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EVALUATING SCALES AND OSSIFIED STRUCTURES AS POTENTIAL AGE ESTIMATORS FOR SPLITTAIL

Historical investigations based on scale analysis indicated that splittail, Pogonichthys macrolepidotus, reach a maximum age of five years. However, we suspected that splittail may live longer because age estimates derived from scale analysis can show bias toward younger ages. We conducted studies in 1996 and 2001 to evaluate scales and five hard structures as potential age estimators for adult splittail.

For the 1996 study, splittail were collected from the Sacramento River, adjacent to the Sutter Bypass, by electrofishing. The 2001 study used splittail collected from Sherman Lake, Big Break, and Nurse Slough (lower delta, Suisun Marsh) by short-set gill netting. Scales, otoliths, opercula, dorsal spines, dorsal rays, and pectoral rays were extracted from each fish. Structures were sectioned following established techniques, and annuli were counted.

In the 1996 work, otoliths were not successfully processed – we could not find a plane that incorporated all growth – and scales consistently underestimated ages of older fish when compared to other structures. Also, dorsal spines, dorsal rays, and pectoral rays provided the most distinct annuli. For this reason and because they might be extracted from splittail non-lethally, we investigated inter-reader precision counting annuli from these three structures in a larger 2001 study. Dorsal spines were the most reliable structure for aging adult splittail as demonstrated by their higher precision (i.e., lower standard deviation) for reader annuli counts among the three structures compared. Also, dorsal spines suggested splittail live to at least age 7. However, there is still a need to validate age estimates from dorsal spines. Currently, we are performing a blind study to determine the accuracy of age estimates derived from the dorsal spines of lab-raised splittail. If annuli are set one per year and the overall pattern appears similar to that of wild fish, we will have good confidence in our age estimates.

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EFFECT OF PHOTOPERIOD AT EMERGENCE AND SUBSEQUENT GROWTH RATE ON SMOLTING PATTERN OF WINTER-RUN CHINOOK SALMON

An experiment was performed to determine the relative effects of photoperiod and growth rate on smolting pattern of winter-run Sacrameto River Chinook salmon. Surplus eyed eggs were obtained from the captive broodstock egg bank program at Bodega Marine Laboratory and transferred to experimental rearing facilities in Seattle. At emergence (November) fry were ponded under 3 different photoperiods (late June, mid-August, and late September) spanning the natural range of emergence timing in this population. Two tanks of fry were reared under each photoperiod, one at a relatively high feed level and the other at a lower feed level, resulting in six treatment groups: EarlyHiFeed, EarlyLoFeed, MidHiFeed, MidLoFeed, LateHiFeed, LateLoFeed. Fish were maintained on their respective, naturally changing photoperiods (adjusted to that seen at Sacramento 38oN) for 9 months. Size measurements and physiology samples were obtained at three week intervals (gill for Na/K ATPase, blood for plasma IGF-I levels). Seawater challenges (72 hours, 35 ppt) were also performed at three week intervals. Complete mortality was experienced during seawater challenges for the first few months of rearing, regardless of photoperiod or feeding rate; suggesting that these fish do not adopt a fry migrant smolting strategy. Subsequently, strong increases in seawater survival occurred during the spring increase in photoperiod (subjective March – April), demonstrating a photoperiod dependent change in smolt status, similar to a yearling chinook salmon smolting pattern. At this point fish from all treatment groups were greater than 75 mm in fork length. Patterns of gill Na/K ATPase activity paralleled patterns of seawater survival. Overall, photoperiod had a stronger influence on smolting pattern than either size or age.

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SCIENCE-BASED RESTORATION MONITORING OF COASTAL HABITATS: A FRAMEWORK FOR MONITORING PLANS

This Manual provides technical assistance in the development and implementation of sound scientific monitoring of coastal restoration efforts. It supports the maximization of societal, ecological, and environmental benefits of coastal habitats throughout the estuaries and freshwater coastal ecosystems of the US. It outlines the steps necessary in the development of a scientifically sound and fiscally responsible monitoring plan and provides tools to assist monitoring plan development and guide decision-making. It provides practitioners with a scientifically sound and statistically valid basis and framework through which monitoring plans can be developed. Volume I is a framework for the creation of a monitoring program, which explains where monitoring fits into the restoration process, how to create a monitoring plan, and important information that should be considered when monitoring specific habitats. Volume II contains detailed discussions of habitats, an inventory of coastal restoration monitoring programs (including those in the Great Lakes region), a review of monitoring techniques manuals and quality control/quality assurance documents, an overview of governmental acts associated with monitoring, a cost analysis of monitoring expenses, and a discussion of socioeconomic issues associated with coastal habitat restoration. The Manual provides readers with abundant references and contacts that can be pursued for further information on preparing a monitoring program. This Manual is for those involved in developing and implementing restoration monitoring plans, both scientists and non-scientists. The Estuary Restoration Act of 2000, was created to promote the restoration of habitats along the US coast. Even with the diversity of habitats that may need to be restored and the extreme geographic range across which these habitats occur, there are consistent principles and approaches that form a common basis for effective monitoring, regardless of the habitat. NOAA is tasked with developing guidance in developing and implementing monitoring plans for projects potentially occurring in any of these habitats.

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ASSESSING CLAMS AS GEOCHEMICAL SENTINELS OF ALGAE AND DISSOLVED OXYGEN IN THE SAN JOAQUIN RIVER

Particulate organic matter (POM) loads in the San Joaquin River (SJR) contribute to degraded water quality, including seasonally low dissolved oxygen (DO), abundant disinfection byproduct precursors, and taste and odor problems. To better understand and manage such impacts, it is important to identify POM sources and how they vary in time and space. Recent isotopic studies indicate that the dominant fraction of POM in the SJR is likely derived from algae. Therefore, a greater focus on the origin of algal material is needed.

We investigate the potential of using clams as natural monitors of algal growth and DO levels in the SJR. Corbicula fluminea (Asiatic clam) selectively feeds on suspended phytoplankton, making it a unique sentinel of the algal fraction of POM. Over its ~10 year lifespan, C. fluminea archives detailed information about its environment in shell growth increments, likely recording variations in its diet and relative bottom water DO.

We present data from an ongoing pilot study in which we are culturing C. fluminea in the laboratory under varied diet isotopic composition and DO concentration. We test two hypotheses: (1) the nitrogen and carbon isotopic compositions of organic matter preserved within the shell layers reflect the clam's diet; and (2) carbon isotopic values of the shell carbonate record ambient DO fluctuations as the clam adjusts metabolic and ventilation rates to counter hypoxic stress. If data support (1), then the clam's shell should provide a novel historical record of the source of nutrients present in the SJR during its life, because different nutrients that support algal growth in the SJR have distinct isotopic signatures. Calibrating the clam's geochemical response to these factors, and comparing the results with field specimens, will determine the future usefulness of employing clams to monitor algal growth and corresponding impacts on water quality in the SJR.

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IS MID-OCEAN EXCHANGE EFFECTIVE IN PREVENTING THE INVASIONS OF ESTUARIES BY ZOOPLANKTON FROM SHIPS' BALLAST TANKS?

The number of non-indigenous invasive species (NIS) in North American estuaries has dramatically increased over the last century. Ships' ballast water has been identified as one of the major vectors of transport of NIS between estuaries worldwide. Various ballast water management strategies have been suggested to reduce the likelihood of high-impact invasions such as the zebra mussel. Mid-ocean exchange of ballast is relatively inexpensive, and is the only management strategy currently being applied routinely to reduce the influx of NIS. Surveys of ballast water entering North American ports suggest that exchange does not remove all estuarine organisms. We conducted experiments aboard container ships to assess the efficacy of mid-ocean ballast exchange for the removal of estuarine zooplankton. Samples were collected from paired tanks at the beginning and end of eight voyages of container ships, in which one tank underwent an exchange and the other was left unexchanged (as a control). The tracer dye used in these studies showed that mid-ocean exchange removed 75-98 percent of the original ballast water. The removal rate of estuarine zooplankton was, on average, proportional to the removal of rhodamine dye. Exchange efficiency however, varied as a function of the population dynamics in the control tanks. These results could help us to understand how efficient mid-ocean exchange is and whether it is an acceptable means of eradicating potential invaders from ballast water.

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NATIVE AND NON-INDIGENOUS FISHES IN NATURAL AND RESTORING TIDAL MARSHES: RESULTS FROM BREACH II

We determined the distribution and abundance of native and non-indigenous fishes as part of the BREACH II project investigating ecosystem status and function in natural (reference) versus restoring wetlands in San Pablo and Suisun Bays. We sampled eight tidal marshes – Ryer restored, Ryer reference, Pond 2a, Napa centennial, Greenpoint reference, Carl's marsh, Greenpoint restoring and Petaluma ancient – approximately bi-monthly between April 2001 and February 2002. We deployed a fyke net (3.1-mm mesh) at the mouth of each channel during moderate spring tides, set during high tide and recovered at low tide. Thirty-seven fyke net sets yielded 11,788 specimens representing 25 taxa. The eight most abundant taxa were: Pacific herring, inland silverside, topsmelt, staghorn sculpin, yellowfin goby, rainwater killifish and three-spine stickleback. Seasonal abundances varied markedly, but were consistent with known life histories of the dominant taxa. Geographic variation in abundance was also observed, but was not significantly related to upstream/downstream location (except for a few individual taxa). Abundance of fishes was also not related to age of site (time since breach). However, native fishes appeared to be more abundant than introduced fishes at restored sites, but not reference sites (although this result was heavily weighted by the high abundance of one native species, Pacific herring). Ordination analysis revealed marked differences in community composition between the three regional clusters (Petaluma, Napa, and Suisun) and strong correlations with seasonality (month), but not with marsh status (reference vs. restoring), marsh age, temperature, or salinity. These results suggest that marshes of >= ten years of age support similar assemblages and abundances of fishes. Further research is needed into the dynamics of younger (more newly restored) marshes, as well as the performance (e.g., growth) of fishes in natural vs. restoring marshes.

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FISHES OF TIDAL WETLANDS OF SAN FRANCISCO ESTUARY: RESULTS FROM THE INTEGRATED REGIONAL WETLAND MONITORING PROJECT

The Integrated Regional Wetland Monitoring project is supported by CALFED to establish a rigorous comprehensive monitoring program to evaluate how (or if) wetland restoration sites in the North Bay and Delta are changing over time, and which ecological functions are (or are not) returning to "normal". The central hypothesis of the Fish, Invertebrate and Food Web Team is that food web structure, habitat supplementation and nekton use change from allochthonous to autochthonous with increasing development of restoring wetlands. We have sampled each of six tidal marshes – Sherman Lake, Brown's Island, Bull Island, Coon Island, Pond 2a, and Carl's Marsh – approximately quarterly since October 2003. We deploy a fyke net (3.1-mm mesh) at the mouth of each of 3 channels per marsh during moderate spring tides, set during high tide and recovered at low tide. October 2003 and February 2004 samples (36 fyke net sets) yielded 3,415 specimens representing 18 taxa, dominated by inland silverside, Western mosquitofish, rainwater killifish and three-spine stickleback. Abundances of total fishes decreased by a factor of 15 from October 2003 to February 2004. Composition and abundance of fishes varied geographically (e.g., Suisun/Delta dominated by Western mosquitofish and Napa/Petaluma dominated by inland silversides). Ordination analyses confirmed both geographic and seasonal separation of fish assemblages. Correlation analyses yielded significant relationships between ordination axis scores and the following environmental variables: month and temperature for axis one, and salinity, temperature and region for axis two scores. Additional IRWM sampling of distribution and abundance of fishes will span from June 2004 (to be presented) through at least summer 2005, with ongoing and future analyses to include trophic dynamics (e.g., food-web structure and function; see companion poster by Simenstad et al.).

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INTEGRATED HYDROLOGY AND WATER RESOURCES ANALYSIS OF NAPA COUNTY TO SUPPORT COMPREHENSIVE LAND-USE PLANNING

Problem Statement: How can the hydrology and water resources (including surface flow, groundwater, and water quality) of Napa County be analyzed and assessed for comprehensive land use planning needs?

Approach: An integrated watershed approach is utilized to simulate the hydrologic cycle and its linked physical processes. The integrated watershed approach includes a distributive analysis across surface water, ground water, and water quality components. This analysis is comprehensive across Napa County using sub-basin areas that are scalable (or nested) such that analysis of larger river units (such as the Napa River) or smaller headwater catchments can occur. The MIKE-SHE model has been selected for use for this analysis.

Results: Currently, baseline results for the water balance of individual sub-basins across Napa County have been developed which indicate varying runoff response to inputs of rainfall, soils, vegetation, topography, and land use according to infiltration conditions. Surface runoff conditions are linked to groundwater simulations through soil/geologic parameters.

Conclusions/Relevance: Hydrologic results shall have direct management application. Napa County land use planners and resource managers shall evaluate the hydrologic effect of various land use scenarios using the MIKE-SHE model. Specific questions to be addressed include: How does replacement of vegetated grassland or chaparral cover to vineyard cover influence runoff and erosion conditions? How do potential fire reduction fuel- management scenarios (including timber management) influence runoff, erosion, and water quality conditions? Additionally, the modeling tool can be applied to evaluate how land use and land management practices can be geographically optimized to reduce erosion and sediment loading to the Napa River and S.F. Bay. The Napa River is a 303(d) listed impaired stream (S.F. Bay RWQCB) for high sediment load. Geographically targeted practices to reduce sediment loading to the river from key sub-watershed areas can be an effective approach toward river management.

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DSM2-HYDRAULIC SIMULATION OF TIDAL GATE OPERATIONS FOR THE SOUTH DELTA: ADAPTIVE MANAGEMENT FOR MULTIPLE BENEFITS

The SDIP includes four new tidal gates in addition to CCF intake tidal gate. Tidal gates can be opened or closed at any time in response to the local tidal stage, tidal flow, or water quality conditions within the south Delta. These tidal gates are designed as "flap gates" that are hinged at the bottom of the channel. The ability to operate the tidal gates with any specified weir crest elevation (i.e., top of the gates) provides a great deal of flexibility.

An adaptive management framework is proposed for the integrated real-time operations of these five tidal gate structures to provide multiple benefits:

(1) Maintain a relatively high CCF stage and limit the CCF inflow to less than 15,000 cfs.

(2) Control high tide conditions to increase tidal flushing of south Delta channels.

(3) Control the minimum tidal stage elevation upstream of the tidal gates.

(4) Control the tidal flushing with relatively low salinity water.

(5) Control the San Joaquin River flow diversion into Old River to increase the flow past Stockton to improve DO and conditions for up-migrating Chinook salmon and to reduce EC in the south Delta channels and reduce the percentage of Chinook salmon smolts diverted towards the CVP and SWP pumping plants.

Tidal stage and flows with full pumping (i.e., CVP at 4,600 cfs and SWP at 8,500 cfs) but without any gates are compared with the tidal stage and flows when the temporary barriers are installed. The hydraulic effects of weirs and gates on tidal flows within the south Delta channels are briefly described. The tidal stage and flows that could be achieved with two examples of south Delta tidal gate operations are contrasted. The full range of potential tidal gate operations can then be described and understood in reference to these example conditions.

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DSM2-PTM FISH ENTRAINMENT ESTIMATES FOR THE SDIP: TIDAL TRIGGERS FOR DELTA SMELT AND CHINOOK MOVEMENT

The South Delta Improvements Program includes increasing the SWP Banks pumping capacity (and CCF diversions) to 8,500 cfs when other Delta constraints would allow. The potential effects of this increased pumping on fish entrainment were evaluated in the EIR/EIS documentation. The DSM2 Delta tidal hydraulics and particle tracking model (PTM) was used to demonstrate the effects of pumping and Delta outflow on the entrainment of "fish-like" particles. Passive particle tracking simulated the likely effects of pumping on larval fish life stages that move directly with the tidal flows in the Delta. Tidal triggers were used to simulate downstream "tidal surfing" behavior of "fish-like" particles. Particles moved to the surface (higher velocity) during ebb-tide periods (declining stage) and moved to the bottom (lower velocity) during slack or flood-tide (rising stage) periods. Particle releases were made from 10 locations on the first day of each 30-day simulation with constant inflows, agricultural diversions and pumping. The daily cumulative percentages of the particles that were entrained at CVP, SWP, and in agricultural diversion and the cumulative percentage of particles moving past Chipps Island and past Martinez (downstream boundary) were reported. These PTM results were summarized for a range of export pumping (CVP of 4,600 cfs and SWP of 0 cfs to 10,300 cfs) with Delta outflows of 5,000 cfs, 7,000 cfs, and 12,000 cfs. A similar series of PTM results were summarized for the ten VAMP cases (five SJR flows with two export pumping rates). These PTM results provide a useful understanding of the effects of Delta pumping on entrainment of particles that may enter the Delta or spawn in various regions of the Delta. The incremental entrainment effects from additional pumping for each region of the Delta were identified from the results.

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CONTRASTING EFFECTS OF NATIVE AND INTRODUCED CORDGRASS (SPARTINA SPP.) ON ESTUARINE INFAUNAL COMMUNITIES

The spread of hybrid Spartina (cordgrass) onto mudflats and into native Spartina foliosa (Pacific cordgrass) in San Francisco Bay is a major concern for managers and restoration planners. In order to understand the direct and indirect impacts of the invasion, we need information on how hybrid Spartina affects infaunal and epifaunal species that are important to the estuarine food web. This study used a comparative approach to examine the effects of S. foliosa and hybrid Spartina on infaunal and epifaunal communities and their food webs. We hypothesized that 1) differences in the structure of the native and invasive cordgrasses would cause differences in density of infaunal epifaunal invertebrate communities and 2) increased biomass of hybrid Spartina relative to S. foliosa would be reflected in a stronger Spartina carbon isotope signal in invaded marshes. Study sites included six S. foliosa marshes and two hybrid Spartina marshes between San Francisco Bay and Bodega Bay. S. foliosa contained significantly higher densities, biomass, and richness of infauna than adjacent mudflats, while in hybrid Spartina these measures were equal to or lower than mudflats. We used stable isotopes of carbon and nitrogen to compare invaded and native marshes. Isotope results were mixed, with some species showing carbon signatures that may indicate inclusion of S. foliosa or hybrid Spartina, while other species at other sites do not. While S. foliosa provides a refuge for infauna, hybrid Spartina does not, but food web effects of the invasive species are less clear. These results show that although these two species of cordgrass are closely-related, they do not provide equivalent ecological functions to benthic invertebrates. This research may advance CALFED's goal of understanding functions of key native and nonnative species, and provides evidence to support efforts to control hybrid Spartina and restore S. foliosa around San Francisco Bay.

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AGE-0 STRIPED BASS DIETS IN THE SAN FRANCISCO ESTUARY (1973-2002)

Age-0 striped bass (Morone saxatilis) abundance indices from the Summer Townet Survey in the San Francisco Estuary have declined since the 1970s and food habits have been thought a possible cause. Nearly 32,500 age-0 striped bass stomachs were analyzed between 1973 and 2002 to monitor what striped bass have been eating and to determine if they have been able to utilize introduced zooplankton species. Young striped bass have adapted well to include many introduced zooplankton species into their diets; the percent of stomachs containing food have remained consistent over the past 30 years. While eating as much as they did historically, striped bass have shifted from native zooplankton to consuming primarily introduced zooplankton. Three introduced copepod species (Pseudodiaptomus forbesi, Pseudodiaptomus marinus and Sinocalanus doerrii) now compose the majority of young striped bass diets, replacing the native copepod, Eurytemora affinis. The native mysid, Neomysis mercedis, has been replaced by the introduced Acanthomysis spp. starting in 1994 as the dominant mysid in young striped bass diets. Gammarus spp. first appeared in young striped bass stomachs in 1987, and has become a dominant amphipod with larger size classes of bass. The inability to utilize introduced zooplankton species does not appear to be an answer to why the age-0 striped bass abundance indices have declined so dramatically.

