Accelerated Growth of Juvenile Salmon in a Managed Pond Relative to Historic and Leveed Sloughs in Suisun Marsh

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Changes to Suisun Marsh, in the San Francisco Estuary, have led to the decline of many native fishes. Levees, duck clubs, and development have confined channel networks and reduced tidal marsh habitat valuable to juvenile fishes. To understand how this altered ecosystem supports native fish, juvenile Chinook salmon (*Oncorhynchus tshawytscha*) were reared in cages for seven weeks in three discrete habitat types: a slough surrounded by historic marsh, a leveed slough adjacent to managed wetlands, and in a duck club pond. Zooplankton, macroinvertebrate, and water quality samples were collected throughout the study period, while fish were measured and weighed every two weeks. Growth rates across time differed significantly between the slough sites and the duck club. Both slough sites saw low or negative growth rates (-0.4 – 1.0 mg/day), whereas fish reared in the duck club pond displayed positive growth (7.7 mg/day). Fish in the leveed slough showed increased growth during adjacent managed wetland draining cycles, but low growth when draining was discontinued. Fish in the historic marsh site displayed low or negative growth throughout the project, likely due to a lack of food resources. The duck club had the greatest abundance of food and provided more consistent and cooler temperatures over the course of the study, which may have offset low dissolved oxygen levels. Additionally, water in the pond was less turbid in comparison to slough sites, which may have enhanced visual foraging success of the salmon. Overall, food accessibility and cooler, stable temperatures allowed fish in the duck club to grow significantly faster than their slough counterparts, highlighting the potential of managed ponds and wetlands as valuable rearing habitats and productive food export systems for juvenile native fishes.

Student Award Competition: Yes

Keywords: salmon, native fishes, managed wetlands, habitat, cages, experimental ecology

Poster Topic Habitat Restoration - Species and Communities

An Assessment of Process-Based Concepts for Channel-Floodplain Reconnection in the Sacramento-San Joaquin Delta

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Historically, native salmonids and other fish spawned and reared in the freshwater marshes that filled the Sacramento-San Joaquin Delta and the floodplains of the channels entering the Delta. Over the past 200 years, widespread diking for land reclamation and flood control has resulted in considerable channel-floodplain disconnection and a dramatic decrease in rearing habitat, in addition to other impacts to native wildlife that historically used the Delta floodplains. This project focuses on using outputs from several recent Delta ecosystem science efforts to identify process-based restoration concepts for reconnecting Delta channels to adjacent floodplains. The project operates at two scales: 1) Delta-wide, encompassing the fluvial, fluvial-tidal, and tidal zones; and 2) local scale, focusing on areas along a corridor through the Delta containing public lands (the Central Delta Corridor) that spans all three zones. During an initial Delta-wide analysis, channel-floodplain reconnection concepts that are appropriate for each zone will be identified. Next, zone-appropriate channel-floodplain reconnection concepts for potential restoration areas along the Central Delta Corridor will be identified, focusing on habitat needs for native salmonids. This presentation will provide an overview of the change in channel-floodplain connectivity throughout the Delta, the extent of the three Delta zones, and a preliminary description of process-based restoration concepts aimed at channel-floodplain reconnection that are appropriate for each Delta zone.

Keywords: Delta restoration, channel-floodplain reconnection, salmonid habitat, multi-benefit management

Poster Topic Habitat Restoration - Species and Communities

South Bay Salt Pond Restoration Project Phase 2: Balancing Habitat Restoration with Public Access and Flood Risk Management in Construction Designs

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Phase 2 of the South Bay Salt Pond Restoration Project proposes to restore approximately 2,200 acres of former salt production ponds into tidal marsh habitat and managed ponds at the Don Edwards San Francisco Bay National Wildlife Refuge (Refuge). The project's goals are to restore and enhance wetland habitats, provide public access and recreation, and maintain existing flood risk management in the South San Francisco Bay. The Phase 2 construction design incorporates these guiding goals and lessons learned from previous phases' construction and ongoing research conducted by the Refuge. Phase 2 proposes to gradually restore and enhance ponds and tidal wetlands with the construction of levee modifications, habitat islands, upland transition zones, ditch blocks, and water control structures. Use of upland transition zones and beneficial re-use of upland fill to create them are new features for the Refuge that was not used in the Phase 1 actions.

At select locations levees would be breached, enhanced, lowered or removed. These activities involve raising, widening, compacting, and otherwise improving existing levees wherever necessary, as well as increasing habitat connectivity and native plant composition. Within specific ponds, habitat islands or upland transition zones would be constructed from imported fill and existing levees to increase the quality, complexity, and availability of bird habitat in the Refuge. At four locations within the Ravenswood Ponds, water control structures would be installed to better manage water levels and water quality in the ponds. Ditch blocks would be placed within existing borrow ditches to enhance natural channel development. The Phase 2 plans also incorporate public access features that balance public engagement with wildlife sensitivities.

