occupied five stations along the main axis of the ship channel and collected profiles of temperature, salinity, and submarine light, as well as characterizing Secchi depth, suspended sediments, and chlorophyll-a near the surface. At selected stations, phytoplankton tows were also performed. During the early spring the water column appeared well-mixed and light penetration depths and Secchi depth were relatively shallow at an average of 0.37m. However, as rain events continued throughout the spring, a distinct halocline was observed throughout San Pablo Bay that led to water column stratification. Secchi depth and light penetration increased nearly threefold during this period and elevated chlorophyll-a (29 ug L^{-1}) was also observed at the eastern end of the transect, peaking in mid-March. A second, smaller chl-a peak followed in the beginning of April. Microscopy suggested that chain forming diatoms became abundant. These results demonstrate that under certain meteorological conditions, spring phytoplankton blooms may occur in San Pablo Bay that would provide food resources for the estuarine food web.

Keywords: San Pablo Bay, stratification, light attenuation, spring phytoplankton blooms

Poster Topic: Water Quality - General

A Decade of Regional Monitoring of Biological Condition in San Francisco Bay Area Streams

Aroon Melwani[1], Paul Randall[2], Bonnie de Berry[2]

[1]Applied Marine Sciences, Inc., Santa Cruz, CA
[2]EOA, Inc., Oakland, CA

amelwani@amarine.com, prandall@eoainc.com, bdeberry@eoainc.com

During 2012 through 2022, a coordinated regional monitoring effort among six San Francisco Bay Area municipal stormwater programs (Alameda County Clean Water Program, Contra Costa County Clean Water Program, Fairfield-Suisun Urban Runoff Management Program, San Mateo County Clean Water Program, Santa Clara Valley Urban Runoff Pollution Prevention Program, and Solano County Resource Conservation District) was conducted to evaluate the biological condition of wadeable streams in the region. Stream bioassessment monitoring was conducted during the spring index period each year using standardized sampling protocols, and biological conditions were assessed using three primary indicators: benthic macroinvertebrates (BMI), benthic algae (diatoms and soft algae), and physical habitat. Over the decade of bioassessment monitoring, 654 randomly selected sites were sampled, representing creeks and channels in both urban (86% of sites) and non-urban (14% of sites) areas. An additional 70 sites were selected on a targeted basis. The majority of sites were found to not currently support healthy biological condition based on BMI and algae index scores. Overall, two-thirds of the sites exhibited California Stream Condition Index (CSCI) scores in the Very Likely Altered condition class, while less than 10% of sites were in the Likely Intact condition class. The extent of poor biological conditions in Bay Area streams was strongly associated with physical habitat and landscape stressors, including impervious area and channel modification. As a result, non-urban sites tended to be associated with the best biological conditions in the region. The regional bioassessment dataset generated through this collaborative monitoring effort has aided stormwater managers in understanding the current status of biological condition of Bay Area streams, in order to prioritize future management actions.

Keywords: water quality, bioassessment, habitat, stressors, biological condition, aquatic, watershed, monitoring

Poster Topic: Water Quality - General

Light Limitation or Low-light Adapted: Phytoplankton Productivity Quantified Using Stable Isotopes Along Floodplain-Estuary Transect

Reed Hoshovsky*[1], Frances Wilkerson[1], Mackenzie Miner[2]

[1] Estuary & Ocean Science Center, San Francisco State University, Tiburon, CA
[2]Department of Water Resources, West Sacramento, CA