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SCHOLARLY JOURNALS IN THE DIGITAL AGE: INTRODUCING SAN FRANCISCO ESTUARY AND WATERSHED SCIENCE, AN ELECTRONIC FORUM ON SCIENCE AND RESOURCE MANAGEMENT OF SAN FRANCISCO BAY, THE SACRAMENTO-SAN JOAQUIN RIVER DELTA, AND THE UPSTREAM WATERSHEDS

The Internet has made a significant impact on publishing results of original scientific research. The most recent and prominent manifestation of open access publishing of peer-reviewed scientific research – The Public Library of Science – has been initiated by researchers. In their view, "…public libraries of science containing the full text and data of any published research article, available free of charge to anyone, anywhere in the world…[provides] immediate unrestricted access to scientific ideas, methods, results, and conclusions [and] will speed the progress of science and medicine, and more directly bring the benefits of research to the public." (http://www.publiclibraryofscience.org/)

In keeping with this spirit of providing open-access publishing, a joint effort by the Bay-Delta Science Consortium, the California Bay-Delta Authority, and the University of California Digital Library invites scientists, managers, stakeholders, and members of the public to read, research, discuss, and publish peer-reviewed research dealing with the San Francisco Estuary via a new online journal, *San Francisco Estuary and Watershed Science*. The new journal provides an electronic forum for online publication of peer reviewed reports presenting original research findings, reviews, techniques, and comments dealing with all aspects of the San Francisco Bay-Delta estuary, its watershed, and related oceanic processes. (http://repositories.cdlib.org/jmie/sfews)

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USE OF HIGH RESOLUTION SATELLITE DATA FOR DISCRIMINATION OF PLANT COMMUNITIES IN SEASONAL WETLANDS

Seasonal wetlands in the San Joaquin Basin's Grassland Ecological Area are an important part of the food supply for migrating and local bird populations. The federal San Luis National Wildlife Refuge (SLNWR) and the private north Grassland Water District (NGWD) are managed in part for avian food production. The water regime for these areas is largely artificial, with management practices including the timing of irrigations and draw-downs to maximize food-producing plants and to minimize undesirable weeds. Wetland managers are exploring ways of meeting dual objectives of habitat management and compliance with San Joaquin River water quality objectives. Any decision support system for wetland management will require an accurate tool to estimate the extent and diversity of moist soil plants.

The current study was designed to test the feasibility of using high-resolution, multi-spectral satellite imagery to classify moist soil plants and uplands vegetation in SLNWR and NGWD. QuickBird satellite imagery was collected on three dates: April 21, May 14, and June 19, 2004. The imagery's 2.4 meter spatial resolution has the potential to discriminate small stands of vegetation. The timing of the three images was selected to capture various vegetation growth stages, through anticipated maximum production values near the end of June.

Wetlands vegetation was classified using supervised classification techniques for the three images. Classification was able to distinguish between several notable species, and to precisely delineate the present boundaries of wetland basins. Uplands vegetation had largely senesced by early May, so only earlier imagery was useful in evaluating uplands species distribution. For wetland basins, multi-spectral imagery could be used as a cost-effective tool for mapping distribution of vegetation. We believe, based on initial results, that this technology will be useful in establishing a baseline habitat map to assess potential impacts of salinity management to meet San Joaquin River salinity objectives.

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METHYLMERCURY TRANSPORT DOWN THE SACRAMENTO RIVER: IN A REGION OF DECREASING METHYLMERCURY CONCENTRATIONS

The Sacramento River is a major source of methylmercury to the San Francisco Bay-Delta (Bay-Delta). Methylmercury originating in sediments and upstream tributaries is transported down the Sacramento River and out to San Francisco Bay. In this study methylmercury concentrations were measured during two field events along a 24 km transect of the Sacramento River starting at Sherman Lake. On December 16, 2003, during high river flow conditions (991 m^3/sec) both unfiltered and filtered methylmercury concentrations decreased at the confluence of the Sacramento River and the deep water shipping channel. On April 27, 2004, during low river flow conditions (340 m^3/sec) unfiltered methylmercury concentrations increased, while filtered methylmercury concentrations decreased. This continuing study seeks to identify the processes responsible for methylmercury loss in this vicinity. The following processes are being investigated: dilution, hydraulic residence time, particle settling, increasing salinity, photo degradation and bioaccumulation. A geo-referenced flow-through sensor package (Conductivity, Temperature, Transmissometry, and Fluorescence) has been developed to map total suspended solids, salinity, temperature, and chlorophyll a during transects planned in the Sacramento River for the summer and winter of 2004. Bottle incubation experiments will be used to estimate photo demethylation rates. Biological uptake rates by plankton will be estimated from previous lab experiments. Statistical analysis (linear regressions and principle component analysis) will be performed to quantify the significance of these processes in potentially controlling methylmercury transport and cycling. These factors should provide for a greater quantitative understanding of the processes controlling methylmercury cycling in surface waters and help to mitigate elevated mercury levels in Bay-Delta fish species.

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HYDROLOGIC REQUIREMENTS FOR RIPARIAN COTTONWOODS (POPULUS FREMONTII) ALONG THE SACRAMENTO RIVER

Riparian Cottonwood (Populus fremontii) seedlings were grown under simulated groundwater recession rate conditions to determine their maximum recession rate tolerance. Daily recession rates equaled 0.0 (no treatment), 1.0, 2.5, and 5.0 cm/day, executed in two three-week trials from June 16 to August 12, 2003. Seeds were collected from Sacramento River sources and 100 seeds were germinated within each of twelve lysimeters. Water treatments were performed on 56 seedlings per lysimeter for Trial 1 and 42 seedlings per lysimeter for Trial 2. Seedling survival rates for Trial 1 treatments were 96% (no treatment), 93% (1.0 cm/day), 96% (2.5 cm/day), and 0% (5.0 cm/day). Trial 2 treatment survival rates were 98% (no treatment), 100% (1.0 cm/day), 98% (2.5 cm/day), and 14% (5.0 cm/day). Seedling root lengths were significantly greater for Trial 1. The 1.0 cm/day treatment seedlings had significantly taller shoots than those exposed to the 0.0 and 2.5 cm/day treatments. Root biomass was significantly greater for Trial 2 and increased with increased water recession, while shoot biomass was greater for seedlings exposed to decreased water recession.

Cottonwood seedling establishment was monitored, with a focus on modified Recruitment Box elevations, throughout the 2003 growing season at three point bars on the third reach of the Sacramento River. Cottonwood seedlings did establish in the surveyed Recruitment Box areas throughout the 2003 growing season. Though none survived within these particular elevations, first year seedlings were found to survive elsewhere at these river sites. The majority of surviving seedlings were found associated with backwaters. Twenty excavated seedlings were found to have root lengths between 90 and 120 cm with an estimated root loss of 15 cm in the extraction process. Field observations combined with Sacramento River flow data indicate that cottonwood seedling mortality within Recruitment Box elevations was the direct result of river stage fluctuations.

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POST-EXCHANGE ZOOPLANKTON IN BALLAST WATER OF SHIPS ENTERING THE SAN FRANCISCO ESTUARY

Ship's ballast water is a major vector by which aquatic organisms are relocated around the globe. The ecosystem of the San Francisco Estuary is among estuarine ecosystems that have been heavily altered by invasions of non-native species. Major intruders to the bay include zooplankton and presumably planktonic larvae of benthic organisms. The alteration of the zooplankton community may indicate a shift in the ecological functioning of the planktonic food web in the estuary. To stem further invasions, the State of California has required exchange of ballast water since January 2000. Prediction of future bioinvasions of zooplankton would require better understanding of the source of ballast water, the efficacy of ballast water exchange in the open oceans, and information on the rate and amount of post-exchange zooplankton. As a part of this on-going collaborative research, we have examined in ballast water the final delivery of not only of the organisms taken at ports of origin but also of those taken during the exchange process. We focused primarily on bulk carriers because they account for a large part of the discharge of ballast water to the Estuary, but also sampled a smaller number of container vessels. Exchange efficiency appeared to be variable as inferred from a wide range of salinity among vessels (25-37). Ballast waters carried zooplankton ranging in abundance from nil to thousands per cubic meter, which included both populations taken at the initial ports (including species previously reported to have invaded the bay) and oceanic populations presumably introduced into the ballast water during exchange. Vessels treated with empty-refill contained fewer zooplankton that appeared to originate from an estuary, suggesting that empty-refill may be preferrable to flow-through exchange as a practice to reduce the delivery of zooplankton.

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DOC AND BR TRENDS, LOADS, AND YIELDS FROM THE SACRAMENTO AND SAN JOAQUIN RIVERS

High levels of dissolved organic carbon (DOC) and bromide (Br) in the Sacramento-San Joaquin Delta waterways are of concern because DOC and Br are precursors of carcinogenic and mutagenic disinfection byproducts (DBPs), such as trihalomethanes and haloacetic acids. The watershed of the Sacramento-San Joaquin Delta covers a large area and includes a variety of ecosystems such that the sources of these two important DBP precursors are still uncertain. The major objective of this study was to provide DOC and Br fluxes for the Sacramento-San Joaquin watersheds and to evaluate the DBP formation potentials for representative source waters. Water samples were collected every two week in the 2003 water year (September 2002 to October 2003) at 35 locations along the Sacramento and San Joaquin Rivers and selected tributaries. For each sample, we measured the concentrations of DOC and Br and determined specific ultraviolet absorbance at 254 nm (SUVA254), which is a typical surrogate for predicting DBP formation in water industry. Stream discharge was combined with DOC and Br concentrations to estimate fluxes for the entire water year. In addition, selected water samples and commercial-grade humic acid were tested for trihalomethane formation potential with different concentrations of Br to evaluate the bromide effect on DBP formation. Results showed that the concentrations of DOC and Br ranged from 0.8 - 13.4 and 0 - 5.9 mg/L, with an average of 2.6 and 1.3 mg/L, respectively. Also, a strong linear correlation was observed between trihalomethane formation and bromide concentrations in our laboratory study. The results of this study provide a first estimation of DOC and Br loads from upstream watersheds to the Sacramento-San Joaquin Delta. The measurement of SUVA254 and the Br-effect study illustrated the reactivity of DOC and Br in forming DBPs.

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SOIL INVERTEBRATE COMMUNITIES IN MEADOW AND FOREST HABITATS ON THE COSUMNES RIVER FLOODPLAIN

In California, most floodplains are disconnected from river water because of dams, water withdrawals, and levees. The Cosumnes River however, is unique in California in that it has a floodplain that is hydrologically connected to its river A stated conservation goal of the Consumes is to restore the landscape from past agricultural use. Understanding the links between flood pulse, habitat diversity and soil invertebrate communities will be important in meeting this goal and restoring floodplain soil fertility. Invertebrate communities, directly and indirectly, affect soil fertility. Floodplain soil invertebrates must adapt to changing moisture regimes from winter floods to summer droughts. To better understand the role soil invertebrates play in floodplain dynamics, we asked how invertebrate communities vary between different floodplain habitats and whether differences in the amount and type of organic matter control the density and diversity of soil invertebrates. We established 5-100 m^2 permanent plots in 4 habitats on the Cosumnes River Preserve floodplain. The habitats included open meadow with high and low algal accumulation and cottonwood forest. Plots have been sampled monthly (except when flooded) for soil solution nutrients using anion exchange resins. Oligochaetes and microcrustaceans were sampled immediately following the fall rains but before flooding, once during winter between flood events, and in early summer. Soil nutrients and properties were measured on the pre- and postflood samples. Initial results suggest that more insect larvae and oligochaetes occur in cottonwood forest soils compared to the other habitat types. Within the meadow, however, more insect larvae and oligochaetes occur in plots that accumulate high amounts of algae. Our results suggest that a restoration plan that includes both open meadow and forested habitats may maximize soil fertility.

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EVALUATING NUTRIENT REGIMES AND PRIMARY PRODUCTIVITY IN WETLANDS IN THE SAN FRANCISCO ESTUARY

This research is part of the CalFED supported IRWM (Integrated Wetland Monitoring) Project designed to compare two natural wetlands (Brown's Island and Coon Island) and four restored wetlands (Sherman Lake, Bull Island, Pond 2A and Carl's Marsh) in the San Francisco Bay and the Sacramento-San Joaquin Delta. Our objective was to evaluate differences in nutrient availability and the contribution of different groups of autotrophs to primary production. Nutrient (nitrate, ammonium, silicate and phosphate) concentrations in the water were determined monthly at the sites during the growing season (ca. March to October) and quarterly during the winter months. Primary productivity of phytoplankton, benthic microalgae, submerged aquatic vegetation, macroalgae and wetland plants was determined monthly during the growing season at all locations. Different methods were employed for each type of autotroph. We measured bicarbonate uptake by phytoplankton and benthic microalgae using ^{14}C assays, oxygen evolution by submerged aquatic vegetation and macroalgae and direct CO_2 uptake by low marsh vegetation (Spartina spp.) using infrared gas exchange techniques. Data collected during the 2004 growing season will be presented. Preliminary observations indicate that nutrients are at non-limiting concentrations, ammonium levels are highly variable and that productivity in the San Francisco Bay is greater than in the Delta. These data are the first to make detailed measurements of nutrients and the dominant sources of primary productivity and may act as useful measures of how restoration stage influences wetland ecosystem structure.

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EARLY LIFE HISTORY OF SACRAMENTO PERCH AND RELEVANCE TO RESTORATION IN ITS NATIVE RANGE

The Sacramento perch, Archoplites interruptus is California's only native sunfish. It is extirpated from most if not all of its original range. Because so little is known about basic biology of Sacramento perch, restoration would be premature without studying the biology first. We are looking at early life history strategies to see if there is some limiting factor that prevents perch from surviving this life stage. To accomplish this goal we raised perch in aquaculture and also looked at them in the wild using light traps for larval capture. The timing of spawning in relation to temperature, photoperiod, and moon phase were examined. A time series of development and growth was documented using digital photography and meristics. The documentation of early life history requirements will allow us to make logical choices about what needs to be in place to allow perch to survive through this life history stage. Restoration strategies can then be developed that will allow perch to be reintroduced into the San Francisco Estuary with some likelihood of success.

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WATER QUALITY IN CALIFORNIA'S RANGELAND WATERSHEDS

Concerns exist about water quality degradation downstream from the 3 million hectares of rangelands surrounding the Central Valley. Cattle grazing these rangelands are known to shed fecal indicator bacteria (e.g., Escherichia coli) and protozoal pathogens (e.g., Cryptosporidium parvum), and their feces contain high concentrations of dissolved organic carbon. We present a water quality dataset collected from 23 rangeland streams across California.

For two years, we enrolled 23 streams representing California's major rangeland types in a water quality survey. Watersheds had grazing as the dominate land use, and area ranged from 5,000 to 50,000 acres. Grab sampling and streamflow estimation was timed to sample storm-flow, snow-melt, and summer base-flow periods. Samples were analyzed for total suspended sediment, turbidity, pH, electrical conductivity, total nitrogen and phosphorus, nitrate, ammonium, phosphate, potassium, fecal coliforms and E. coli using standard analysis methods.

Water quality results will be presented and discussed relative to standards, watershed characteristics, and temporal variability. Maximum observed nitrate level was 12.4 ppm with a mean of 1.5 ppm. Thirty percent of streams exceeded phosphate levels of concern for eutrophication. Bacteria levels were high relative to water quality standards. Maximum observed fecal coliform concentration was 33,800 cfu/100mL with a mean of 6,710 cfu/100mL. Distinctly higher bacteria levels were found on watersheds with rainfall-runoff dominated streamflow generation, compared to snowmelt and snowmelt/rainfall-runoff dominated systems. Pronounced flushing of nitrate and bacteria occurred on rainfall driven systems, with maximum concentrations and fluxes occurring during the first 2 storms of the water year.

This dataset allows comparison of grazed rangeland water quality to existing and proposed water quality targets and to other land uses. These results provide guidance to target water quality concerns, assess relative pollutant contributions in multiple use basins, and develop monitoring plans to address water quality temporal variability.

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STUDIES ON UPTAKE, DISTRIBUTION AND METABOLISM OF DIURON IN THE ESTUARINE MACROPHYTE SPARTINA FOLOSIO

Diuron, (N'-(3,4-chlorophenyl)-N,N-dimethylurea), is a commonly applied phenylurea herbicide used to control broad leaved weeds. Herbicides such as diuron can enter wetland ecosystems, and potentially threaten the survival of tidal plants, which act as buffers against tideland erosion. This study examines the bioavailability and biogeochemistry of diuron as an environmental toxicant to plants in estuarine ecosystems. Pacific cordgrass, Spartina folosio, were exposed to environmental levels of diuron in Hoagland nutrient solution. Plants were transplanted from a reference wetland site, and then grown and treated over a duration of 4 weeks in a controlled environment (85% constant humidity, photoperiod of 16 h light, 25 C, and an 8 h dark period, 19 C). Nutrient solution was monitored bi-weekly for diuron and its metabolites, N'-(3,4-dichlorophenyl)-N,N-dimethylurea (DCPMU), N'-3,4-dichlorophenylurea (DCPU), and 3,4-dichloroaniline (DCA), while potted sand, and plant tissue, including shoots and roots, were analyzed at the completion of the exposure study. Concurrent to our chemical measurements, other investigators evaluated the response of the plants by measuring carbon dioxide uptake, photosynthetic inhibition (fluorescence toxicity inhibition) and reflectance. These results will be integrated with field measurements to provide valuable information about the fate and effects of herbicides in California wetlands which can be used by CALFED and other resource managers for planning wetland restoration projects.

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SALMON THERMAL CRITERIA FOR THE STANISLAUS – LOWER SAN JOAQUIN RIVER WATER TEMPERATURE MODELING AND ANALYSIS

As part of a CALFED sponsored water temperature modeling project for salmon restoration on the Stanislaus and Lower San Joaquin River a review and assessment of water temperature criteria was completed for Central Valley fall-run Chinook salmon and Steelhead rainbow trout.

Thermal criteria are generally based on life stage, such as adult immigration, spawning, egg incubation, and juvenile rearing and smoltification. Although the terminology varies, common management approaches have been to define either (1) optimal and suboptimal conditions or (2) optimal, chronic, and acute conditions for each life stage. When assessing water management options, water temperatures are compared to criteria and a penalty applied if, for example, the water temperature falls into an undesirable tier (i.e., suboptimal and/or acute), thus providing a means to compare operating/management scenarios.

A common problem with these methods is grappling with the discontinuous (step function) nature of the criteria, which does not represent actual fish response to thermal stress, e.g., the physiological response of a 1C deviation above optimum is different than a 10C deviation.