All of these project features resulted from a compilation of knowledge from engineers, environmental scientists, stakeholders, biologists, the public, and the ongoing research conducted by the Refuge and its partners.

Keywords: habitat restoration, south bay salt pond, tidal, wetlands, marsh, wildlife

Poster Topic Habitat Restoration - Species and Communities

Avian Response to Restoration of North Bay Salt Ponds: Managed vs. Breached Ponds

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San Francisco Bay (SFB) is important habitat for migrating and wintering waterbirds, and much as 15% of SFB wintering waterfowl are found in North Bay salt ponds. The Napa-Sonoma Marshes Wildlife Area and surrounding areas comprise over 5100 ha of wildlife habitat, and thus are the focus of intense multi-agency efforts to achieve restoration and wildlife management goals. Since tidal flow has been restored to 61% of the pond area, the challenge central to the restoration is to balance needs of marsh species with needs of migratory waterbird populations as breached ponds transition to tidal marsh. We examined the waterbird response to restoration efforts and compared use of managed ponds to breached ponds. We collected water quality data and conducted spatially-explicit high tide (HT), counts of all waterbirds in 14 ponds monthly from Dec 2002 – May 2017. Across all ponds, waterbird abundance has increased since surveys began. Dabbling ducks were most abundant in the fall on larger, lower salinity ponds, but there was no difference between managed and breached ponds. Diving ducks were associated with larger, lower salinity managed ponds, and were most abundant in winter. Small and medium shorebirds were both most abundant on lower salinity managed ponds in the fall. In summary, restoration efforts appear to have been successful at providing HT habitat for increased abundances of waterbirds. In particular, managed ponds are important HT habitat for diving ducks and shorebirds. However, as breached areas transition to tidal marsh, loss of shallow roosting and foraging habitats may result in increased pressure on managed pond habitat resources, and present challenges for managers attempting to maintain migratory waterbird populations. Examination of waterbird abundances and behavior in breached and managed ponds at low tide would help managers better understand the importance of these varied habitats throughout the tidal cycle.

Keywords: salt ponds, north bay, waterfowl, shorebirds

Poster Topic Habitat Restoration - Species and Communities

High- and Low-Tide Waterbird Use of the Cullinan Ranch Restoration Area

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Cullinan Ranch, a former tidal wetland in Napa-Sonoma Marsh, was diked in the 1880's for farming. In 2015, tidal flow was restored to 1200-acres of this site. Given that this site has subsided nearly two-meters below mean sea level, sedimentation and transition to tidal marsh are expected to take up to 60-years; however, the reintroduction of tidal flow created potentially valuable interim open-water habitat for waterbirds. To assess response to initial restoration efforts at Cullinan ranch, we conducted post breach high and low tide waterbird surveys in fall 2017, and winter and spring 2016 – 2017. We observed a total of 30,690 birds from 50 species in year 1, and 25,103 birds from 43 species in year 2. Dabbling ducks (20,000 total), and diving ducks (27,517 total), were the most abundant guilds across both years. We used multifactorial ANOVA to compare abundance of foraging or roosting dabblers, divers, and all birds, among study years, seasons (winter, spring), and tides. There were significantly more foraging birds in year 1 ($p < 0.05$), and more birds were roosting during winter ($p = 0.05$). We found significantly more foraging ($p < 0.01$), and roosting ($p < 0.01$), dabbling ducks in year 1. Foraging diving ducks were also significantly more abundant in year 1 ($p < 0.05$), and roosted more in winter than in spring ($p < 0.05$). We found no differences in abundance between high and low tide, potentially because water level, and therefore habitat availability, changed very little across the tidal cycle. Our results suggest that waterbirds, particularly dabbling and diving ducks, are responding to foraging and roosting habitat created by initial restoration of tidal flow to Cullinan Ranch. Continued efforts to understand habitat evolution and waterbird use of this site can inform adaptive management practices aimed at optimizing wetland habitat quality.

Keywords: salt ponds, north bay, waterfowl, shorebirds, tidal restoration

Poster Topic Habitat Restoration - Species and Communities

Managing Expectations - An Assessment of Land Use and Ecological Restoration in the Sacramento - San Joaquin Delta