rhoshovsky@sfsu.edu, fwilkers@sfsu.edu, Mackenzie.Miner@water.ca.gov

A stable isotope of carbon (^{13}C), when incorporated into bicarbonate, can be a powerful analytical tool to trace and quantify the uptake of inorganic carbon by phytoplankton. The fixation of bicarbonate occurs during photosynthesis and can be used as a proxy to determine phytoplankton productivity in aquatic systems. Phytoplankton productivity in the northern San Francisco Estuary (nSFE) is characteristically low, even among other comparable estuaries. Light limitation, a result of high turbidity, is a driving theory to explain low productivity. Counterintuitively however, as water clarity in the nSFE increases, an expected rise in phytoplankton productivity has not been observed. A similar counterintuitive observation occurs when comparing the turbid Yolo Bypass floodplain (YB) where productivity is high and the relatively clear Sacramento River where productivity is low. A parallel theory to light-limitation is that phytoplankton in these systems are chronically low-light adapted, hindering productivity when conditions are ephemerally optimal. We present over 70 'productivity versus irradiance' curves along a transect of the YB (5 stations) and nSFE (4 stations) downstream from West Sacramento to Grizzly Bay between March and November of 2023. The initial slope of these curves indicates the efficiency at which phytoplankton utilize light and the saturation point indicates the photosynthetic capacity of phytoplankton. Initial results show a downstream trend of increasing efficiency in light utilization by phytoplankton, with a variable downstream trend in photosynthetic capacity. This suggests that a physiological change is occurring in phytoplankton as they are advected downstream. Further processing and analysis of this data may illuminate where along this transect this physiological change is occurring and what factors may be the cause. These results can lead water managers to a more thorough understanding of hydrologic factors controlling the base of the food web.

Keywords: phytoplankton, productivity, light, carbon, isotope, floodplain, estuary, physiology, chlorophyll, nutrients

Poster Topic: Water Quality - General

Monitoring and Mapping Mercury Pollution Associated with Atmospheric Rivers in South San Francisco Bay

Niky Taylor[1], Kristin Byrd[1], Mark Marvin-DiPasquale[2], Jennifer Agee[2], Jacob Fleck[3], Brian Bergamaschi[3], Emily Richardson[3], Chak Wa Cheang[1]

[1]USGS Western Geographic Science Center, Moffett Field, CA
[2]USGS Water Resources Mission Area, Moffett Field, CA
[3]USGS California Water Science Center, Sacramento, CA

ntaylor@usgs.gov, kbyrd@usgs.gov, mmarvin@usgs.gov, jlagee@usgs.gov, jafleck@usgs.gov, bbergama@usgs.gov, erichardson@usgs.gov, ccheang@contractor.usgs.gov

Mercury is a neurotoxin which has polluted the San Francisco Bay since the Gold-rush era. Historical mining and modern-day sources of Mercury pollution pose risks to wildlife and human health, and extreme precipitation events—like atmospheric rivers—can lead to increased transport of mercury through watersheds. Between fall 2022 and spring 2023, northern California was hit by a sequence of severe atmospheric rivers, triggering several runoff events which impacted water quality and washed an unknown amount of Mercury into the estuary system. Our goal is to map and quantify this influx over the series of atmospheric river events. Previous studies have mapped mercury in water bodies by taking advantage of the biogeochemical relationships between mercury and water quality variables visible with remote sensing. These relationships include 1) Colored Dissolved Organic Matter (CDOM) and dissolved mercury and methylmercury, and 2) Total Suspended Sediments (TSS) and particulate mercury and methylmercury. Preliminary results from an in-water dataset suggest that these relationships are applicable in South San Francisco Bay. To estimate mercury pollution associated with the recent atmospheric rivers, we created a Sentinel-2 satellite image time series of TSS over the course of the atmospheric river events from October 2022 through April 2023 (7 cloud-free images). The time series revealed large increases in TSS in January and March 2023 at creek outflows following periods of intense rainfall. An especially large event followed a series of 6 atmospheric rivers and 16 inches of rain (measured at Oakland South by CA Department of Water Resources) in late December to early January. These shifts in water quality suggest similar changes in mercury flux into the bay, but the exact nature of that flux is uncertain. Future research aims to develop a mercury mapping approach for San Francisco Bay and provide water quality context to managers and restoration groups.