To overcome the impractical nature of discontinuous criteria, a continuous function was developed. A single optimal temperature was identified, below which conditions were favorable for a particular life stage. For water temperatures greater than this optimal, a penalty (P) was assigned according to a non-linear function: P = (Delta T)^(beta), where Delta T represents departures above the optimum and beta is the exponent. Optimum temperatures varied by life stage as did exponents in the equation. Modifying these parameters changed the function shape allowing more stringent conditions for certain life stages (e.g., egg incubation). Final values for the parameters were determined based on temperature-mortality data identified in the literature and professional judgment. These criteria were then successfully tested using simulated water temperatures for preliminary management alternatives on the Stanislaus River.

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GENERALIZED MOVEMENT OF TWO OSMERID SPECIES IN RESPONSE TO DIFFERENT OUTFLOW CONDITIONS FROM THE UPPER ESTUARY

Two native Osmerids species from the upper San Francisco Estuary (SFE), delta smelt Hypomesus transpacificus and longfin smelt Spirinchus thaleichthys, were analyzed using the Department of Fish and Game's 20-mm Survey data (1995-2001) in response to different outflow conditions. Outflow through the estuary has been at the forefront of water management issues, not only for water quality issues, but also fish concerns. The central abundance position of each species was compared to three different outflow conditions (high, average, low) and the position of the 2 psu isohaline (X2) during the spring and early summer rearing periods. Outflow conditions had a strong influence on the geographic position of both delta smelt and longfin smelt, but distribution with respect to X2 was not affected. The distribution patterns were consistent with larvae moving from upstream freshwater spawning areas to downstream estuarine rearing areas. The results support the idea of using X2 as an organizing principle in understanding the ecology of larval fishes in the upper SFE. Additional years of sampling will likely lead to additional insights into the early life history of both these species as well as other upper SFE fishes.

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OBTAINING RESEARCH PERMITS FOR FEDERALLY-LISTED ENDANGERED OR THREATENED ANADROMOUS SALMONIDS IN CALIFORNIA

The Endangered Species Act (ESA) requires that researchers studying federally-listed salmonids obtain a research permit from the National Marine Fisheries Service (NOAA Fisheries). Many research projects related to the California Bay-Delta Program would likely require such permits. The NOAA Fisheries Southwest Region encourages research on listed endangered and threatened anadromous salmonids, and finds the knowledge gained helpful in designing science-based management strategies for species recovery. "Take" of listed species for scientific purposes or to enhance the propagation or survival of the affected species is permitted under section 10(a)(1)(A) of the ESA. NOAA Fisheries has a simple three-step process for permitting research on listed anadromous salmonids. First, the researcher submits an application describing the proposed research, its significance, and how the research may affect listed salmonids. Second, public and peer review of the proposed research is invited and a biological opinion is prepared analyzing potential effects on listed salmonids. Third, a permit is issued, based on criteria developed through the biological opinion.

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SELENIUM DEPURATION: EFFECTS ON GROWTH AND TISSUE CONCENTRATIONS IN SPLITTAIL (POGONICHTHYS MACROLEPIDOTUS)

This study determined growth and tissue burden of splittail fed a control diet (0.4 mg Se/kg-1) for 21 weeks after 9 months exposure to 0.4, 12.6, 26.4, and 57.6 mg Se kg-1 dry diet. Fish were sampled at 1, 3, 7, 13, 21 weeks. After a 21-week depuration, fish body weight previously fed 57.6 mg Se kg-1 diet were significantly lower ($P<0.05$) but had higher growth rate than those fed the lower Se concentration diets. No significant differences in body weight were observed among fish previously fed 0.4, 12.6, and 26.4 mg Se kg-1diet. Fish body weight previously fed diet contiang 57.6 mg Se kg-1 diet increased by 152% while fish previously fed diet with 0.4 mg Se kg-1 diet increased only by 20% after a 21-week depuration. Liver and muscle Se concentrations from fish previously fed <12.6 mg Se kg-1 diets did not change significantly ($P>0.05$) whereas those previously fed 26.4 Se mg kg-1 diet decreased significantly after a 7-week depuration. In fish previously fed 57.6 mg Se kg-1 diet, liver Se concentration decreased significantly after a 1-week of depuration. Liver Se concentrations showed no significant difference between 13- and 21-week depuration among all treatments. Fish previously fed diets containing >26.4 mg Se kg-1 showed a significant decrease in muscle Se concentration after a 3-week of depuration. Muscle Se concentrations in fish previously fed diets containing >12.6 mg Se kg-1 remained significantly higher than those previously fed the control diet after a 21-week depuration. These results indicate that growth of splittail was significantly affected by feeding 57.6 mg Se kg-1 diet although a higher compensatory growth was observed during 21-week Se depuration. A 21-week depuration was not long enough to deplete the Se accumulated in muscle from fish previously fed 12.6 mg Se kg-1 diet.

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EMBRYONIC AND LARVAL DEVELOPMENT OF SACRAMENTO SPLITTAIL POGONICHTHYS MACROLEPIDOTUS

The early development of Sacramento splittail, a native cyprinid in northern California, USA, was examined under controlled laboratory conditions. By using both in-vivo and preserved specimens collected from artificial insemination and natural fertilization in captivity, the developmental stages were characterized from the onset of fertilization to metamorphosis following the staging system well established for zebrafish, a commonly used cyprinid for laboratory testing. Splittail is a non-guarding, obligatory plant spawner, producing transparent adhesive eggs with large perivitelline space. Its embryonic development shares a meroblastic cleavage pattern with other teleosts, and its developmental sequences are similar to those of other cyprinids (e.g., zebrafish). However, its developmental rate differs from zebrafish primarily due to differences in total definitive somite numbers and rate of somitogenesis. Splittail prelarvae are demersal, preferentially seeking substrata. The larvae swim up in the water column when the first swimbladder chamber is inflated. The behavior of prelarvae in captivity suggests that they seek weedy or debris shelters at the water bottom presumably to avoid predators and surrogate in the substrate to obtain better oxygen circulation in floodplains, assumably using the numerous secretary cells to hold their position on the substratu.

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SACRAMENTO RIVER BANK PROTECTION PROJECT RIVERBANK MAPPING AND INITIAL GEOGRAPHIC INFORMATION SYSTEM RESULTS

During 2001, the U.S. Army Corps of Engineers received biological opinions from NOAA Fisheries and the U.S. Fish and Wildlife Service for the Corps' Sacramento River Bank Protection Project (SRBPP). Both opinions noted the lack of baseline information and required the documentation of all rock revetment and general habitat conditions within the project area before further programmatic consultation under the Federal Endangered Species Act.

As a result, the SRBPP Interagency Working Group designed a study protocol for collection of four basic riverbank attributes revetment, vegetation, in-stream features, and other features that could be recorded using Global Positioning Systems technology and displayed in a Geographic Information Systems database. A total of 24 sub-variables were collected for the four attributes. Mapping was done by a three-person team in a river jet boat. Over 475 miles of banks of the Sacramento River between Collinsville to and Colusa, and along Steamboat, Sutter, Georgiana, and Miner sloughs were mapped.

Amounts and type of rock revetment and natural banks varied widely. Sutter and Steamboat were 83 (18 of 24 miles) and 76 (11 of 13 miles) percent reveted, respectively, while Georgiana Slough was 46 percent (10 of 24). The mainstem Sacramento River was 66 percent (189 of 287 miles).

These results have many implications for future scientific research and management decisions related to the lower Sacramento River system. Managers and scientists may now be able to determine target or threshold levels for restoration or allowable system manipulation for various attributes such as revetment, fluvial function, large woody debris, and shaded riverine aquatic habitat.

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CARBON ISOTOPES AS A TOOL FOR INVESTIGATING SOURCES AND CARBON CYCLING IN THE SAN JOAQUIN RIVER

Biological and chemical oxygen demand contributing to low dissolved oxygen in the Stockton River Channel is partly caused by an influx of dissolved organic carbon (DOC) and particulate organic carbon (POC) from the upstream San Joaquin River (SJR). Characterizing organic material in the river aids in the identification of sources and leads to better management practices for the reduction of these loads to the river. Moreover, the degradation and production of organic matter within the SJR is of interest in terms of applying adaptive management strategies to reducing loads of organic matter downstream.

We apply a novel automated analytical technique to obtain concentrations and carbon isotopic compositions (d13C) of both DOC and DIC to evaluate the cycling of carbon in the river. Ease of sample collection and analysis allows us to generate high-resolution data. As part of a pilot study, we collected samples along a downstream transect of the SJR from Mud Slough to Mossdale on two occasions: once in mid-March and once in late September 2003.

During lower flow in September, DOC d13C values of the SJR were more similar to that of the major tributaries than at higher flow in March. d13C values are similar between DOC and POC in the tributaries, but POC d13C is 1-4 per mil lower than that of DOC in the SJR, likely indicating that the POC has undergone less degradation than the DOC.

A positive correlation exists between DOC and DIC concentrations in the SJR, especially in March (high flow period). DIC d13C values are lower in September than in March, and a slight correlation exists between d13C of DOC and DIC in September (low flow period). This slight correlation and more negative DIC d13C overall in summer may be indicative of degradation of DOC in the river producing isotopically light CO2 in situ.

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SCIENCE TO SUPPORT RESTORATION PLANNING IN A SEVERELY DEGRADED ENVIRONMENT: THE MERCED RIVER DREDGER TAILINGS REACH

Adaptive management approaches to river restoration are highly demanding of baseline scientific data. These support the generation of specific project objectives from which to derive testable hypotheses that explore project uncertainties, and the selection of performance criteria that form the basis of monitoring and evaluation. Conversely, 'predictive' river management generally required only hydrological data and construction of flow simulation models prior to project implementation, instead using factors-of-safety to buffer project uncertainties rather than extensive data collection. As a result, restoration projects are frequently lacking in pertinent data, requiring the rapid generation, integration and historical contextualization of data during project inception. Data deficiencies are especially acute in highly disturbed environments that have few reference counterparts, such as the Dredger Tailings Reach of the Merced River. Here, restoration planning must contend with significant flow regulation, a lack of coarse sediment supply, and the consequences of gold dredging that has produced a floodplain of tailing piles. Baseline data collection has included detailed topographic surveys, investigation of the dredger tailings' volume and texture, estimates of flood flow inundation levels, estimates of sediment transport potential, assessment of mercury content in tailings and surrounding waters, and periodic surveys to establish an empirical geomorphic and biological baseline. Results indicate that the contemporary floodplain is largely inaccessible to flood flows, that the channel sediment is frequently too coarse for spawning habitat, that very little sediment transport occurs other than re-distribution of gravels at augmentation sites, that the coarse floodplain sediment has little stratigraphic differentiation above the water table, and that levels of mercury are mostly very low. These results, while mostly anticipated, provide a rigorous (and potentially transferable) scientific basis to the restoration of functional channel and floodplain habitats in the reach, using process- and form-based rehabilitation techniques to improve the prospects for native fish and riparian vegetation.

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A GUIDED APPROACH TO MULTI-OBJECTIVE PLANNING: "NATURAL FLOOD PROTECTION"; A PLANNING AND DECISION-MAKING TOOL

Problem Statement

The need for consistent guidance in planning for multi-objective flood management has grown over the past decade. Drivers include recent State subvention funding changes, the District's updated mission to provide watershed stewardship and an expanded capital flood protection program. Concurrently, the communities that we serve have become increasingly educated and articulate regarding environmental stewardship and community amenities. Finally, mitigation requirements have made single-purpose projects virtually infeasible.

Approach

Using an intensive collaborative process, we first defined "natural flood protection" in terms of nine critical elements – objectives – that in concert would constitute a successful multi-objective project. These include flood protection, ecology, geomorphology, water quality, life-cycle costs and local partnerships. Each objective was then explored in depth, collaboratively drawing on the knowledge and experience of over fifty District staff and outside experts. Individual topic-teams determined the most essential criteria within each objective and developed rating scales to evaluate alternatives on each criterion.

Results

A tiered decision-making tool was developed to infuse the knowledge and experience of over fifty colleagues into the planning and selection of flood protection projects. The tool provides clear planning guidance via descriptions of desirable project elements and a standardized and comprehensive means to compare alternatives' likelihood of meeting multiple objectives.

Conclusions/ Relevance

Over the next decade, our agency will spend over two hundred million dollars to provide much-needed flood protection in an urban/suburban setting. Threatened and endemic species occupy the riparian corridors that will be touched by these projects. Clear and consistent guidance is vital to the continued success of our unique natural, social and economic assets. The planning and decision-making tool clearly describes the functions and features of a successful multi-objective river project. Furthermore, it "daylights" the inherent balances and tradeoffs required of decisionmakers when selecting a project for completion.

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SPATIAL AND TEMPORAL DISTRIBUTION OF TWO CO-OCCURRING COPEPODS IN SUISUN BAY, CA

Our investigation attempts to determine how two co-occurring species of invasive copepods, E. affinis and P. forbesi partition habitat and whether their populations are structured by predation. We sampled along the low salinity zone in Suisun Bay and the Delta regularly throughout the course of a year, and then performed a stage-based life history analysis of both populations. Our initial results show distinct spatial and temporal habitat use that corresponds to both physiographic and biotic parameters.

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PHYSICAL MODELING EXPERIMENTS TO GUIDE RIVER RESTORATION PROJECTS: PROJECT OVERVIEW AND EXPERIMENTAL DESIGN

California Bay-Delta agencies have identified several strategies for restoring Bay-Delta tributaries, including: 1) injecting gravel to compensate for coarse sediment loss due to dam retention and in-channel mining; 2) removing dams to open access to upstream habitats and restore fluvial geomorphic continuity; and 3) reconstructing river channels and floodplains in balance with a regulated flow regime. The projects that the Resource Agency has already funded that use these techniques (Tuolumne, Merced, Stanislaus Rivers, and Clear Creek) highlight several significant gaps in scientific understanding of fluvial geomorphic processes, particularly concerning how episodic sediment delivery influences bed texture and mobility, and how floodplain and channel geometry and stability are influenced by changes in the discharge and sediment supply regimes. Stillwater Sciences, in association with San Francisco State University and University of California at Berkeley, is conducting a series of physical modeling experiments that address fundamental scientific questions underlying the restoration strategies of gravel augmentation, dam removal, and channel-floodplain reconstruction. Gravel augmentation and dam removal experiments will be conducted in a large gravel-bed flume, while channel-floodplain reconstruction experiments will be conducted in a floodplain basin that will maintain a meandering channel of stable width. We will test hypotheses for the spatial and temporal evolution of channel bed texture and geometry following pulses of sediment delivery, and for the potential mobilization of coarse bed armor due to the injection of finer gravel. This project also seeks to establish quantitative relationships between equilibrium channel geometry and the full distribution of discharges and sediment supply events, whether natural or regulated. Progress on these questions will represent significant advances in geomorphic science as well as applied river restoration practice.

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ACCURATELY ESTIMATING ABUNDANCE OF JUVENILE SPRING CHINOOK SALMON IN BATTLE AND CLEAR CREEKS

The length-at-date criteria for designating runs of juvenile Chinook salmon (Oncorhynchus tshawytscha) were developed using mainstem Sacramento River fall Chinook. Chinook in the Sacramento River tributaries experience different spawning and emergence timing, and temperature regimes and therefore may be mis-assigned. Furthermore, in Clear and Battle Creeks, spring and fall Chinook salmon overlap in spawn timing and geographical distribution, making accurate run-designation of these at-risk species difficult. On Clear Creek, since 1998, a rotary screw trap (RST) has been placed downstream of most Chinook spawning habitat to estimate production of emigrating runs of Chinook. However, this trap catches both spring and fall Chinook of the same length simultaneously making accurate production estimates problematic. A temporary barrier weir was placed in Clear Creek in 2003 to separate fall and spring Chinook spawning areas. A second RST was operated above the weir to sample only juvenile spring Chinook. If the adult fish above the barrier were all spring Chinook then the length criteria mis-assigned 95% of the juvenile spring Chinook as fall run. Genetic analysis of tissue samples collected from both creeks may assist in developing better run designation criteria and production estimates. Spawning, emergence timing and temperature regime data were analyzed to estimate that 1850 daily temperature units were required for juvenile emergence (DTUE) in Clear Creek in 2003. We estimated Battle Creek DTUE in 2001 and 2002 to be 1550 and 1850. Interpretation of the Battle Creek data is less straightforward, because variable numbers of fall Chinook were passed through the Battle Creek barrier weir, the weir is not fish tight, and early spawners were probably impacted by high water temperatures and redd superimposition by fall Chinook. Accurate DTUE estimates may be used in developing tributary specific run designation criteria. We present graphical methods for estimating DTUE.

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DISTRIBUTION AND SOURCE OF POTENTIAL DISINFECTION BY-PRODUCT PRECURSORS WITHIN THE SACRAMENTO-SAN JOAQUIN DELTA

Sacramento-San Joaquin Delta water is characterized by high concentrations of disinfection byproduct-forming (DBP-forming) materials, frequently resulting in trihalomethane (THM) and haloacetic acid (HAA) concentrations above the current US-EPA maximum contaminant level (MCL) for drinking water. Aromatic compounds, including vascular plant-derived lignin, are believed to be the primary source of DBP-forming compounds in the Delta system. This study investigates spatial distribution and temporal variation in lignin across the Delta. Results will be used to elucidate (1) lignin and dissolved organic carbon (DOC) source information relevant to mitigation efforts/best management practices (BMPs), (2) distribution of lignin 'hot spots' across the Delta system, and (3) patterns of lignin degradation.

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EFFECTS OF PESTICIDES ON ANTIBODY RESPONSE AND CYTOKINE TRANSCRIPTION OF JUVENILE CHINOOK SALMON (ONCORHYNCHUS TSHAWYTSCHA)

Results from U.S. National Water-Quality Assessment (NAWQA) studies show, that contamination from pesticides is widespread in streams and ground water throughout the nation's agricultural and urban areas, often times exceeding guidelines for the protection of aquatic life. Environmental pollution has been associated with a higher incidence of disease in fish. Pesticides have been shown to have an immunosuppressive effect on fish, but relatively little is known concerning the toxic effects of specific chemical pollutants on immune defense mechanisms. The objective of our study was to examine the immune response of pesticide-treated salmon to an administered antigen, and to measure the transcription of several cytokines in responding fish. We exposed juvenile Chinook salmon to sublethal concentrations of two widely used insecticides, the organophosphate chlorpyrifos and the pyrethroid esfenvalerate, followed by immediate immunization to dinitrophenylated-keyhole limpet hemocyanin (DNP-KLH) by intraperitoneal injection. Serum- and tissue samples were collected six, eight and ten weeks after immunization. The expression of four cytokines was quantitated by real-time TaqMan PCR. Antibody titers in serum samples were determined by enzyme-linked immunosorbent assay (ELISA). The number of individuals producing a measurable antibody response to DNP-KLH increased with weeks passed after immunization. In comparison to unexposed fish, fewer salmon were categorized as antigen-responsive when pre-treated with esfenvalerate and chlorpyrifos. In addition, esfenvalerate-exposed fish had significantly lower antibody titers eight weeks after immunization. Cytokine induction patterns in response to pesticide treatments and immunization will be discussed. Stresses upon the fish immune system by environmental pollutants may not be overtly apparent, but immunosuppression may be an important factor affecting the health of pacific salmon populations.