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Decades of efforts aimed at improving aquatic and terrestrial ecosystems of the Sacramento - San Joaquin Delta and Suisun Marsh have failed to address declining species populations. Environmental planning and implementation actions undertaken to meet different policy objectives or legal requirements can create confusion over the meaning of ecological restoration and what outcomes should be expected. To provide clarity we evaluated land use and environmental projects within the region. We analyzed trends in urban, natural, and agricultural lands using development plans and Farmland Mapping and Monitoring Program data (1990-2014). We also reviewed the purpose and landcover characteristics of restoration projects (N=131) in the EcoAtlas database. Agriculture persisted as the dominant land use within the region, occupying 73.2% (555,800 acres) of the landscape in 2014, and declined 9.5% over the study period. Urban land use occupies 10.7% (81,200 acres) and increased 49.4%. Natural lands occupy 15.5% (117,900 acres) and have increased 21.4% over the study period. Importantly, using FMMP categories, natural lands are areas not in agricultural production, which generally exist in the linear margins of agricultural fields, on levees or leveed channel margins, or on instream islands. Environmental projects were largely focused (48%) on directly offsetting impacts through ESA/CESA or addressing them through ecological infrastructure (24%). Ecosystem services (e.g. carbon capture) accounted for 3%. Only 12% of were ecological restoration projects, with only 6 riparian or wetland projects with connectivity to riverine or tidal waterways. We posit that the efficacy of ecological restoration within the region is largely untested, given the past focus on maintaining baseline conditions. We suggest that policy and planning efforts aimed at recovery of ecosystem function and species populations leverage the rich systems-based science currently available and consider a robust concept of sustainable ecological restoration, implemented at biologically relevant scales.

Keywords: Restoration, agriculture, mitigation, planning, policy

Poster Topic Habitat Restoration - Species and Communities

Scaling Up Native Species Propagation Methods to Accommodate Large Transition Zone/Ecotone Projects of the Future

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Around the San Francisco Bay, project sites totaling approximately 35,000 acres of tidal marsh are currently awaiting restoration, many of which include large transition zone/ecotone habitats, a habitat type fundamental in protecting against sea level rise, providing wildlife refugia, and increasing biodiversity. Pilot projects to test methods for restoring baylands processes are a high priority, particularly to identify the most effective techniques to restore significant acreage in the face of sea level rise. The Oro Loma Horizontal Levee Demonstration Project constructed an ecotone slope at the Oro Loma Sanitary District facilities in San Lorenzo, CA. The ecotone slope was designed to serve as a buffer to impending sea level rise, test nutrient removal from wastewater discharge, and restore upland habitat.

The native plant propagation methods for the project were designed to "scale-up" and to reduce the cost of growing large numbers of plants in a traditional nursery setting. The entirety of the propagation cycle, including seed collection, was compressed from a typical 2-3 year timeline to one year. Over 70,000 locally-sourced plants were grown to vegetate the ecotone slope, utilizing various methods. The majority of plants were propagated vegetatively and rhizomatously at a division bed nursery constructed on the Sanitary District property within close proximity to the project site. Within the abbreviated timeline, the species chosen for the project thrived in the division bed nursery environment, were able to withstand the planting and harvesting process, and have successfully established on the newly graded slope.

The project established a low-cost, low-labor method for large-scale plant propagation and can inform propagation methods for future large-scale ecotone/transition zone restoration projects. The resilience and vigorous growth of the chosen species demonstrates the possibility of bulk propagation using small-scale farming methods to grow and transplant propagules for transition zone projects at a greater scale.

Keywords: Habitat restoration, Transition zone, Ecotone, Propagation, Tidal marsh

Poster Topic Habitat Restoration - Species and Communities

Funding Science & Restoration in SF Estuary Ecosystems: An Overview of New CDFW Grant Programs

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

The Wetlands Restoration for Greenhouse Gas Reduction Program was developed in 2014 to support projects that restore or enhance natural ecosystems in order to reduce greenhouse gas emissions and provide ecological co-benefits. This program is funded through the Air Resources Board's Cap-and-Trade Program as part of its overall greenhouse gas reduction strategy.

Two grant programs were developed in response to the Water Quality, Supply, and Infrastructure Improvement Act of 2014 (Proposition 1): the Watershed Restoration Grant Program and Delta Water Quality and Ecosystem Restoration Grant Program. Proposition 1 provides funding to implement the three objectives of the California Water Action Plan: more reliable water supplies, restoration of important species and habitat, and a more resilient and sustainably managed water resource system (e.g., water supply, water quality, flood protection, and environment).

These grant programs are contributing to implementation of the California Water Action Plan, State Wildlife Action Plan, California EcoRestore, federal recovery plans, and other relevant State and federal initiatives. As of July 2017, a total of $96.1 million was awarded to 81 projects statewide, 22 of which ($34.1 million) occur within the Estuary. These SF Estuary projects include scientific studies designed to address priority science needs consistent with the Delta Science Plan, and projects to acquire important habitats, or plan and implement habitat restoration actions. Key activities of the grant programs will include tracking implementation and communicating outcomes to inform future management decisions.

For more information please see: www.wildlife.ca.gov/Explore/Organization/WRGB

Keywords: Watershed, Delta, funding, grants, science, habitat, ecosystem, salmon, smelt, fish

Poster Topic Habitat Restoration - Species and Communities