Keywords: Mercury, Methylmercury, remote sensing, water quality, atmospheric rivers

Poster Topic: Water Quality – General

Managing Cyanobacterial Blooms in the Sacramento-San Joaquin Delta System: Understanding Microbial Diversity, Environmental Triggers, and Toxicity

Andreja Kust[1,2], Keith Bouma-Gregson[3], Ted Flynn[4], Vivian Klotz[4], Judy Westrick[5], Nicholas Peraino[5,] Spencer Diamond[1,2], Jillian F. Banfield[1,2,6,7]

[1]Department of Earth and Planetary Science, University of California, Berkeley, Berkeley, CA, USA.
[2]Innovative Genomics Institute, University of California, Berkeley, CA, USA.
[3]U.S. Geological Survey, California Water Science Center, Sacramento, CA, USA.
[4]Division of Integrated Science & Engineering, California Department of Water Resources, West Sacramento, CA, USA.
[5]Lumigen Instrument Center, Department of Chemistry, Wayne University, Detroit, MI, USA
[6]Department of Environmental Science, Policy and Management, University of California, Berkeley, CA, USA.
[7]Monash University, Melbourne, Victoria, Australia.

andreja.kust@berkeley.edu, kbouma-gregson@usgs.gov, Theodore.Flynn@water.ca.gov, Vivian.Klotz@water.ca.gov, judy.westrick@wayne.edu, nperaino@chem.wayne.edu, sdiamond@berkeley.edu, jbanfield@berkeley.edu

The Sacramento-San Joaquin Delta has experienced an increase in the diversity of cyanobacterial blooms, some of which can be harmful to both the environment and public health. Over an eight-month study in a year with high rainfall, we employed comprehensive DNA analyses (including both targeted and whole-genome metagenomics), tests for cyanotoxins, and thorough water quality assessments. Our aim was to unravel the factors that initiate cyanobacterial blooms, influence their microbial composition and toxicity, and lead to their eventual decline.

Our research uncovered that both types of cyanobacteria—those that can and cannot fix nitrogen from the air—were present and could produce a variety of toxins, not just the commonly known microcystins. Interestingly, we found toxins in the water as early as April, despite low numbers of cyanobacteria at that time.

This study highlights the complex nature of cyanobacterial blooms in the Delta and underscores the importance of considering a higher diversity of cyanobacteria in water management strategies. Our findings suggest that current water management practices may need to be adapted to better address the variety and toxicity of cyanobacterial blooms for the safety of our communities and ecosystems.

Keywords: Cyanobacteria, Biodiversity, Cyanotoxins

Poster Topic: Water Quality – General

Origin and Development of the 2022 *Heterosigma* Bloom from Observations and Modeling

Richard Dugdale[1], Alex Parker[2], Frances Wilkerson[1]

[1]Estuary & Ocean Science Center, San Francisco State University, Tiburon, CA
[2]CSU Maritime Academy, Vallejo, CA

rdugdale@sfsu.edu, aparker@csum.edu, fwilkers@sfsu.edu

We examined our 30 year-long data set for the EOS seawall in Central San Francisco Bay for clues on the origin and development of the August 2022 *Heterosigma* bloom in the lower San Francisco Estuary. The sequence of concentrations of ammonium, nitrate, and high chlorophyll was exactly as we have described for the Bay/Delta ecosystem: Phase 1 - ammonium declines to concentrations allowing nitrate uptake by phytoplankton to begin, at about 1 µM; Phase 2 - rapid uptake of nitrate begins; Phase 3 - with both ammonium and nitrate uptake in progress, rapid increases in chlorophyll occur, i.e. a bloom. The Bay appeared to behave as previously seen in numerous enclosure experiments made with water from various locations and examination of other Bay data sets. The surprising conclusion was that the Bay was acting as a single water mass and nutrient phytoplankton system. The next step was to apply the NAMFLO Model to simulate the bloom. The model includes uptake kinetics for both nitrate and ammonium uptake by phytoplankton and most critically a term for the well-known repression of nitrate uptake by ammonium. The model was initiated with seawall data for August 5, 2022 and run to Aug 30. The goal for the model was to simulate ammonium, nitrate and chlorophyll. Modeled ammonium, nitrate and phytoplankton biomass plots gave satisfactory fits to the seawall data, suggesting that the bloom as observed at the seawall developed within a cohesive parcel of water.