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WILDLIFE RESPONSES TO RIPARIAN RESTORATION DESIGN FEATURES

Riparian restoration projects along the Sacramento and San Joaquin Rivers have benefited fish, wildlife, and natural processes on thousands of acres. Fifteen years ago, the initial projects demonstrated the feasibility of implementation. Today, restoration projects have become more sophisticated to meet multiple goals. Physical and biological features certainly influence long-term survivorship and the selection of vegetation. However, current plant designs do not simply match plants to site conditions. Restoration plans must consider wildlife requirements, neighboring land use, public access, and long-term management practices. Project implementation must be conducted within an adaptive management framework.

Working with partners, such as PRBO Conservation Science, River Partners develops specific design features to attract targeted wildlife species on nearly 3,000 acres on California Department of Fish and Game, US Fish and Wildlife Service, and private lands. Aided with the help of the California Wildlife Habitat Relations database and other information sources, we develop specific designs with testable hypotheses.

We will focus on the response of bird usage to these specific design features, and outline predicted wildlife responses as the vegetation matures. In addition, we will present how new information, such as distribution patterns of the valley elderberry longhorn beetle or habitat preferences of riparian brush rabbits, is being incorporated into plant designs. The testing of these designs through wildlife monitoring provides a feedback loop to evaluate our assumptions and project hypotheses. We will discuss results from bird monitoring of a three-year old restoration plantings. Similar testing of other project hypotheses will ensure that these projects continue to maximize wildlife benefits and fit into the modern landscape.

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"SHORT SEA SHIPPING: REDUCING VESSEL TRAFFIC IMPACTS TO THE BAY AND DELTA"

The volume of marine cargo moved through US seaports is anticipated to grow by at least 100% over the next 15-20 years. To accommodate that growth, ports throughout the US are positioning themselves to meet the demand since the availability of facilities precedes actual cargo. In the Bay, the Port of Oakland has recently completed new terminals and is anticipating further growth. The Ports of Stockton and Sacramento are planning to further increase ship channel depths to 30-35 feet. Typically, most San Francisco Bay seaports including those in the Bay Delta are designed to accommodate large seagoing vessels.

However, new ways of looking at regional cargo logistics could reduce the environmental impacts of what are often unnecessarily duplicative facilities. "Short sea shipping," a recent concept that has developed a following is defined by the US Maritime Administration as "…commercial waterborne transportation that does not transit an ocean. It is an alternative...that utilizes inland and coastal waterways to move commercial freight from major domestic ports to its destination." In the Bay, short sea shipping is likely to be an important method for handling future volumes of cargo by positioning the Port of Oakland as the major international import/export seaport and using barges to move cargo to and from the various smaller ports to/from Oakland.

In terms of impacts on the Bay-Delta ecosystem, barges require only shallow channels, reducing the demand for deep dredging, they also require only shallow alongside depths at wharves and concurrently reduce the demand for maintenance dredging. Furthermore, shallower channels in the Delta are likely to reduce salinity intrusions into that sensitive water body. Among shipping experts, the notion of short sea shipping is gaining traction both for its salutary economic and environmental consequences. It is a policy that merits attention in the Bay and Delta.

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THE USE OF OTOLITH MICROSTRUCTURE AND MICROCHEMISTRY OF REVEAL PATTERNS IN THE EARLY LIFE HISTORY SPLITTAIL

The splittail (Pogonichthys macrolepidotus) was recently remanded as "threatened" under the Federal Endangered Species Act but is a species of high concern in the San Francisco Estuary. Previous studies have suggested that year class strength is set at early life stages when environmental conditions are optimal. Our current research on the early life history of splittail is designed to address this issue. With the aid of otolith analysis for age and growth estimates, we will be able to determine if growth rates of young-of-year splittail vary spatially and temporally in the system in relation to environmental gradients. One key question we plan to address is if young splittail exhibit enhanced growth rates in floodplain habitats versus adjacent reaches of river channel. We have validated that young-of-year splittail otoliths deposit daily growth increments and are currently processing the otoliths of fishes collected during field sampling in 2002 and 2003. From these samples, we will estimate hatch dates, age, and growth rates of splittail from throughout their entire range including the Petaluma River, Napa River, Suisun Marsh, Sacramento River, Yolo Bypass, Butte Creek/Sutter Bypass, Cosumnes River, San Joaquin River, and the Delta. Lastly, we will employ the technique of otoliths microchemistry to determine of strontium isotopes and trace elements vary spatially in larval fish to develop baseline information for the classification of adult splittail natal source. The otolith data collected from these fish will be compiled together with data on food habits, habitat associations and genetic population structure to provide a complete description of the early life history.

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OTOLITH ELEMENTAL FINGERPRINTS DISCRIMINATE NATAL TRIBUTARY WITHIN AND AMONG NUCLEAR DNA-IDENTIFIED STOCKS OF SPLITTAIL

Otolith elemental fingerprints have a potentially powerful application in splittail stock identification. If natal tributaries differ in environmental characteristics (i.e., chemical constituents of the water), otolith elemental fingerprints may correspond to genetically-identified stocks. Further, otolith elemental fingerprints may even provide greater detail of splittail stock structure than existing nuclear DNA techniques by discriminating the specific natal tributary of individuals not just among but within the genetically distinct stocks. In this study, we investigated the ability of otolith elemental fingerprints to serve as natural markers for the natal tributaries of splittail. First, we collected samples of age-0 fish from their natal tributaries over two years to establish the efficacy of the otolith elemental signature as a marker. We also used nuclear DNA techniques to confirm the stock identity these fish. Second, we obtained samples of older juvenile and adult fish of unknown origin from downstream regions in the estuary, as well as within some of the tributaries, over multiple years and applied nuclear DNA and otolith elemental fingerprint data from these fish to classify the stock identity and natal tributary of each fish.

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SEDIMENT FLUX MONITORING IN THE NORTH DELTA

Physical processes such as water and sediment movement exert strong influences on species and habitats in Central Valley streams and the Sacramento-San Joaquin Delta. In particular, accrual of sediment is critical to restoring ecological function to those areas that have previously been leveed off from streams.

The present work quantifies the differences in current and sediment flux regimes in the Cosumnes and Mokelumne Rivers, upstream of their confluence. The Cosumnes River is the last undammed river flowing into the Central Valley, whereas the Mokelumne River is highly regulated. Current and Sediment Flux Monitoring Stations (CSFMS) were constructed and deployed on each river. Each CSFMS recorded time-series measurements of current velocity, temperature, optical backscatter (a measure of suspended sediment concentration), water surface elevation and distance to the bed (a measure of bedload transport).

Total sediment transport potential is estimated by supplementing measured data with historic sediment transport analysis of the rivers. Estimates of potential mercury transport are made by coupling the sediment transport with mercury estimates of others.

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TRANSPLANT STUDIES WITH THE INTRODUCED ASIATIC CLAM TO MEASURE METHYLMERCURY ACCUMULATION IN THE SACRAMENTO-SAN JOAQUIN DELTA

A series of clam transplant studies were conducted with the Introduced Asiatic clam, Corbicula fluminea, to determine the temporal and spatial pattern of methylmercury uptake in the Estuary and the primary factor(s) controlling it. Four thousand clams were transplanted into replicate cages at six locations and change in body burden, tissue weight, and a suite of water quality parameters measured monthly at each site. Most of the methylmercury uptake and tissue growth occurred between March-June. The rate of methylmercury uptake was more variable (0.6 to 4.5-fold increase) than was tissue growth (1.3 to 1.8-fold increase) demonstrating that site-specific tissue concentrations are primarily determined by changes in methylmercury. The rate of change of methylmercury body burden in clams (ng-methylmercury per clam per month) was positively correlated to aqueous unfiltered methylmercury divided by chlorophyll concentration. Change in tissue weight (gms per clam per month) was positively correlated with chlorophyll concentration. Therefore, site-specific changes in methylmercury tissue concentration (ng-methylmercury per gm- dry tissue weight) are predicted to be a function of unfiltered aqueous methylmercury divided by chlorophyll concentration squared.

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150 YEARS OF SEDIMENT DEPOSITION, EROSION, AND GEOMORPHOLOGIC CHANGE IN SOUTH SAN FRANCISCO BAY

Since the California Gold Rush of 1849, trends in sediment deposition, erosion, and the geomorphology of South San Francisco Bay have been altered by both natural processes and human activities. On the eve of a large-scale tidal wetland restoration project of up to 15,100 acres of South Bay salt ponds, it is essential that we advance our understanding of this dynamic estuary. In order to assess spatial and temporal variations in sedimentation processes within the bay, along with changes in tidal flat extent, we analyzed a series of five hydrographic and topographic surveys collected from 1858 to 1983.

South San Francisco Bay experienced a net loss of sediment from 1858 to 1983. However, within this timeframe, there have been periods of both deposition and erosion. From 1858 to 1898, net sedimentation was near zero. From 1898 to 1931 and from 1956 to 1983, sediment loss approached 3 x 10^6 m^3/yr. During the intervening period, from 1931 to 1956, sediment accreted at a rate of approximately 3 x 10^6 m^3/yr. From 1858 to 1983 tidal flat area decreased by 40%. During this same time period, more than 80% of tidal marshes were converted to salt ponds, agricultural fields, and urban areas.

To aid in the development of salt pond restoration plans, the California Coastal Conservancy funded a topographic LIght Detection And Ranging (LIDAR) survey along with a bathymetric survey of South San Francisco Bay in the spring of 2004. These recently collected data will be combined with our historical time series to determine changes that have occurred within the past 20 years. In addition to providing information regarding the feasibility of wetland restoration, this research provides information essential for the development of geomorphic and hydrodynamic models of South San Francisco Bay.

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MERCURY METHYLATION AND DEMETHYLATION RATES IN SALTMARSHES BORDERING THE HAMILTON ARMY AIRFIELD ON SAN PABLO BAY

The re-establishment of wetlands in the San Francisco Bay/Delta System using dredged material has the potential for mobilizing mercury present in the sediments. The origin of this contamination in the Bay System is largely from the historic mining of mercury in the nearby coastal mountains. Inorganic mercury can be methylated by certain bacteria in anoxic sediments to methylmercury (MeHg). MeHg is highly toxic and can accumulate in food webs. To estimate standing pool sizes of MeHg in coastal marshes this study evaluated the methylation and demethylation potential in two wetlands near the Hamilton Army Air Field (HAAF) on San Pablo Bay, using a stable isotope approach. Mean sediment concentrations ranged from 0.79 to 1.80 ng MeHg/g DW, i.e. from 0.11 to 2.58 % THg. MeHg concentrations in the macrophytes usually exceeded those in the sediments. Mean MeHg concentrations in macrophytes varied from 1.08 ng/g DW in Spartina stems to 5.59 ng/g DW in roots. The MeHg concentrations in macrophytes found in this study are in the same range as published for other saltmarshes, and greatly exceed those published for another freshwater wetland. Overall, rates of mercury methylation in sediments showed large variability within and among sites. Methylation rates decreased in the order epipelon>macrophyte-vegetated >non-vegetated, and mean values varied between 0.22 and 4.61 % Hg/12 h in the light and between 0.12 and 6.01 % in darkness. Daily MeHg degradation rates varied between 15 and 80 % of MeHg (administered as the Mz 200 isotope). This study will provide site-specific information, needed as a basis for wetland design and management in the San Francisco Bay area.

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INTEGRATING SCIENCE AND MANAGEMENT IN RESTORATION PLANNING AND DECISION MAKING BLACKLOCK RESTORATION IN SUISUN MARSH

Problem Statement: Integrating science into the decision making process while moving forward with restoration planning and implementation in a timely manner.

DWR, in cooperation with the USBR, DFG, SRCD, and USFWS, have acquired and are preparing a restoration plan to restore tidal influence to a 70 acre parcel in Suisun Marsh.

The restoration goal is to develop a self-sustaining tidal marsh that will aid in the recovery of listed and special status plant and animal species. This goal will be pursued through an integrated program of science investigations that will inform the ultimate restoration plan and provide baselines for adaptive management.

Relevance: Upon implementation of the Restoration Plan, this project will contribute to CBDA's ERPP goal of 5,000-7000 acres of restored tidal wetlands in Suisun Marsh.

Approach: In developing a restoration plan for this site, physical, geochemical, and biological landscape life history attributes used to competitive advantage by specific species will be identified. These attributes will be compared to those that are now available, or would be in the near future with adequate trajectories of sediment accretion, hydraulic characteristics, and geomorphology.

The project team will evaluate existing information, conduct specific process studies and hydraulic modeling, and collect continuous tide, flow, and sediment data to develop the preferred restoration alternative. These tools will be used to develop a restoration plan for the parcel.

As a result of physical constraints of the system, integration of science in the decision making process may be driven by factors beyond the control of the scientists and decision makers. Thus, science integration and decision making will be an adaptive process.

Since acquiring the property in December 2003, the agencies have been managing the property and will continue to do so until the Restoration Plan is approved and implemented. Additional funding will be sought for project completion.

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GC/MS SCREENING FOR CURRENT-USE PESTICIDES: EVALUATING AN INVASIVE ASIAN CLAM POTAMOCORBULA AMURENSIS AS A SENTINEL ORGANISM

Accumulation of current-use pesticides by bivalves in San Francisco Bay, followed by biomagnification by upper food web species, such as the green sturgeon and diving ducks, is of concern. A multi-class approach was chosen to screen the most toxicologically relevant pesticides from the California Central Valley that may accumulate in Potamocorbula, based on a review of the physico-chemical properties, toxicological characteristics, and available methodologies. Analytical methods were developed for a subset of pesticides, representing eight chemical classes, selected based on usage, persistence, bioaccumulation potential, and toxicity. Pursuing a multi-class screening approach precluded use of class-specific fractionation techniques, which isolate only a narrow range of components with similar physico-chemical properties; and instead demanded the selective removal of major and minor biogenic matrix components. Towards this end, simple, broad-based cleanup and fractionation techniques (including solid-phase extraction, size-exclusion chromatography, and adsorption chromatography) were developed to remove pigments, phospholipids, fatty-acids, sterols, terpenoids and other matrix interferences from clam tissue extracts. Resultant extracts preferentially retained all targeted classes of current-use pesticides while achieving detection limits of ~0.1-ppb. These detection limits represent concentrations approximately one-to-two orders of magnitude less than the predicted upper concentration limits for Potamocorbula exposed to water concentrations of these pesticides. Applying this approach to screening Potamocorbula collected in the channel adjacent to Roe Island from 1999 – 2003 indicated no current-use pesticides were present above detection limits, with the exception of molinate, a high use thiocarbamate. Molinate concentrations in Potamocorbula decreased from 40-ppb to <1-ppb between June and August, 2000, correlating well with water concentrations of molinate determined over the same interval. Additionally, persistent organochlorine contaminants were investigated and found to be present at extremely low concentrations in Potamocorbula, with PCBs ranging from 50 – 70-ppb, PCDDs/PCDFs <2-pptr, DDTs from 5 – 17-ppb, and chlordanes from 1 – 4-ppb.

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ECOLOGICAL SCORECARDS OF ECOSYSTEM HEALTH FOR THE SACRAMENTO AND COSUMNES RIVERS

The Nature Conservancy is constructing ecological scorecards for two riverine ecosystems (the Sacramento and Cosumnes Rivers) that are the focus of large-scale conservation and restoration efforts. The scorecards track the health of these systems, and the status of known threats to ecosystem viability. They are also intended to provide some measure of the effectiveness of conservation investments. The scorecards have four fundamental components: (1) a set of focal biodiversity targets, which are intended to serve as a coarse-filter/fine-filter approach for representing ecosystem health; (2) a limited suite of key ecological attributes for each target, along with specific indicators that provide quantitative information for measuring target status; (3) defined quantitative ranges of variation for each indicator that correspond to different status ratings; and (4) assessments of the current status of each target, based on rollups of key ecological attribute and indicator status, with a final integration of target status into an overall measure of biodiversity health. Assessing riverine ecosystem health is an important, yet daunting task, even in well studied systems such as the Sacramento and Cosumnes. Expertise on a wide variety of subject areas is required to select appropriate indicators, and incomplete knowledge mandates that subjective decisions be made (especially when defining status ratings). We therefore view the indicators we have selected, and the ratings we have assigned, as working hypotheses, and we invite comments and feedback on our scorecards.

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FATE AND TRANSPORT OF DIURON IN THE WATERS OF CALIFORNIA

Recently, we have completed 4 related studies concerning diuron: algal toxicity identification and evaluation in the Sacramento-San Joaquin Delta watershed, the run-off of herbicides applied to roadsides along highways, the sorption of herbicides to soils, and the modeling of herbicide mobilization by overland flow.

Diuron was the sole cause of algal toxicity in a year-long study (2000-2001) of 14 sites in the urban creeks in the Sacramento and Stockton areas and agricultural drains in the Sacramento River watershed and Delta. Toxic concentrations ranged from <2ug/L to more than 10ug/L. In our storm-water field study of 5 roadside herbicides, only diuron produced concentrations (storm mean of 1ug/L to a maximum sample of more than 10ug/L) in the run-off sufficient for observed toxicity to aquatic test organisms.

In pesticide grab sample monitoring by the DWR Office of Water Quality, diuron is one of the few compounds frequently detected. It is found throughout the Central and Southern portions of the State Water Project (at concentrations of <1ug/L up to more than 10ug/L), nearly always during winter or early spring. However, sampling is typically only 3 times per year so the maximum concentration and overall load is highly uncertain.

One of 13 pesticides on the Groundwater Protection List of the California Department of Pesticide Regulation, it is the most heavily used in recent years (from 1993 through the latest data) varying modestly from 1.1 to 1.5 million pounds/year. It is also listed as a potential carcinogen.

The primary route of degradation is microbial, producing 3,4-dichloroaniline (3,4DCA), which is also seen as the metabolite persisting in urine and is believed to affect occupationally exposed humans.

Increased monitoring and development of better management practices are warranted.

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THREE-DIMENSIONAL HYDRODYNAMIC MODELING TO IMPROVE UNDERSTANDING OF MECHANISMS RELATING FLOW TO ABUNDANCE OF ESTUARINE BIOTA

The abundance or survival of several estuarine biological populations in the San Francisco Estuary is positively related to freshwater flow. These relationships have been described in terms of the location of the 2 psu (practical salinity units) isohaline. The goal of this project is to determine the mechanisms which relate freshwater flow, and resulting estuarine salinity, to the abundance of estuarine biota. As a step toward this goal, a hydrodynamic model was applied to improve understanding of transport mechanisms in the San Francisco Estuary with a focus on San Pablo Bay, Carquinez Strait and Suisun Bay. Observations in these regions indicate strong vertical velocity shear, frequent salinity stratification and large variability in salinity during the tidal cycle. In addition, currents and salinity in shoal regions can be substantially different than in the adjacent channels. Therefore a three-dimensional model that captures spatial and temporal variability in salinity and currents was applied. The model was calibrated using tide and current data and then applied to predict salinity. The predicted salinity showed good agreement with observed salinity on both the tidal time scale and seasonal time scale over a large range of Delta flow. The calibrated hydrodynamic model was then applied to provide insight into transport mechanisms. The relative importance of various transport mechanisms varied spatially and with the magnitude of freshwater flow from the Delta. Given the dynamic nature of tidal hydrodynamics and transport in the San Francisco Estuary and the variable behavior of estuarine biota, these results demonstrate that a three-dimensional model is an appropriate tool to evaluate and refine hypotheses of relationships between freshwater flow and abundance of estuarine biota.

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THREE-DIMENSIONAL SALINITY SIMULATIONS IN TIDAL SLOUGHS

Hydrodynamic modeling of South San Francisco Bay tidal sloughs was performed to assist the development of the South Bay Salt Pond Initial Stewardship Plan. Tidal hydrodynamics in these sloughs are characterized by a large tidal range and strong salinity gradients. In order to capture the spatial and temporal variability observed in the tidal sloughs a three-dimensional model was applied.

The model was calibrated using tide and current data and then applied to predict salinity. The three-dimensional simulations accurately predicted salinity in the South Bay and tidal sloughs during a full range of tidal and flow conditions.

The calibrated model was applied to predict salinity under pond management scenarios. The predicted effects of the pond discharges on slough salinity were often transient and local. Therefore a high resolution model that resolves spatial and temporal salinity variability throughout the tidal cycle is required to estimate the effects of managed pond discharges.

The simulation results were analyzed to provide insight to salt transport mechanisms. Transport of salt in the sloughs depends strongly on tidal dispersion mechanisms and is affected by vertical salinity stratification and shear.

The three-dimensional model resolves these transport mechanisms without a large number of site-specific empirical parameters. In contrast, one-dimensional and two-dimensional models require dispersion coefficients to approximate the salt transport resulting from three-dimensional transport mechanisms. These dispersion coefficients are valid for a limited range of conditions and may function poorly during high flow periods and periods of particularly strong or weak tides. Furthermore the dispersion coefficients may not be valid for project conditions which result in altered tidal prism or salinity gradients in the sloughs. Because the only site-specific parameters in the three-dimensional model are bottom roughness coefficients, the model is a more reliable predictive tool than lower dimensional models.

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USE OF STEELHEAD ADULT AND REDD SURVEYS TO ESTIMATE ESCAPEMENT AND HELP MANAGE RESERVOIR RELEASES

Abundance estimates of naturally spawning steelhead are not available for the American River, or for many other Central Valley rivers. Fish entering Nimbus Hatchery provide yearly adult steelhead counts. However, hatchery counts do not provide information regarding numbers of fish spawning in the river, which is needed for determining the status of the listed species.

Our primary objective in this work is to devise a method for providing yearly estimates of in-river spawning steelhead abundance or an index of abundance that will be comparable from year to year. Secondary objectives include determining how the managed flows affect steelhead spawning locations, timing, and egg to fry survival and determining what proportion of in-river spawning steelhead are of natural (vs. hatchery) origin.

Abundance estimates based on redd counts ranged from 201 to 486 spawners in 2002 through 2004 while hatchery returns ranged from 883 to 1,759 steelhead. Abundance estimates based on adult steelhead counts were 343 and 307 in-river spawners in 2003 and 2004 respectively. By mapping redds in GIS, we documented steelhead redd dewatering areas and identified effects of proposed and actual flow changes on redds. Steelhead often selected side channel areas for spawning, especially during higher flows. We found that most in-river steelhead spawners appear to be hatchery produced fish and that spawning peaks later in the river than in the hatchery. Steelhead spawning data (redd locations and water depths) was used to help manage Nimbus releases during the steelhead run each year and identified upstream effects of Delta fish protection standards.

The protocol developed through this work could likely be adapted to other Central Valley rivers where visibility and access is adequate to conduct spawning surveys, either counts of adult steelhead or redds, during the winter months.

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IRWM PILOT PROJECT: MONITORING BIRDS IN TIDAL WETLANDS OF THE SAN FRANCISCO ESTUARY

To assist the California Bay-Delta Authority (CALFED) in the assessment of conservation and restoration efforts in the San Francisco Estuary, we have implemented a comprehensive monitoring program for avian species in the tidal wetlands of Suisun and San Pablo Bays, as well as the Delta, as part of the Integrated Regional Wetland Monitoring (IRWM) project. Our pilot project, focused on tidal marsh habitat (the subject of major restoration activities in the Estuary), will lay the foundation for a longer-term avian monitoring program to assess changes in ecosystem processes affected by wetland restoration.

Bird species' presence and function in a given marsh are determined by physical and biotic factors, as well as demographic constraints imposed by their life histories. We are investigating how the heterogeneity of physical processes, plants, habitat, and landscape affect the structure and ecological function of the tidal marsh bird community. We are examining distribution and abundance patterns of a broad spectrum of ecologically and taxonomically diverse birds in both restoring and natural marshes. We are also assessing important stressors on bird populations, such as predators and flooding risk. Collaboration with the other IRWM teams will allow us to study interactions of birds with vegetation and how birds may be limited or influenced by landscape-level factors, hydrological and geomorphic processes, and prey (fish and invertebrates).

To implement this program, we are using a combination of general marsh surveys that provide information about most species, and specialized surveys for taxa that can only be so monitored (such as Clapper Rails and Black Rails). An important component of our program is to determine reproductive success of select species in restored and reference marshes, which has not previously been studied. In addition, we will analyze reproductive performance of heron and egret colonies in relation to habitat composition and heterogeneity.

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STEELHEAD REDDS AND EVOLUTION OF INTER-GRAVEL DISSOLVED OXYGEN LEVELS IN THE LOWER AMERICAN RIVER

Dissolved oxygen (D.O.) levels were monitored in steelhead redds during the Spring 2004 spawning run. The American river is a regulated river controlled by Folsom and Nimbus dams. Spawning habitat is limited, and studies have shown that spawning steelhead often construct redds in areas with marginal inter-gravel D.O. The hypothesis of this study is that steelhead and other salmonids modify the stream bed and improve D.O. levels during spawning. The project began after observing salmonids spawning in areas where inter-gravel D.O. is known to be low.

Miniature drive point tips were installed in four steelhead redds. All sampling tips were placed at the depth of the egg pocket, and each redd was instrumented with four tips that formed a longitudinal transect from the upstream side to the tail spill of the redd. Field parameters including p.H., D.O., water level, and surface water velocity were measured at each site. A flow-through cell and micropurging technique minimized impact on the redds.

Results show a higher level of D.O. in the egg pocket than other nearby inter-gravel sites. Average upstream D.O. was 5.5 mg/l, average egg pocket D.O. was 8.2 mg/l, tail spill D.O. was 6.9 mg/l, and the downstream D.O. was 5.3 mg/l. The D.O. spike around the egg pocket is interpreted to show modification and enhancement of gravel permeability by spawning salmonids.

Average D.O levels decreased from 7.2mg/l to 3.0mg/l during the study period. As the spawning season progressed, lower surface water velocity, lower hyphoreic flow, infiltration of fines, and accumulating metabolic waste have all contributed to oxygen consumption. This project explains the importance of modifications that salmonids make to their environment, and helps explain spawning site selection in areas with low inter-gravel D.O. levels.

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OBSERVATIONS OF CIRCULATION, STRATIFICATION, AND TURBULENCE IN THE STOCKTON DEEP WATER SHIPPING CHANNEL

A series of field experiments are being conducted to understand the physical mechanisms associated with low dissolved oxygen events in the Stockton Deep Water Shipping Channel (SDWSC). We are investigating how diurnal heating, tidal mixing, and freshwater inflow affect the balance of dissolved oxygen in the channel. The first set of measurements was made during August 2004. The measurements were designed to characterize the vertical, longitudinal, and temporal variability of the circulation and temperature fields. Several moorings were deployed along a 15-km longitudinal section of the San Joaquin River downstream of Stockton. Each mooring consisted of an upward-looking ADCP and a vertical array of thermistors. Additional moorings were placed in tributaries to the main channel to measure inflow and water level. Concurrent with the moored deployments, shipboard ADCP/CTD-DO cruises were conducted during spring and neap tides. Shipboard SCAMP microstructure profiles were taken during the cruises to determine the vertical structure of turbulent kinetic energy dissipation. Collectively, these data will help address questions about role of vertical stratification, tidal mixing, and freshwater inflow on dissolved oxygen in the SDWSC.

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METHYL MERCURY ACCUMULATION IN CHINOOK SALMON REARING IN THE SACRAMENTO RIVER AND THE YOLO BYPASS

In its methyl form, mercury has been shown to be damaging to several species of fish as well as to humans. The literature indicates a strong correlation between inundation of previously oxidized soils, such as that which can accompany flood plain or wetland inundation, and increased microbial methylation of mercury. As a consequence, there is concern over the potential for proposed wetland restoration in and around the San Francisco estuary to result in a significant increase in methyl mercury levels. Concern is perhaps greatest in locations such as the Yolo Bypass, a 59,000 acre floodplain that receives inflow from Cache Creek, the source of approximately 50% of the total methyl mercury load to the San Francisco estuary. Methyl mercury has been shown to bioaccumulate at higher trophic levels, creating the potential for higher body burden in predatory fish species such as Chinook salmon that use the Yolo Bypass as a primary rearing area. Our study builds on this research, through a comparison of methyl mercury accumulation in juvenile hatchery Chinook salmon placed in enclosures in the Sacramento River and in the Yolo Bypass during a winter 2004 flood event. For each of the study 2004 groups, we examine methyl mercury content and growth rate To provide an indication of temporal variability in bioaccumulation in floodplain salmon, we analyzed methyl mercury levels of Coded Wire Tagged (CWT) released in Yolo Bypass each year during 2001-2004.

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COMPARING CHINOOK SALMON CARCASS COUNTS WITH WEIR COUNTS ON MOKELUMNE AND STANISLAUS RIVERS

Carcass surveys have been performed on many rivers in California's Central Valley since the 1950's. Various techniques have been used over time but since the early 1970's mark-recapture estimates have been made, primarily with what is called the modified Schaefer method. Statisticians however have repeated called for use of the Jolly-Seber method. The Jolly-Seber method requires somewhat higher numbers of recoveries and so may not be effective in all situations. During the 2003 fall-run survey season carcass surveys and weir counts were performed on both the Stanislaus and Mokelumne Rivers. We evaluated the use of Schaefer and Jolly-Seber estimates on these two rivers against counts of fish entering the river. In the Mokelumne where there were approximately 2,000 natural spawners, the Schaefer method estimated the wild spawning fish best. On the other hand, the Jolly-Seber more accurately represented the fish on the Stanislaus River which had approximately 5,000 wild spawners. We also evaluated the timing of upstream migration compared to spawning timing, which indicates early fish arrive weeks before spawning begins. Length frequency was compared between the two count methods and indicates that smaller fish maybe underrepresented in the spawning surveys. This and future studies will allow managers to develop more accurate estimates of chinook spawner abundance in the Central Valley.

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EVALUATION OF CHINOOK SALMON REDD COUNTS AND THEIR LOCATION IN THE TUOLUMNE RIVER

Restoration efforts, especially spawning habitat, increased greatly during the 1990's. Concurrently, interest with salmon spawning, where they spawn and the characteristics of habitat has increased. Since the 1950's CDFG performed spawning surveys in the San Joaquin River basin. Redds counts were added to those surveys in the 1980's. The survey crew counts redds as they float a riffle area in a boat. These counts are often a portion of the actual number that are present in the riffle. More accurate numbers of redds per riffle, to compare to the number of females that spawn would be useful. A field check of subsets of the riffles on the Tuolumne River and use thereof as a calibration for the redd numbers obtained by the spawning escapement crews was designed. Past counts of redds could then be "corrected" so that 20 years of data could be analyzed in a new way. Primarily goal is to develop this calibration mechanism and secondary goal evaluate how salmon used the riffles for spawning. The survey was performed in 1998 and 1999. Riffles (60 to 70 total) were stratified by extent of use and size. Each of these dimensions was given three categories of large, medium and small. Randomly three riffles were chosen from each of the nine groups. These riffles were surveyed on foot three times each year, redds mapped and counts compared to carcass survey redd counts. Counts are most affected by use of the riffle. High use counts are 1/3 of actual, medium use counts are ½ of actual and low use are usually the same. The top and bottom (half) of the riffle get 70% of the redds which is more evident in steeper riffles. This information will be useful in designing future gravel infusions.

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"OTOLITHS, INCREMENTS AND ELEMENTS": KEYS TO A COMPREHENSIVE UNDERSTANDING OF FISH POPULATIONS AND RESTORATION

One of the primary goals of the CALFED Ecosystem Restoration Program focuses on the recovery/restoration of the native fish populations through management of water quality, quantity and habitat restoration. Understanding how native fish populations utilize habitats within the San Francisco Estuary will provide the key to unlock the problems faced by ecosystem managers.

Fish otoliths or "ear stones" are biogenic structures in the inner ear of the fish, and are constructed of layers of calcium and protein, which are formed daily. The daily formation of fish otoliths allows researches to determine the age, growth rate and health status of an individual fish. Second, trace amounts of chemical elements can be incorporated into the calcium carbonate, which is derived from the surrounding waters. Different habitats or regions of the estuary vary in the concentration of these chemicals, thus recording location of a fish. By unlocking the information within the otolith, we can quantify the link between habitat use and fish health.

In this poster session, we present information regarding native species life history dynamics as revealed with otolith microstructure and microchemistry techniques. Lewis, et al and Rose et al, describe how a native goby, the longjaw mudsucker (Gillichthys mirabilis) and top smelt (Atherinops affinis) utilize saltmarsh habitats of San Pablo Bay, and how contaminants in saltmarshes can influence growth and survival. Feyrer et al. and Zang et al. describe the migration history and population structure of a freshwater marsh inhabitant the Sacramento splittail (pogonichthys macrolepidotus). Lastly, Rosenfield et al. and Hobbs et al. describe the migration history and habitat utilization of the pelagic longfin smelt (Spirinchus thaleichthys) and the threatened delta smelt (Hypomesus transpacificus). The information provided in this poster session will provide key information for the restoration of native fish populations.

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EXPERIMENTAL DESIGN APPLIED TO ADAPTIVE MANAGEMENT OF INVASIVE SPECIES

We have developed an adaptive management framework for control of perennial pepperweed (Lepidium latifolium) at the Cosumnes River Preserve that closely follows the recommendations of the July 2003 CALFED workshop on Adaptive Management of Non-native Invasive Species (NIS). Our project inventories and monitors existing pepperweed populations at the Cosumnes River Preserve to provide background data of the baseline condition from which to statistically analyze population change. Targeted research on control of pepperweed will use a scientific hypothesis-testing approach to refine our conceptual model and guide future adaptive management actions. This ongoing research is explicitly designed to add to existing knowledge about relationships between management techniques and ecosystem processes by testing hypotheses on weed control and restoration success.

We have modeled pepperweed population expansion trajectories and the effects of extrinsic factors on these trajectories in unmanaged populations, allowing us to block our sampling sites for experimental treatments by significant extrinsic factors that affect pepperweed population dynamics. Performance of management techniques will be measured not only by changes in pepperweed density, abundance and rate of spread, but also by tracking changes in native species population dynamics at treated versus untreated sites. This information will aide in quantifying impacts of pepperweed in relation to ongoing restoration projects at the Preserve. The results of this adaptive management methodology can be used to model future management scenarios, and thus identify best management practices for pepperweed based on site-specific characteristics of areas targeted for restoration and management. The project and methodology support CALFED initiatives on adaptive management by examining baseline conditions and management interventions in a scientific framework. This approach also meets the goals of CALFED NIS management by using replicable methods which can limit future expansion of pepperweed and improve restoration success of riparian vegetation.

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DOES SHREDDING WATER HYACINTHS AFFECT MERCURY SPECIATION?

Eichhornia crassipes (water hyacinth) is a non-native plant species found in abundance in the San Francisco Delta. Water hyacinths have become a problem by clogging the waterways and wetlands of the delta. They are also known to accumulate mercury, especially in the root system. Previous attempts to curb their proliferation have centered on the use of herbicides which subsequently pose environmental concerns. Current methods include shredding the water hyacinths with specialized boats. This research is to better understand the ability of water hyacinths to phytoremediate mercury, and to determine the effect of shredding on mercury speciation in the hyacinths.

Plant samples were collected from the Dow Wetlands and grown in 1ppm $HgCl_2$ under (1) aerobic conditions, (2) anaerobic conditions, and (3) with shredded plant material only. Water hyacinth roots and shoots samples were analyzed for mercury using CVAA. Plants were also analyzed at Stanford Synchrotron Radiation Lab using X-ray absorption spectroscopy (XAS), a method to examine speciation that is element-specific and non-invasive.

As expected the roots had a greater concentration of mercury than the shoots, and shredded hyacinths had a lower mercury uptake than live hyacinths. XAS data revealed that roots undergo speciation changes from a more ionic form in aerobic live plants, becoming more covalent in anaerobic conditions, and more so in shredded plants. During the summer of 2004 these data will be compared with concurrently collected XAS data on known inorganic and methylmercury forms, to complete the speciation process and determine whether shredding is affecting the degree of mercury methylation. This is strongly relevant to the CALFED goal of minimizing mercury methylation in the Delta.

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DEVELOPING A STANDARD ASSESSMENT METHODOLOGY FOR THE SACRAMENTO RIVER BANK PROTECTION PROJECT

An Interagency Working Group for the Sacramento River Bank Protection Project has developed a Standard Assessment Methodology (SAM) to compare T&E fish species responses to habitat features affected by bank protection projects in support of past and future consultations with NOAA Fisheries and U.S. Fish and Wildlife Service on T&E salmonids and Delta smelt. The SAM integrates knowledge regarding biological requirements of the T&E fish species with habitat analysis using field surveys, GIS, hydraulic models, geomorphic meander migration models, riparian growth and potentially woody debris recruitment models. Because of the difficulty in separating the effects of bank protection on the T&E fish species from all other factors, an approach based upon tracking seasonal and long-term habitat quality for each T&E fish species was adopted. Using assumptions related to differences in predation risk, food availability, and growth, six habitat variables (bank slope, floodplain inundation, bank substrate, in-stream structure, aquatic vegetation, and shade) are translated through conceptual models to derive responses for each species and life stage. Next, a series of habitat evolution scenarios are developed at various time intervals to represent the long-term changes in habitat conditions. Scenarios may be developed by field measurements, professional judgment, or more explicit modeling techniques. Comparisons and compensation requirements are made based upon differences in modeled species response from the pre-existing environmental baseline. Pilot testing at a number of sites demonstrates that the SAM is capable of discriminating the habitat requirements of particular life stages of the T&E fish species. Successful application of the SAM to meet the needs of T&E species is dependent upon the restoration of larger scale riverine processes through riprap removal and levee setback projects. The SAM will influence future scientific research, watershed management, ecosystem restoration, and levee system integrity within the CALFED area of influence.

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ELEMENTAL MERCURY, CAN IT BE RECOVERED EFFICIENTLY BY GOLD SUCTION DREDGES?

By now everyone knows that millions of pounds of elemental mercury were lost during California's Gold Rush and as a result, mercury is still found in California's rivers and streams today. Although normally dispursed in sediment, mercury occasionally concentrates in streams, usually on bedrock, in amounts that are visible to the naked eye (i.e., hotspots). A current urban legend purports that recreational gold miners using suction dredges recover substantial amounts of mercury from such hotspots in their pursuit of gold. The legend and the fact that there are several thousand recreational dredgers in California, led state and federal agencies to consider offering incentives to encourage recreational dredgers to recover and turn in mercury. Unfortunately, no one knew if "off the shelf" gold dredging equipment would recover mercury efficiently.

In October 2003, United States forest Service, Department of Fish and Game, and State Water Resource Control Board staff dredged a mercury hotspot in the South Fork of the American River at Lotus California. The recovery results indicated that "off the shelf" suction dredges are not efficient at recovering liquid elemental mercury.