Keywords: nutrients, phytoplankton, HABs, modeling

Poster Topic: Water Quality - Nutrients

Assessing Nutrient and Phytoplankton Effects of a Major Change in Wastewater Discharge to the San Francisco Estuary

Frances Wilkerson[1], Pat Glibert[2], Sarah Blaser[1], Stephen Randall[1], Benjamin Gustafson[1], Richard Dugdale[1], Alex Parker[3]

[1]Estuary & Ocean Science Center, San Francisco State University, Tiburon, CA
[2]University of Maryland, Cambridge, MD
[3]CSU Maritime Academy, Vallejo, CA

fwilkers@sfsu.edu, glibert@umces.edu, sblaser@sfsu.edu, srandall1@mail.sfsu.edu, bgustaf@sfsu.edu, rdugdale@sfsu.edu, aparker@csum.edu

A major source of nutrients to the San Francisco Estuary (SFE) are wastewater treatment plants. Feeding the northern SFE is the Sacramento County Regional wastewater treatment plant (Regional San) located in the upper Sacramento River. In 2021, Regional San upgraded its treatment ("EchoWater project") to include biological nutrient removal (nitrification and denitrification) that reduced their nitrogen discharge by > 65% and shifted the dominant form of effluent nitrogen from ammonium to nitrate. This decrease in ammonium and total inorganic nitrogen is likely to reduce nitrification rates and change phytoplankton productivity rates in the river downstream. This poster examines the changes in nutrients, phytoplankton biomass and productivity rates since 2021, up to 2024. A series of 17-18 stations were sampled at the end of March and September by the same research team from above Regional San in the Sacramento River along a downstream transect through Suisun Bay to Carquinez Bridge. Pre-upgrade sampling occurred in a variety of "water year" conditions, from below normal (2012, 2016), dry (2013) to drought conditions in 2014 and 2015. Post-upgrade sampled in critical drought years 2021 and 2022 and wet 2023. Besides reductions in ammonium as expected, nitrate also decreased, and water clarity improved. How these changes influenced phytoplankton and the likelihood of blooms with consequences for the pelagic food web will be presented. The poster addresses water quality goals of the Estuary Blueprint and informs management actions that alter nutrient sources or aim to re-establish historic food web processes.

Keywords: nutrients, phytoplankton, wastewater, productivity

Poster Topic: Water Quality - Nutrients

Multi-omic and Biogeochemical Insights into the Dynamics and Activity Ammonia-oxidizing Archaea Blooms in South San Francisco Bay

Anna Rasmussen, Christopher Francis

Stanford University, Stanford, CA

arasmuss@stanford.edu, caf@stanford.edu

South Bay is the largest subembayment in San Francisco Bay (SFB) and receives large inputs of ammonia from wastewater treatment plants leading to high ambient concentrations of ammonia in the water column. Though harmful algae blooms are surprisingly rare in this region, other microbial blooms can be supported by the high concentrations of ammonia. We have observed massive ammonia-oxidizing archaea (AOA) blooms in the South Bay through general microbial surveys. AOA are some of the most abundant microorganisms on Earth and carry out the first step of nitrification, thus playing a critical role in the nitrogen cycle by oxidizing ammonia to nitrite. Transient or recurring blooms of AOA have been reported in a handful of estuarine and coastal environments, often leading to nitrite accumulation in waters. Our research has revealed that these AOA blooms are regular features of South Bay over the last decade, leading to accumulation of nitrite in the oxygenated water column over kilometers of the South Bay channel and for weeks to months during the autumn. We have examined the dynamics and activity of microbial populations over the course of an AOA bloom in South SFB by measuring nitrification rates, quantifying AOA abundance, and analyzing metagenomic and metatranscriptomic data. Nitrification rates were correlated with AOA abundance, and both increased several orders of magnitude between bloom (autumn) and non-bloom seasons. From bloom samples, we recovered an extremely abundant, high-quality *Ca. Nitrosomarinus catalina*-like AOA metagenome-assembled genome (MAG) that dominated gene transcription during the bloom. Our research confirms AOA are not only abundant, but also active during blooms thus influencing nitrogen cycling and water quality in SFB.