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RELATIONSHIPS AMONG SPECIES RICHNESS, SITE ATTRIBUTES AND SURROUNDING LAND USE IN SACRAMENTO VALLEY RIPARIAN AREAS

To support development of setback guidance and assessment methods for riparian areas in Western Placer County, we evaluated relationships among species richness, site attributes and surrounding land-cover at twelve sites. These sites represented a random sample, stratified by riparian width, of accessible sites along streams and smaller rivers in the Sacramento Valley and adjacent foothills. At each site, a one-hectare plot was established along the stream bank, and plot attributes, including vegetation structure, were recorded. Available GIS data were used to determine the proportion of land within 250 m, 1 km and 5 km that was in urban, agricultural and natural land-cover types. In the plots, multiple area searches were conducted for vertebrate and butterfly species. A single area search also was conducted for odonates (dragonflies and damselflies), and small mammals were trapped. In these data sets, there were not significant correlations between species richness and riparian attributes. However, there were significant correlations between vertebrate species richness and the proportions of different land-cover types within 250 m to 5 km. Riparian-associated bird species were positively correlated with the proportion of surrounding area in natural vegetation and negatively correlated with the proportion of agricultural lands. Mammal species richness also was positively related to the proportion of natural vegetation, and was negatively correlated with the extent of developed lands. Amphibian and reptile species richness was negatively correlated with the extent of agricultural lands. Though they should be interpreted with caution because of the small sample size, these results indicate that adjacent land uses may strongly affect the habitat value of Sacramento Valley riparian areas, and that such effects should be considered in habitat assessments and in developing setbacks.

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A FUNCTIONAL ASSESSMENT METHODOLOGY FOR CENTRAL VALLEY RIPARIAN AREAS

Indicator-based assessments of the functions provided by wetlands are a cost-effective tool for conservation planning, and are becoming widely used. However, most of these methods produce ratings by combining numerous, disparate variables using rules or equations that may lack a mechanistic basis. Consequently, communicating, interpreting, and defending the results of these assessments can be problematic. To avoid these potential problems, we have designed an assessment methodology for Western Placer County's riparian areas that consists of a single key variable for each category of functions. These key variables were selected as being strongly related to multiple functions, and not requiring intensive on-site measurements. For habitat functions, this variable is cover of natural vegetation on the floodplain and adjacent land. For hydrologic and geomorphic functions, the variable is the hydraulic connectivity of the floodplain and stream channel. For biogeochemical functions, the variable is quantity of runoff from the floodplain and adjacent land. These three variables are used as indicators of functional capacity (i.e., the amount of function provided) and integrity (i.e., resemblance to unaltered conditions). In this functional assessment methodology, the scores for these three indicators are not combined into a single quantitative assessment score, but instead each indicator's value is reported for all evaluated sites. The results produced by this assessment method are readily communicated and interpreted, and can contribute to conservation and restoration planning at site, watershed and regional scales. Though this approach was developed for Western Placer County, it or a comparable methodology would be applicable throughout the Central Valley and adjacent foothills.

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ORGANIC CONTAMINANTS IN SEDIMENTS FROM STEGE MARSH, SAN FRANCISCO BAY, CA

Surface sediment samples from Stege Marsh, San Francisco Bay, CA were analyzed to investigate the levels and sources of persistent organic pollutants and to assess their potential adverse effects. Chemical data were compared to sediment quality guidelines (SQGs) to rank areas that warrant further detailed study on the actual occurrence of toxicity of contaminants in sediments on aquatic organisms. Total PAH (polycyclic aromatic hydrocarbon) concentrations ranged from 2,590 to 10,700 ng/g (dry wt.). PAH distribution patterns and selected PAH ratios indicated that emission from fuel combustion is likely a major source of PAHs. Stormwater runoff from adjacent urban area entering via Carson Creek may be a major pathway transporting PAHs into Stege Marsh. Total PCB (polychlorinated biphenyl) concentrations ranged from 148 to 9,940 ng/g. PCB congener distribution patterns were similar to Aroclor 1240. Concentrations of total DDTs and chlordanes ranged from 41.4 to 176 ng/g and 10.8 to 85.1 ng/g, respectively, and were much higher than those in ambient San Francisco Bay sediments. Emerging pollutants such as polybrominated diphenyl ethers (PBDEs) and phthalates will be analyzed and updated soon. In all samples, PEL (probable effects level) quotients of PAHs were above 1. PCBs, DDTs and chlordanes exceeded PEL up to 18 times, indicating that higher incidence of adverse effects on aquatic organisms are expected. Estimated body residues of PCBs, DDTs and chlordanes in fish tissue using theoretical bioaccumulation potential (TBP) were above EAP human health risk threshold and California screening values. The results from this study indicate that Stege Marsh is highly contaminated by organic chemicals and likely to impact human health and aquatic life. When SM sediments need to be dredged, it is important to note that they are not available for beneficial uses, such as habitat restoration.

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NEW LIDAR AND BATHYMETRIC SURVEYS OF SOUTH SAN FRANCISCO BAY FOR SALT POND RESTORATION PLANNING

The planning of restoration of salt ponds requires high quality data on elevations and depths in the project area. Without this data, efforts to design a successful restoration must rely on available data, which are often outdated and incomplete. In the spring and summer of 2004, two surveys were conducted to collect data for planning of salt pond restoration in South San Francisco Bay and as a pre- restoration baseline. From May 5 to 21, an airborne topographic LIDAR survey was made of the pond areas, intertidal mudlats (flown at tides below Mean Lower Low Water), marshes, and the 100-year floodplain. The survey area was more than 300 km^2, extending from the Alviso ponds to Oakland airport on the east shore and to San Francisco airport on the west shore. Data density was greater than one point per square meter. Georeferenced digital video was also collected during the survey. In July and August 2004, a bathymetric survey from Hunters Point south was conducted. Bathymetric surveys of the ponds were also conducted in 2003 and 2004. The combined topographic and bathymetric data set will be used by scientists and managers to improve the probability of a successful restoration of the South San Francisco Bay salt ponds. Preliminary maps of these surveys and of geomorphic change in the bay since the 1980s will be presented.

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RECONSTRUCTING CONTAMINANT DEPOSITION IN A SAN FRANCISCO BAY MARINA, CALIFORNIA

Proper site characterization is an important first step for the management of persistent metal contamination of shallow sediments. Site characterization is particular challenging in estuaries due to multiple sources of contamination, release histories, and depositional patterns. The Seaplane Lagoon at the former Alameda Naval Air Station on San Francisco Bay is ideal for demonstrating quantitative techniques for understanding the deposition of contaminated sediments since it has a well-defined geometry, limited exchange with the Bay, limited contributions from upland areas, and an identifiable pre-contaminant surface from the original dredging in the 1930s. The Seaplane Lagoon is typical of conditions encountered at many active and closed military bases where liquid and solid wastes were improperly disposed of over decades. Twenty five sediment cores 1-3 meters in length were collected from the 45 hectare Seaplane Lagoon to determine both spatial and historic variability of sediment contamination resulting from discharge of industrial wastewater. Within the lagoon sediments, Cs-137 from atmospheric weapons testing and Ra-226 from the release of luminescent paint facilities on the base are unique tracers for sediment deposition. Experiments on total metal variability under investigation at the Advanced Light Source, Lawrence Berkeley National Laboratory, have demonstrated the capability to simultaneously quantify a number of metals (Ti, Cr, Mn, Fe, Ni, Cu, Zn, Kr, Rb, Sr, Pb) in wet sediments using X-ray Fluorescence spectroscopy. Utilizing a 250 micron spot size we have resolved spatial correlation patterns corresponding to sub-seasonal timescales. Kriging estimates of radionuclide and metal concentrations over the entirety of the lagoon are utilized to create a 3-D image illustrating spatial variability of deposition, a critical tool to regulators managing sediments at the contaminated lagoon.

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COSUMNES GEODATABASE: LEVERAGING SPATIAL DATA FOR FLOODPLAIN SCIENCE

Effective data management and organization can accelerate collaborative research in ecosystem science. Too often, data are collected in varying formats and structures, which can lead to extensive efforts at reconciliation among researchers. We are successfully using Geographic Information Systems (GIS) and database technology, however, to coordinate data collection efforts from a variety of disciplines. We discuss integrating the efforts of the Cosumnes Research Group by using the geodatabase concept for data organization. Our efforts allow researchers to investigate the interrelationships of various ecosystem components in the Cosumnes River watershed.

Developed by ESRI Inc., the geodatabase, short for geographic database, is a storage format based on relational database technology. A geodatabase is a single-container repository, which supports multiple formats of spatial and non-spatial data, including maps, tables, text, images, and associated metadata. A robust, centralized container is ideal for storing, editing, analyzing, serving and archiving natural resource data; furthermore, geodatabases have the potential for sophisticated rules and relationships among objects. This makes a geodatabase ideal for cataloging environmental information for the Cosumnes River watershed.

Aside from serving as a central data store, maps produced from the geodatabase are insightful and provide a resource for better decision-making. Spatial attribution, the framework for data element storage, allows better field coordination, improved sampling design, and temporal coverage of research protocols. Other benefits of the geodatabase concept are: project maps can be standardized; field data can be uniform in their site description; and advanced spatial analyses can be conducted. These benefits are critical to collaboration in the Cosumnes River floodplain and promote better communication in the greater CALFED community. By integrating our information assets using the geodatabase concept, we are able to get more research value out of the investment in GIS technology.

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SEDIMENT GEOCHEMISTRY AND MERCURY IN BIOTA AT HAAF AND CHINA CAMP, SAN PABLO BAY, CA

Clean dredged material from San Francisco Bay harbors and channels will be used to restore nearly 1000 acres of lost wetlands at the Hamilton Army Airfield (HAAF) site. Wetlands tend to produce the conditions for methylation of mercury when other forms of mercury are present, as they are in most of the sediments of San Francisco Bay. Analysis of surficial soils/sediments at HAAF and China Camp showed mobilization of mercury as MeHg. Management of mercury methylation in reconstruction of the HAAF salt marsh will require knowledge of characteristics of the sediments that relate to mercury methylation and the uptake of mercury in resident biota. We took soil/sediment cores at the intertidal zones and selected upper marsh sites at HAAF and China Camp, sectioned them by depth, and analyzed the geochemical constituents. Analytes were THg and MeHg, PSD, AVS, TOC, Fe, Al, selected trace elements, and mineralogy. Eh/pH measurements on depth sections were made in situ. Clams, snails, and mussels were collected as found at the sample sites and were analyzed for THg and MeHg. Sulfide and redox potential in intertidal sediments were inversely related to depth, the redox cline occurred within 2-5 cm of the surface, and MeHg concentrations were highest at the surface and declined with increasing Eh negativity. THg increased with depth and was inversely related to MeHg (rho = -0.60 to -0.89). Bioaccumulation was evidenced by all organisms with THg in mussels and crabs averaging 15-30 ng/g ww and snails averaging 100 ng/g. Biota MeHg in THg ranged 10-90%. Bioaccumulation factors (BAF, dw basis) were 12 for the snails and 1-4 for the crabs and mussels. Results will be used in parameterization of QnD:HAAF, a testable and iterative site-specific model for management of mercury in wetlands restoration at HAAF.

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INFORMATION ACQUISITION AND ADAPTIVE WATERSHED MANAGEMENT: AN APPLICATION TO IN-STREAM WATER TEMPERATURE AND SALMON SURVIVABILITY

This research provides an empirical tool for developing adaptive watershed management strategies with an application to in-stream water temperature and threatened salmon populations. Summer rearing for Coho salmon occurs in water that may exceed 18^{o}c, at which time the salmon produce a heat stress protein, lowering their survivability. When the temperature exceeds 24^{o}c the salmon experience acute respiration problems, which is fatal within two hours.

Implicit in adaptive management is information acquisition and data collection. Information contained in data allows managers to understand system dynamics, predict trends, and thereby adapt watershed management strategies to improve their effectiveness. However, estimating complex environmental systems faces obstacles from limited data and ad hoc distributional assumptions. The sequential entropy filter (SEF), first presented by Kaplan and Howitt, estimates watershed processes when the data comes from small samples and with minimal distributional assumptions. The SEF also captures changes in model parameters over time and space, thereby facilitating empirical economic analyses of adaptive watershed management strategies.

In the empirical illustration in-stream water temperature daily cycles are a function of stream flow, air temperature, and riparian shade. The management variables, flow and shade, can be changed slowly by altering water withdrawals and restoring riparian shade habitat, respectively. The results from adaptive management simulations show the mean and amplitude of the temperature cycles respond to changes in the shade and flow parameters, and a change in both parameters modifies the cycle to avoid the critical 24^{o}c threshold, and reduce exposure to temperatures above 18^{o}c.

This analysis provides a useful empirical tool for evaluating economic and environmental tradeoffs critical to achieving scientifically-determined watershed goals such as improving watershed management, protecting fish populations, and restoring habitat and ecosystems. Furthermore, the research methodology advanced in the research is sufficiently general, thereby facilitating application to watersheds within throughout the Bay-Delta.

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FISH PASSING TRASHRACKS: THE INFLUENCE OF BAR SPACING AND WATER VELOCITY

Within the Sacramento-San Joaquin Delta Ecosystem, trashracks (large metal grates that protect diverted-water channels and associated fish-salvage facilities) are hypothesized to inadvertently facilitate predation (e.g., by striped bass, Morone saxatalis) on vulnerable, small resident and migratory fishes. Experimental observation of several Delta fishes' behavior around trashracks (90.8-kl flume) showed that fish resisted passage through 3.8-cm or 15.2-cm clear trashracks, if they could maintain position in the flowing water (either 31 or 62 cm/s average velocity). Whereas no striped bass (10 – 50 cm SL) or larger winter-run Chinook salmon (Oncorhynchus tshawytscha 15 cm SL) passed either trashrack, > 60% of the threadfin shad (Dorosoma pretense) passed the two trashracks at 31 cm/s and ca. 100% passed each rack at 62 cm/s. At 62 cm/s, ca. 50% of <10 cm SL winter-run Chinook, 100% of <10-cm SL splittail (Pogonichthys macrolepidotus) and 100% of the adult Delta smelt (Hypomesus transpacificus) passed each rack (bar spacing without effect on the level of passage). At 31 cm/s there was a significant difference (1 cm) in SL between the shad that passed and those that did not pass. Bar spacing affected the residency time (before passing) in front of the racks, being significantly lower in the presence of the 15.2 cm clear rack than in front of the 3.8 cm rack. This was most notable at 62 cm/s. Understanding interspecies- and intraspecies-specific behaviors around these structures is essential to understanding how predatory environments are set up in these altered aquatic systems. Research supported by the California Department of Water Resources and CALFED.

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EFFECTS OF METHYLMERCURY ON GREEN STURGEON, ACINPENSER MEDIROSTRIS, BIOENERGETICS AT VARIOUS LIFE STAGES

Restoration projects in California may accelerate the methylation of mercury (Hg), increasing related risks to wildlife and human health. Green sturgeon are considered a species of special concern In California, and nothing is known regarding the effects of this toxicant on its lifestages' bioenergetic parameters essential for efficiently using resources and survival. Spawning and development of this species is limited to two watersheds in California, Klamath/Trinity and Sacramento river systems. Both of these watersheds are known to be contaminated with mercury and methylmercury. Three experiments were conducted to determine the effects of methylmercury on green sturgeon bioenergetics. Green sturgeon eggs, larvae, and juveniles were exposed to methylmercury via three routes: egg immersion, larval injection, and dietary exposure. We investigated the effects of methylmercury on embryonic development, hatching success, and growth following exposure to aqueous concentrations of methylmercury during the water hardening phase of the egg chorion post fertilization. Newly hatched, exposure naive, sturgeon larvae were injected with one of four dose regimes of methylmercury into the yolk sac. We examined the effects of methylmercury, administered by injection, on larval growth, oxygen consumption, swimming performed and survival. Juvenile green sturgeon were exposed for 40 days to four different dietary concentrations of methylmercury. Measured parameters include growth, swimming performance, oxygen consumption and survival. Our developmental and bioenergetic data will assess the risks of physiological compromise in green sturgeon embryos, larvae and juveniles exposed to methylmercury, assisting ecologists in evaluating risks and benefits of proposed restoration efforts slated for the Sacramento, Klamath and Trinity River watersheds.

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EVALUATING STORM DRAIN FILTERS FOR POLLUTANT REMOVAL

Storm water originating from street and highway run-off contains pollutants such as used engine oil / grease and metals that are either dissolved or bound to particulates. Many of these pollutants are toxic to aquatic life at very low concentrations and threaten to degrade water quality in California's water bodies such as the Sacramento/San Joaquin Delta. As the population and related automobile use grows, pollutant loading will increase unless control technologies (also known as Best Management Practices or BMPs) are implemented. With funding from the California Integrated Waste Management Board, the Center for Regional Environmental Science and Technology (CREST) and the Office of Water Programs at California State University Sacramento are collaborating on a project to evaluate the ability of drain inlet filters to remove these pollutants from storm water run-off. In the first phase of this work, the abilities of different drain inlet filters to capture and retain oil and grease are being evaluated. Four commercially-available filters are being tested. Initially, water containing concentrations typical of urban runoff is being passed through the filters. Later, oil will be directly applied to simulate an accidental or illegal disposal scenario. The study design, analytical methodology, and preliminary results on oil and grease removal under typical storm water conditions will be presented. The second phase of the project involves the development and testing of a bench-scale, three-stage filter to remove particulate matter, oil and grease, and dissolved metal ions. Preliminary results will be presented on the types and concentrations of different metal ions in Sacramento area storm water and the ability of a second filtering stage to selectively remove and retain these metal ions.

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APPLICATION OF A SPATIALLY-EXPLICIT ECOSYSTEM MODEL FOR REDUCING METHYLMERCURY RELEASES FROM RESTORED WETLAND AREAS

The restoration effort of the former Hamilton Army Air Field (HAAF) presents significant questions on strategies to limit the production of methylmercury (meHg). These questions include the temporal and spatial-scale of meHg production as well as the dynamics of its trophic transfer through the food chain. The Questions and Decisions™ (QnD™) screening model system was created to provide an effective and efficient tool to incorporate ecosystem, management, economics and socio-political issues into a user-friendly modeling framework. The model is written in object-oriented Java and can be deployed as a stand-alone program or as a web-based (browser-accessed) tool. The QnD model links the spatial components within geographic information system (GIS) files to the abiotic (climatic), biotic and chemical/contaminant interactions that exist in an environmental system. The model development is iterative and can be initiated through conversations with scientists, potential model users or stake-holders.

An initial version of the QnD model for the Hamilton site (QnD:HAAF) was designed to use experimental results from current and on-going US Army Corps of Engineers research at the HAAF site. The prototype model was constructed with four idealized marsh habitats (Salicornia-dominated marsh, Spartina-dominated marsh, Mudflats and SubTidal areas) with representative plant, invertebrate and higher trophic-level species. Simplified methylation/demethylation relationships were combined with bioaccumulation factors to simulate elementary uptake/release dynamics. Two, 14-day scenarios were simulated at an hourly time step to represent seasonal dry and wet periods. Results from simulations indicate a significant seasonal meHg production/export potential along with related trophic transfer levels. An important aspect of this meHg production/transfer is the elevation of the different habitats and their oxic/anoxic status in relation to other influences such as light conditions. The model results and design are iterative so that both scientific and management issues can be modified and tested adaptively for further collective learning.

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PARTNERS IN THE RIPARIAN RESTORATION PROJECT AT THE BATTLE CREEK WILDLIFE AREA

In 1983, the Wildlife Conservation Board (WCB) funded the purchase of the 582-acre Battle Creek Wildlife Area (BCWA), which is managed by the California Department of Fish and Game (DFG). Last year, WCB awarded a restoration grant to Ducks Unlimited for wetland construction and riparian restoration along the Oak Tree Trail at BCWA. River Partners is responsible for the design and implementation of the 21-acre riparian restoration component of the grant. The main riparian restoration activities include: 1) planting of riparian species, predominantly mid-canopy shrubs and vines; 2) planting of an herbaceous understory, native grasses and sedges; and 3) the removal of invasive plants, Himalayan blackberry and tree-of-heaven.

The riparian restoration project at Oak Tree Trail is relatively small, yet requires a high degree of coordination with DFG and local stakeholders due to pre-1914 water rights to Gover Ditch flows. Gover Ditch, which is diverted from Battle Creek, runs through the BCWA, and also feeds a smaller ditch that will be utilized to maintain the new wetland. To provide visual and ecological continuity between the new wetland and the adjoining riparian area, we included native plantings along the wetland perimeter. The planting design also addresses the hydrologic influence of an existing wetland that is managed by the DFG and populated by beavers.

Battle Creek, which provides critical habitat for federally listed species, including Chinook salmon and steelhead, is an important source of regional hydropower and irrigation. The goal of habitat conservation projects, such as this riparian restoration project, is to improve the quality and connectivity of habitat for wildlife species, and this goal is best achieved when stakeholders work in close coordination.

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MICROMETEOROLOGICAL MEASUREMENT OF EVAPOTRANSPIRATION FROM RIPARIAN VEGETATION

At two different sites along the Cosumnes River in Central California, this study was initiated with support from John Muir Institute of the Environment to provide evapotranspiration data to an existing hydrologic and ecologic study. This additional research focuses on the effects of vegetation on groundwater availability, and provides improved parameterizations of the water lost from California's watersheds via evapotranspiration. Using two different techniques we calculate the amount of water lost from the hydrological budget through evapotranspiration and likewise observe the effect of groundwater availability on the riparian ecosystem.

Two towers, each over twenty meters tall, at two different sites along the river are used in this study. Both towers include measurements of ground heat flux, net radiation, ecosystem surface temperature, wind velocity, temperature and relative humidity. After estimating the aerodynamic resistance of the vegetation using two independent techniques, these measurements are used to calculate latent energy and evapotranspiration at half-hour and one-hour intervals.

The expanse and biometeorological uniformity of only one of the two sites is sufficient to support the use of eddy-covariance. We estimate both carbon and water flux at this site. Using this more direct measure of evapotranspiration at the more ideal site we can provide some degree of validation of the energy balance/infrared thermometry technique we use to estimate aerodynamic resistance and evapotranspiration at both sites.

The eddy-covariance tower became operational in January 2004 and the other tower has been collecting data since July 2003. Preliminary analysis of the July site, which has very poor fetch, places the aerodynamic resistance estimate as a function of wind speed to the power of -.07. This is encouraging, and approximately what we expected as the trees below the tower could be classified aerodynamically as somewhere between a uniform canopy and an isolated object.

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SOURCES AND TRANSFORMATIONS OF ORGANIC MATTER WITHIN THE STATE WATER PROJECT

The California State Water Project (SWP) transports water from the Sacramento-San Joaquin Delta in northern California over 400 miles for use as drinking water in southern CA. Delta water contains high concentrations (3-8 mg/L) of dissolved organic material (DOM). These high concentrations are problematic because during disinfection with chlorine and ozone, a fraction of the DOM can react to form disinfection byproducts (DBPs) that are harmful to human health. The amount of DBPs that form is a function of the amount and type of DOM in water entering treatment plants. Depending on whether water travels directly through the California Aqueduct or is stored in reservoirs along the way, transit time in the SWP south of the Delta ranges from weeks to years, with a mean residence time of months. This is ample time for biological and chemical processes to alter the quantity and quality of DOM, changing its potential to form DBPs. Aquatic sources (e.g. phytoplankton and periphyton) can be added during storage in reservoirs and travel through the aqueduct. In addition, organic matter may be transformed or lost through microbial degradation and photolytic decay. This project is designed to study the effects of primary production and microbial and photochemical processing on DOM during transit through the SWP, with particular reference to the formation or removal of DBP precursors. Data will be presented for water samples collected in the spring of 2004 along a transect between San Luis Reservoir 70 miles south of the Delta and Silverwood and Castaic Reservoirs near Los Angeles. Water samples were analyzed for concentration and chemical composition of DOC, as well as for DBP formation potential. Using this data in conjunction with isotopic tracers and chemical characterization (e.g. lignin, carbohydrates, amino acids) the additions, losses and transformations of DOM in the SWP can be quantified.

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SOURCES OF DISSOLVED PESTICIDE CONCENTRATIONS TO THE YOLO BYPASS, AND IMPLICATIONS FOR NATIVE FISH

Seasonal inundation of the Yolo Bypass floodplain creates important habitat for spawning and rearing of native fish. The floodplain is being considered for restoration, but one concern is the potential for pesticide effects on native fish. Although more than half of the floodplain is farmed and elevated concentrations of pesticides have been detected in the source waters, minimal data are available on pesticide concentrations in the Bypass itself. The objective of this study is to evaluate the potential sources of pesticides to the Bypass, especially those that coincide in time with critical life stages of native fish. Dissolved pesticides can be transported directly into the Bypass from source waters or can desorb from flooded soils.

The first part of the study involved measuring the direct inputs of pesticides when the Yolo Bypass was inundated in mid-February 2004. Water samples were collected weekly from February through April from the five major water sources to the Bypass and within the Bypass itself. Dissolved pesticides were analyzed using solid-phase extraction and gas chromatography/mass spectrometry (GC/MS). Three herbicides (hexazinone, simazine, and metolachlor) and one insecticide (diazinon) were detected most frequently and at the highest concentrations.

The second part of the study assessed the desorption of pesticides from agricultural soils and from bed sediment transported to the Bypass during high flows. Pesticides associated with soils or sediment were extracted using microwave-assisted extraction, cleaned with carbon column and gel-permeation chromatography, and analyzed by GC/MS. Laboratory incubations of sediment slurries with XAD-resin were used to estimate the desorption potential of the sediment-associated pesticides. The results from this study will help resource managers evaluate the potential pesticide exposure of native fish in the Yolo Bypass in any future restoration.

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RESPONSE OF AQUATIC INVERTEBRATES FROM CONTRASTING HABITATS TO FLOODING IN THE COSUMNES RIVER FLOODPLAIN

The Cosumnes River system is of great interest to ecosystem restoration research because it provides a unique opportunity to study ecosystem responses to a natural flood regime in the Central Valley. The objective of this study was to intensively monitor the assemblages of aquatic invertebrates throughout a flood season and assess the effect of different hydrologic residence times on these assemblages.

Throughout two flood events in the spring of 2004, we collected aquatic invertebrates. We sampled from three habitats with differing hydrological characteristics. In addition to physical characteristics, we also measured polyunsaturated fatty acids as diet biomarkers in zooplankton and stable isotope tracers in seston to examine the transfer of energy through the food web.

We observed the least diversity and density of aquatic invertebrates during the peak of the flooding. As the floodplain started becoming disconnected from the river, the aquatic invertebrate density and diversity in the floodplain increased at a faster rate than in the river. This increase is attributed to the higher residence time of the water in the floodplain, which in turn affects the ecological processes within the water column. During the ponding phase of the flood cycle, we observed a decline in aquatic invertebrate diversity. We explored the relationship between this decline and deterioration of the invertebrate environment such as changes in food quality and increase in predation.

Aquatic invertebrates are an essential link in the food web between primary producers and higher trophic levels including native fish. Better understanding of the mechanisms that regulate these assemblages can contribute to enhanced management and restoration of floodplain-river systems … hopefully resulting in happy native fish.

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MODELING UNCERTAINTY USING BAYESIAN NETWORKS FOR MERCURY TMDL DECISION ANALYTICAL SUPPORT

Problem Statement: Water quality impairment due to high mercury fish tissue concentrations (Hg-fish) and elevated mercury aqueous concentrations is a widespread problem in several sub-watersheds that are major sources of mercury to the San Francisco Bay. Several mercury Total Maximum Daily Load regulations are currently being developed to address this problem. Decisions about control strategies are being made despite very large uncertainties about current mercury loadings, relationships between total mercury (Hg_T) loading and methyl mercury (MeHg) formation, and relationships between control efforts and Hg-fish.

Approach: This work proposes a novel decision analytical alternative to the current use of safety factors and deterministic models for mercury TMDL decision support, one that is fully compatible with an adaptive management approach. The approach uses a probabilistic (Bayesian) network (BN) model of the relationships between potential mercury control efforts, Hg_T loadings, MeHg concentrations, and Hg-fish in the Cache Creek watershed, a major source of mercury to the Bay Delta. The stochastic empirical models used to generate the needed probability distributions are based on the same empirical models currently being used by the Cache Creek mercury TMDL workgroup. The significant difference is that model input uncertainty and model error are explicitly included and propagated throughout the model using BN algorithms.

Results: Model results include 1) probabilistic estimates of Hg_T loads and MeHg concentrations within watershed segments; 2) probabilistic estimates of the downstream effects of various control strategies on Hg_T loadings, MeHg concentrations, and Hg-fish; and 3) probabilistic inferences about unmonitored total mercury sources given observations from monitored sources.

Relevance: This work demonstrates an approach to handling uncertainty in a complex and highly uncertain TMDL decision process. The various sources of uncertainty are integrated and propagated as decision risk, allowing decision makers to simultaneously consider uncertainties in mitigation/implementation costs and in meeting various environmental/ecological targets.

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TRANSBOUNDARY ECOLOGICAL EFFECTS OF RESTORATION IN AN AGRICULTURAL LANDSCAPE

There is increasing recognition of the critical role of agricultural lands in harboring wildlife and other biodiversity in large-scale conservation efforts. Simultaneously, there has been a growing focus on conservation and restoration of non-production areas within a matrix of agricultural lands. While advocacy of such plans has increased dramatically in the last decade, there are still too few data to understand whether these efforts pose net risks or benefits to farmers working lands adjacent to conservation and restoration areas. Faced with this uncertainty, farmers and farm advocates have voiced many concerns about large scale habitat restoration efforts, while proponents of these plans have depicted the proposed landscape alterations as benefiting agricultural production as well as wildlife conservation. We are conducting surveys to determine the distribution of a suite of pests that have been identified by farmers along the upper Sacramento River, including small mammals, weeds, insects and pathogens, in order to determine how restored and remnant forest affect the distribution of these pests. Specifically, we are surveying these species in 27 orchard edges that are either adjacent to restoration sites, to remnant riparian forests, or to other orchards between April 2004 and August 2005. We will present the main results associated with the first year of mammal, insect and pathogen surveys. By assessing the effects of restoration on the distribution of agriculturally important pests, we aim to provide useful information on the consequences of restoration on the agricultural communities. The focus of this work on restored and remnant riparian forests is particularly significant given the conservation value of riparian habitats along the Sacramento River, the legal mandate and extensive efforts to restore riparian habitat in the area, and the social and political controversy over the potential positive and negative impacts of restoration for regional farmers.

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EARLY LIFE HISTORY OF THE SACRAMENTO PERCH: A SUITABLE NATIVE FISH MODEL FOR TOXICITY TESTING?

Populations of the Sacramento perch (Archoplites interruptus), the only Centrarchid native to California, are declining. The release of anthropogenic toxicants in the Sacramento-San Joaquín River systems poses serious concerns. The objectives of this study were: (1) to describe the early development of perch and (2) to assess its suitability as a model for developmental toxicity study. Embryos were obtained by induced spawning in the laboratory. Gross morphology and histological analyses were integrated to describe the early development.

A total of 4,006-16,260 larvae were collected per female. Prelarvae tend to adhere to the spawning substrate or sediment during the critical organogenesis stages. Swim-up larvae and exogenous feeding occurred within four days post-fertilization. Primordial germ cells were observed in 10 day-old larvae, but sex differentiation occurred after 43 days. The high fecundity of females provides a potentially large source of embryos for toxicity testing. Results suggest that perch is amenable for sediment toxicity testing due to characteristics of the prelarval stage. However, the absence of external sexual dimorphism on early life stages and the extensive maintenance required for larval rearing hinders the use of perch to evaluate gender-specific effects of toxicants. To date, this is the first comprehensive study of Sacramento perch early development.

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DIAGNOSING THE HEALTH OF GILLICHTHYS MIRABILIS: OTOLITH MICROSTRUCTURES, MORPHOMETRICS AND DEMOGRAPHICS AS INDICATORS OF FISH HEALTH

The main goal of the EPA funded Pacific Estuarine Ecosystem Indicator Research (PEEIR) Project is to develop an integrated suite of indicators to evaluate impacts of stressors across multiple levels of biological organization, trophic structure, life stage, space and time in California's salt marshes.

The goby Gillichthys mirabilis (longjaw mudsucker) is an excellent organism for studying salt marshes due to its life history, large size, availability, and hardiness. All aspects of its biology (ecological, reproductive, physiological, cellular, molecular, etc.) are being studied by the PEEIR Team in order to develop sound indicators of G. mirabilis health.

The Ecological Indicator Component (EIC) of PEEIR is currently analyzing the demography, morphometry, and growth of several G. mirabilis populations throughout California. Otolith analyses will provide us with individual measures of developmental stability and growth rates; while morphometrics (e.g. hepatosomatic index, gonadosomatic index, condition factor, etc.) will be used to evaluate the condition of each specimen. Demographic studies (e.g. length-frequencies, age structures, sex-ratios, etc.) will allow us to compare individual measurements of fitness with population trends.

The patterns we observe will be compared to G. mirabilis biomarker analyses, the overall condition of other taxa (invertebrates, plants, etc.), soil chemistry and several other measures of ecosystem health being evaluated by various PEEIR participants. The final goal is to develop models that will better describe how salt marsh ecosystems function and how anthropogenic contaminants affect these ecosystems at sublethal levels.

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A COMPARATIVE ASSESSMENT OF RESTORATION STRATEGIES FOR THE LOWER TUOLUMNE RIVER USING A LIMITING FACTORS APPROACH

CALFED's lower Tuolumne River Adaptive Management Forum Report states that "the [Tuolumne River] Restoration Plan would be strengthened if the scientific basis and expectations of the restoration approach chosen are clearly spelled out (this should include which other alternatives were evaluated and rejected and why)." The report also recommends that a limiting factors analysis be used to assess "the extent to which restoration of habitat in the lower Tuolumne River can be expected to increase species abundance and resilience." Population modeling is used to assess the relative benefits, in terms of salmon population dynamics, of different approaches to, and scales of, salmon restoration. In particular, the following questions are addressed:

1) What are the benefits of the large-scale river restoration approach for enhancing salmon populations, relative to the resources required to implement that restoration approach;

2) How much of the river would need to be restored before discernable benefits to salmon populations would be expected;

3) Are there less expensive restoration strategies that achieve the same objectives for salmon populations and, if so, how do we evaluate the tradeoffs with reduced benefits for other species or ecosystem functions;

4) To what extent does mortality outside the system affect salmon population dynamics.

In many cases, the primary benefit of population modeling is not the predictions per se, but rather the generation of testable hypotheses that will help determine what is the most appropriate combination of restoration, monitoring, and research.

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WETLAND FLUXES OF DISSOLVED ORGANIC CARBON AND SEDIMENT AT BROWNS ISLAND, CALIFORNIA: BALANCING THE WATER BUDGET

Dissolved organic carbon (DOC) and sediment fluxes to and from tidal wetlands have the potential to affect water quality and ecosystem restoration; therefore, accurate measurements of these fluxes are crucial. This study measures net fluxes of DOC and sediment for Browns Island, an established tidal wetland in the Sacramento-San Joaquin River Delta.

Accurate measurements of DOC and sediment fluxes require high-intensity sampling and development of a water budget that accounts for all water that enters and then exits the island control volume during a tidal cycle. The U.S. Geological Survey continuously measures fluxes of water, DOC, and sediment for several weeks each season with an instrument package containing an acoustic Doppler current profiler, spectral photometer, colored-dissolved-organic-matter fluorometer, and a nephelometric turbidity sensor. Water flux is measured using the index-velocity method, and instruments are calibrated using velocity-weighted, cross-sectionally averaged water samples.

Initial measurements of tidally averaged water flux in the main channel of Browns Island indicated an average flood-biased imbalance of 13 percent, resulting in biased calculated fluxes of sediment and DOC onto the island. We believed that a secondary channel connecting the main channel to New York Slough was responsible for this imbalance. Therefore, an instrument package was placed in both the secondary and main channels in fall 2003. The combined tidally averaged water flux from both channels reduced the imbalance to 3 percent. While previous deployments indicated that the DOC flux mainly was onto the island, the improved calculated tidally averaged flux was off the island. The tidally averaged sediment flux however continued to be onto the island. Future deployments will collect data in both the main and secondary channels to improve our estimates of the water budget, and subsequently, the quantity of DOC supplied by Browns Island, and the quantity of sediment deposited on Browns Island.

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OVERVIEW OF RESEARCH PROJECTS FOCUSED ON THE RECOVERY OF SALMONIDS IN THE CALIFORNIA CENTRAL VALLEY

Numerous research projects addressing important basic and applied scientific questions related to salmon and steelhead are conducted in the Central Valley of California throughout the year. Results from these projects (e.g., trends in salmonid distribution, habitat use, genetics, etc.) provide essential information on which to base management actions intended to achieve CALFED ecosystem restoration and listed-species recovery program objectives. The California Department of Fish and Game and National Marine Fisheries Service are the State and Federal agencies, respectively, that review and permit research projects affecting anadromous salmonids protected under the California Endangered Species Act and Federal Endangered Species Act. We present an overview of the types of salmonid research projects in the Central Valley currently permitted under the California and Federal Endangered Species Acts and identify data gaps that, if filled, would increase the certainty in management decisions related to endangered and threatened species recovery.

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THE SAN FRANCISCO BAY-DELTA SCIENCE CONSORTIUM: COLLABORATIVE RESEARCH, MONITORING, AND OUTREACH

Supported by the California Bay-Delta Authority, the San Francisco Bay-Delta Science Consortium is an organization with the mission "**To foster collaboration and the practice of interdisciplinary science in the San Francisco Bay-Delta region**." In pursuit of this vision, the Consortium unites 15 universities, private organizations, and Federal and State agencies involved with aquatic science research, monitoring, and education in the San Francisco Bay-Delta system. Leaders from these member institutions regularly meet to communicate needs and interests, brainstorm ideas, and provide guidance for Consortium-sponsored collaborative projects. Some of these projects include maintaining and updating a list of resources (e.g., office and lab space, vehicles, and equipment) that member institutions may share, building new office and laboratory facilities for member organizations to occupy, maintaining and promoting the free on-line journal *San Francisco Estuary and Watershed Science*, developing a common data management system, offering research grants, and hosting workshops. The complexity of the Bay-Delta system demands multidisciplinary studies. Different institutions each offer unique expertise and resources. By working together, Consortium institutions produce a quality and quantity of science unattainable by institutions working alone, prevent the overlap of projects and resources, and convert scientific knowledge into improved management practices.