Keywords: estuary, nitrification, ammonia-oxidizing archaea, blooms, nitrite, metagenomics, biogeochemistry

Poster Topic: Water Quality - Nutrients

Carbon and Nitrogen Uptake of a Rare *Heterosigma akashiwo* Bloom in San Francisco Bay

Matthew Rothschild*[1], Reed Hoshovsky[2], Frances Wilkerson[2], Richard Dugdale[2], Alexander Parker[1]

[1]California State University Maritime Academy, Vallejo, CA
[2]San Francisco State University, Tiburon, CA

mrothschild29@csum.edu, rhoshovsky@sfsu.edu, fwilkers@sfsu.edu, rdugdale@sfsu.edu, aparker@csum.edu

Heterosigma akashiwo is a mixotrophic red-tide species known for producing episodic toxic blooms in high nutrient surface coastal waters. Last observed in the San Francisco Bay in 2002, a large bloom of *H. akashiwo* was detected in Central San Francisco Bay during summer 2022 and a smaller bloom was observed in the in summer 2023. The 2022 bloom persisted from July through early October and grew in algal density and geographic extent, moving down into South San Francisco Bay as well as north into the mesohaline San Pablo Bay. During late August reports of fish kills began and CA public health officials recommended that people and pets avoid prolonged exposure to the Bay's waters. While the underlying mechanism that gave rise to the bloom have yet to be determined, it is hypothesized that the persistence and geographic expansion of the bloom was driven in part to high inorganic nutrient concentrations supplied via municipal wastewater treatment facilities. *H. akashiwo* has been shown to grow well on ammonium-N, nitrate-N and urea-N but shows better assimilative capacity for ammonium. As part of a multi-collaborator project to characterize the bloom, we measured dissolved inorganic nutrients and rates of primary production (carbon uptake) and nitrogen uptake within the location of the *Heterosigma* bloom from late August through the end of the bloom in mid-October 2022. Dual-labeled stable isotopic tracer techniques were employed to measure light saturated daily uptake of carbon, nitrate, and ammonium. These results will be useful in developing nutrient management policy to confront this emerging challenge to water quality in the Bay.

Keywords: Heterosigma, nitrogen, Central Bay, primary production, harmful algal bloom

Poster Topic: Water Quality - Nutrients

High Frequency Water Quality Monitoring and Synthesis in South San Francisco Bay

Ariella Chelsky, Martin Volaric, Lilia Mourier, Daniel Killam, David Senn

San Francisco Estuary Institute, Richmond, CA

ariellac@sfei.org, martinv@sfei.org, liliam@sfei.org, dank@sfei.org, davids@sfei.org

San Francisco Bay (SFB) receives some of the highest nitrogen loads among estuaries worldwide, yet historically has not experienced water quality problems typical of eutrophic systems. However, the unprecedented harmful algal bloom that occurred in August 2022 indicates that the resilience of the system may be declining. This event highlights the need for monitoring of SFB to track changing conditions and to better understand the impacts of nutrients on the system.
The Nutrient Management Strategy at the San Francisco Estuary Institute (SFEI), has been collecting water quality data throughout SFB for over 10 years (2013-present). This monitoring program includes a network of high frequency moored sensors at sites spanning Central through Lower South San Francisco Bay. The array measures a suite of environmental variables (e.g. chlorophyll-a, nitrate and water velocity) at 15-minute intervals.
The data collected from this sensor network are being used for several synthesis efforts led by SFEI, including projects focused on fluxes out of managed salt ponds into the sloughs of Lower South Bay, as well as nutrient balances in South Bay, and examinations of the causes and impacts of the 2022 HAB event. The data are also being used for model development, and to inform managers on how to mitigate nutrient inputs to the Estuary. This poster will summarize our monitoring efforts to date and highlight some of the synthesis work that has stemmed from this long-term high frequency dataset.

Keywords: water quality, HABs, dissolved oxygen, nitrogen, wastewater, high frequency data

Poster Topic: Water Quality - Nutrients