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USING MONITORING OF RESTORING MARSHES IN SAN FRANCISCO BAY TO GUIDE FUTURE RESTORATION

Since the early 1970s, over 45 tidal marsh restoration projects have been constructed around San Francisco Bay, restoring tidal action to more than 2800 acres. Over the next 20 years, with current initiatives being implemented it is likely that tens of thousands more acres will be restored. Unfortunately, monitoring of the long-term evolution and performance of first generation restoration sites was rarely carried out. This meant that our collective learning experience to answer key practical design questions has been impeded.

In 1986, with the support of local foundations and citizens groups, the first long term monitoring studies were initiated at Muzzi Marsh and Coyote Creek Lagoon. In later years long-term monitoring was started in other restored sites. There are, as of the year 2004, 32 years of restoration history and up to 18 years of systematic monitoring data from tidal wetland restoration projects in San Francisco Bay. There is now sufficient information from these monitoring efforts, and from 'snapshot' observations of other restored sites in San Francisco Bay, to provide guidance for the next generation of restoration design. This will allow us to construct future restoration projects more successfully and economically.

Funding from the State Coastal Conservancy to The Bay Institute has allowed the documentation of this experience to produce a design guidelines report. Its target audience includes agency staff and environmental professionals involved in tidal wetland restoration in San Francisco Bay.

This design guidelines report is intended to be a 'Version 1.0' that will help restoration practioners by providing an assessment of how well we can answer key design issues based on what we know now. We anticipate that new insights will be provided in future years by continued monitoring data from restored sites. At some point, we hope there will be a 'Version 2.0'.

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PALEOCLIMATE RECORDS FROM SAN FRANCISCO BAY ESTUARY AND CORRESPONDING RESEARCH TO ITS LARGER WATERSHED REGION

The San Francisco Bay and its Watershed contains sedimentary and tree ring evidence of past climate conditions spanning much of the Holocene period. This evidence reflects conditions over a large portion of the state of California. Investigations of paleo- climate in San Francisco Bay and its watershed extend relatively short historical records documenting climate variability and change. We review paleo-climate records from the San Francisco Bay estuary and its watershed, including lowland floodplain rivers in the Central Valley, mountain lakes in Sierra Nevada and tree ring chronologies from the entire watershed region. Paleo-climate records from the San Francisco Bay estuary include cores collected from the open bay and from marshes spanning the salinity gradient in the northern reach of the estuary. These records indicate a long-term trend towards higher salinity in the Bay over the last 2500 years, with periodic shorter-term variations in estuarine salinity. The archives from the San Francisco Bay estuary and its watershed (primarily sediment cores, tree-rings, geomorphic evidences, and lake sediments), all contain records showing large fluctuations in climate over the past 5,000 years, with unusually wet and dry periods lasting up to decades or centuries. In general, conditions were wetter and cooler in the period of 4000 – 2000 cal yr B.P., and drier, warmer and more variable over the past 2000 years. The Medieval Climate Anomaly (ca. A.D. 900 - 1200) appeared to be an unusually dry period, with warmer coastal surface waters. The Little Ice Age (ca. A.D. 1400 – 1700) was a time of unusual wetness, with cooler than average coastal waters. A notably benign period, with relatively little variability has been seen in many records from about A.D. 1850 – 1950. Many of the records showed variability with the most common periodicities of ca. 55, 70, 90, 100, 150, and 200 years.

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BENTHIC MACROINVERTEBRATE COMMUNITIES OF THE LOWER SACRAMENTO RIVER WATERSHED

The objective of this study was to characterize the range of benthic macroinvertebrate (BMI) communities and habitats in wadeable streams in the southeastern Sacramento River watershed. Over a period of two years, fall and spring BMI samples, as well as habitat, water quality and land use data, were collected from a range of low gradient (valley floor) and high gradient (sierra foothill) sites, including both agriculture-dominated and urban-dominated water bodies. The largest differences in BMI community composition occurred between low and high gradient sites. We developed two gradient-specific ranking systems of BMI community integrity (Biotic Indices -- BIs). In low gradient, agriculture-dominated waters, upstream communities appeared more impacted than downstream assemblages. In high gradient, urban-dominated waters, sites near urban centers appeared most impacted. Habitat, substrate, and water quality were important to BMI community integrity. At some sites, poor habitat resulted in highly degraded BMI communities, hindering the detection of water quality impairment. All sites, except those least affected by human activity, manifested higher BI scores in the fall. These seasonal differences may be related to natural temporal variation, anthropogenic factors, or both. We make several recommendations for integrating these findings into management efforts. (1) Low and high gradient data should be analyzed separately. (2) BMI integrity data should be compared only between samples collected in the same season. (3) Lack of instream habitat and effective riparian zones correlated strongly with impacted BMI communities, indicating an emphatic need for habitat remediation and riparian zone improvement to re-establish healthy BMI communities. (4) Communities impaired by poor habitat may not be sensitive indicators of water quality impairment. (5) Evaluation of water quality conditions at sites with poor instream habitat may depend on the use of artificial substrates or examinations of zooplankton, which depend less on high quality instream habitat for effective measurements.

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DEVELOPING RECOVERY OPPORTUNITIES FOR CALFED AT-RISK PLANT SPECIES OCCURRING IN ALKALI VERNAL POOLS

At-risk plant species, including Greene's (Tuctoria mucronata) and alkali milk vetch (Astragalus tener), are extremely rare plants endemic to vernal pool wetlands occurring on alkali soils in the Central Valley. Exterpation of populations of these species due to loss of habitat, invasion by non-native invasive plants, and fluctuations in climate has reduced these species populations.

Our studies were desinged to determine physical and biological components of the vernal pool habitats where these At-risk species occur and which factors may negatively or positively influence their population sizes. The goal of these studies to identify through experiments specific management opportunities that could result in species population enhancement and recovery.

A year of baseline studies have been conducted on the soils, hydrology, water chemistry, and native and non-native plant species composition have been collected. Results indicate there is a strong correlation with the At-risk species and the timing, depth and duration of water ponding in the vernal pools. Specific interactions with non-native plants is still being investigated and will be presented separately.

A model of habitat structure and function is being developed based on the physical and biological components and the ecological processes occurring. The next steps in the study will be to implement specific experiments, particularly on non-native plants to determine if their control will result in the increase of the At-risk plant species.

The ultimate goal is to develop a management plan for the vernal pools that support the At-risk species. The management activities will be based on the results of specific experiments that will identify methods that improve the At-risk species populations. The information gathered could lead to the establishment of new populations of these At-risk species which are key milestones in the CALFED program.

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THE USE OF ENVIRONMENTALLY-SENSITIVE STREAMBANK STABILIZATION FOR RIVER AND STREAM RESTORATION

Conventional streambank stabilization practices may not offer the benefits that environmentally-sensitive vegetation techniques provide for habitat enhancement and water quality improvement. Although scientific evidence supports this claim, few agencies have the guidance and tools to evaluate, select, and design techniques for use in stream restoration. To address this need, the National Cooperative Highways Research Program (NCHRP) funded a study to review published research, survey agencies across the nation, further develop environmentally-sensitive techniques, design typical drawings, and develop technique selection software.

An exhaustive literature review revealed numerous published articles regarding the characteristics and potential benefits of environmentally-sensitive streambank stabilization. Surveys discovered the primary concerns agency personnel have with environmental techniques include: limited experience designing, installing, and monitoring new techniques; lack of long-term post-construction data; scarcity of hydraulic guidelines; and the potential for failure prior to optimum vegetation establishment. Approximately one third (1/3) of the agencies reported obstacles experienced with environmentally-sensitive techniques, however none reported unsatisfactory performance.

Design guidelines and specifications for environmentally-sensitive techniques were prepared in accordance with the information obtained from the literature review and surveys. Once criteria were established for each technique, a selection software program was developed to relate the strengths and weaknesses of each technique to site conditions and project restrictions. The software provides users with a reliable, straightforward approach to selecting innovative techniques for streambank protection.

Current environmental issues call for the implementation of improved techniques in the rivers and streams of California. These techniques provide a stepping stone to maintain the integrity of levees, improve water quality for agricultural and urban use, uphold recreational opportunities, sustain the health of our soil resource, and restore healthy ecosystems to provide essential wildlife habitat. The findings, information, and tools provided by this venture are critical to the success of future streambank stabilization projects.

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RESTORATION ON THE SAN JOAQUIN RIVER NATIONAL WILDLIFE REFUGE

In 1999, the US Fish and Wildlife Service (USFWS) and the Natural Resources Conservation Service added 3,166 acres of flood-prone farmland to the San Joaquin River National Wildlife Refuge (Refuge), near the confluence with the Tuolumne River. In 2001, CALFED's Ecosystem Restoration Program awarded funding for wetland and riparian habitat restoration on the Refuge. The area lies within the Army Corps of Engineers Non-Structural Flood Protection Demonstration Project, which calls for strategically breaching levees to reconnect physical river processes required for ecological health and function of river systems.

In 2002, River Partners initiated restoration on 777 acres of contiguous native riparian vegetation within the Refuge. Goals for this project include restoration of habitat for the endangered riparian brush rabbit, threatened valley elderberry longhorn beetle, and neotropical migratory birds. River Partners has customized its plant design of thirteen native tree and shrub species and an understory planting to benefit these and other characteristic riparian wildlife species. Dense, shrubby patches will harbor and protect the endangered riparian brush rabbit being reintroduced by the Endangered Species Recovery Program (ESRP). Approximately 28,000 elderberry plants will provide habitat for the threatened elderberry longhorn beetle. Groves of trees, clusters of shrubs and willows, and areas of open canopy will provide structural diversity for neotropical migratory birds. Additionally, USFWS is in the process of restoring seasonal and permanent wetlands next to the newly restored riparian areas providing expanded habitats for waterfowl and shorebirds.

River Partners completes an annual census of trees and shrubs, and conducts plot surveys within the understory planting. ESRP monitors the riparian brush rabbit using radio-tracking technologies. PRBO Conservation Science assesses bird population responses to restoration and songbird re-colonization with point counts. These extensive monitoring surveys indicate the health of the system and the success of the restoration project.

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EVALUATING PHOSPHORUS SOURCES AND CYCLING IN THE SAN FRANCISCO BAY-DELTA ECOSYSTEM USING ISOTOPIC TECHNIQUES

Phosphorus is an essential nutrient influencing primary productivity and is therefore an important factor in the cycling of carbon, nitrogen, and sulfur in the San Francisco estuary. Phosphorus has only one stable isotope so it cannot be used as a natural isotopic tracer. However, the oxygen atoms bound to phosphorus are potentially useful isotopic tracers of phosphate sources and sinks. In particular, since phosphate acquires its d18O largely through equilibration with the d18O of water, and oceanic and terrestrial waters (which includes wastewater) have very distinctive d18O values, the d18O of phosphate should be useful for quantifying mixing of different phosphate sources. To test this hypothesis, we have developed a new method for analysis of the d18O of phosphate (McLaughlin et al., 2004), and have applied it to understanding phosphorus sources and cycling in the San Francisco Bay-Delta ecosystem.

In October 2002, we collected samples from a transect across the estuary. Phosphate d18O ranged from +10.1 to +20.1 ‰. Most of the Bay samples showed strong ($r^2 > 0.8$) positive correlations with salinity, water d18O, and nitrate d18O, suggesting that simple two-component mixing of oceanic and riverine sources of salt, water, phosphate, and nitrate could explain the compositions of most of the samples collected during this period. However, a sample from one near-shore Bay location showed a low phosphate d18O (but not low water or nitrate d18O values) that fell off the mixing line and was similar to d18O values found at river sites; hence, it is possible that there are local point sources of terrestrial phosphate at this location. These pilot study data suggest that phosphate d18O can be an effective tool for identifying phosphorus point sources and understanding phosphate dynamics in the ecosystem. Analyses of samples from subsequent Bay transects are in progress to help clarify these relations.

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RESERVOIR-INDUCED CHANGES IN FLOW REGIME IN THE TRIBUTARIES TO THE SACRAMENTO AND SAN JOAQUIN RIVERS

Rivers in Mediterranean-climate regions tend to be more heavily impounded than rivers in humid climates because demand for water is greater (to supply irrigated agriculture) and runoff is out-of-phase with demand. The Sacramento and San Joaquin Rivers are excellent examples of heavily-impounded Mediterranean-climate rivers, with impounded runoff indices, IR (ratio of reservoir capacity divided by mean annual runoff) of 0.80 and 1.20 respectively, contrasted with values of 0.20 or less typical of humid Atlantic climate regions. For 14 major rivers draining into the Central Valley, we compiled historical gauging records pre- and post-dam and calculated changes in flow statistics, and we compiled reservoir capacities for the large foothills dams alone as well as cumulative reservoir capacities for all upstream reservoirs. These rivers have experienced large changes overall in magnitude and seasonal distribution of flows, but the extent of hydrologic alteration is highly variable depending on IR and specific reservoir operation rules. Flood peaks for the two-year flood (Q2) declined on average 56% and 81% in the Sacramento and San Joaquin River basins, respectively. Plots of mean monthly flows pre- and post-dam show a range of changes, with the correlation coefficient between pre- and post-dam values, Ô, of 0.26 (i.e., low correlation between pre- and post-dam patterns) for the Tuolumne River, where spring-early summer snowmelt flows have been eliminated, and 0.27 for Putah Creek, where winter peaks have been eliminated and summer baseflows increased by Monticello Dam (IR = 4.63). Most rivers show reductions in peak flows, and many show increases in summer baseflow.

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CALIFORNIA DEPARTMENT OF FOOD AND AGRICULTURE'S PURPLE LOOSESTRIFE CONTROL PROJECT IN THE SACRAMENTO-SAN JOAQUIN DELTA WATERSHEDS

Purple loosestrife (Lythrum salicaria) is a riparian noxious weed that if left unmanaged or uncontrolled, has the potential to grow explosively and cause severe adverse impacts to biodiversity, wildlife habitat, and water flow in the Sacramento-San Joaquin River Delta and associated watersheds (Delta). To date, purple loosestrife has appeared in the Delta in small isolated populations that are still amenable to control efforts. With funding from the California Bay-Delta Authority Ecosystem Restoration Project (CBDA-ERP), the California Department of Food and Agriculture (CDFA) is leading a survey, mapping, and control project to decrease the number and size of existing purple loosestrife populations, and to prevent the establishment of new populations. This project fulfills several of the CBDA-ERP's goals, including the multi-regional priority for the 'control and eradication of nonnative invasive plants such as … Lythrum salicaria'. At the inception of this project, there was only one known purple loosestrife infestation in the Delta, at White Slough. The CDFA and cooperators conduct annual surveys for purple loosestrife in the Delta and adjoining watersheds. The location and populations size of all detections are mapped. As a result of this effort, 39 additional populations have been discovered, mapped and controlled since year 2000. The CDFA uses an integrated pest management approach for purple loosestrife control, including physical removal of loosestrife plants by digging, clipping and bagging seed heads to prevent reseeding and downstream spread, the application of an aquatic glyphosate-based herbicide (with surfactant), and the release of biological control agents. Site-specific Best Management Practices are implemented in order to use the control methods best suited to control each specific infestation. The relevance of the management findings of this project is that purple loosestrife can be kept from spreading into the Delta and taking over this sensitive ecosystem.

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STREAMBED TOPOGRAPHY AND ITS INFLUENCE ON HYPORHEIC FLOW IN SALMON SPAWNING GRAVELS, LOWER AMERICAN RIVER

Streambed alteration projects often do not consider the influence of channel morphology on 3-D subsurface flow. Laboratory experiments have shown that high water velocities are critical in the delivery of dissolved oxygen to the embryo and the removal of waste produced by the developing eggs. Spawning preference has also shown to be correlated in areas of significant upwelling or downwelling. Understanding the influence of channel spanning bars can be used as a predictive tool to enhance subsurface flow through spawning gravels and can assist solute transport modeling in low gradient streams.

Research was conducted in the Lower American River (Sacramento, CA), to investigate the relationship between streambed topography, 3D subsurface flow, and high-use spawning areas under various flow regimes. Field investigations were conducted in an area historically altered by human activities (flow release, dredging and habitat restoration). Surface-subsurface pressure measurements and tracer tests (meter scale) at Lower Sunrise Access revealed flow paths that left and returned to the stream (in 3-D) due to the influence of a transverse bar. Field investigations around other channel-spanning bars showed similar trends; glides and pools were dominated by downwelling conditions, runs by upwelling conditions, and riffles were evenly upwelling/downwelling.

The influence of the transverse bar at Lower Sunrise Access was simulated under a higher/lower stage and gaining/losing conditions in Visual MODFLOW. Flow paths that left and returned to the stream were observed under the low stage simulations, with longer sweeping paths taken during losing conditions. During simulations of higher stage and gaining conditions, flow paths were observed to rapidly converge beneath the stream.

Implications of these results can be used by modelers and design experts to plan restoration projects. Flow paths that left and returned to the stream were optimized when channel-spanning bars were submerged during lower flow regimes.

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WATER QUALITY MODELING OF THE NORTH DELTA AREA

A water quality model was developed on top of a one-dimensional, Mike 11 hydraulic model of the North Delta area. The hydraulic model was produced to examine flood impacts and area contributions of sub-tidal, inter-tidal, and supra-tidal habitats available for various restoration possibilities on the McCormack-Williamson tract.

The water quality model was produced to examine any water quality effects that the restoration might have on the region and to produce local boundary conditions for future multi-dimensional modeling of the restoration area.

Temperature and electrical conductivity data were collected on the boundary conditions of the North delta model to facilitate the calibration and verification of the water quality model. After the model was calibrated, it was used to again examine various restoration alternatives on McCormack-Williamson tract, refined through the hydraulic model, to examine both the hydraulic and water quality implications of the alternatives.

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RESTORATION RESEARCH OF EELGRASS (ZOSTERA MARINA) IN SAN FRANCISCO BAY

There have been few attempts at eelgrass restoration in San Francisco Bay, and these have had minimal success. Protecting and restoring productive eelgrass beds is a high priority for the National Oceanic and Atmospheric Administration (NOAA), however, little is known about which factors (turbidity, substrate type, temperature, etc.) govern eelgrass restoration success within the Bay.

Two research efforts are currently underway that intend to document the current status of eelgrass and the limiting factors that control eelgrass restoration. The Bay-wide Eelgrass Research Project, funded by the California Department of Transportation (CALTRANS) and NOAA's National Ocean Service (NOS) Eelgrass Pilot Recovery Project, funded as a partnership with NOAA Fisheries (NMFS), were initiated in Spring 2003.

The Bay-Wide Eelgrass Research Project

As part of the mitigation required by NMFS for the San Francisco-Oakland Bay Bridge East Span Seismic Safety Project, CALTRANS is funding research to further understanding of eelgrass characteristics to improve restoration efforts in San Francisco Bay. The goal of the Bay-Wide Eelgrass Research Project is threefold: 1) Describe the current status of eelgrass and its distribution; 2) Describe the current condition/health of eelgrass communities; and 3) Define the desired conditions for eelgrass habitats in San Francisco Bay.

National Ocean Service Eelgrass Pilot Recovery Project

NOS and NMFS have partnered in an eelgrass recovery project that was initiated at several sites within the Bay. The recovery project is providing recovery rate data to help plan restoration projects and help in the computation of interim losses of eelgrass resources for computing restoration ratios. Moreover, the recovery project has identified both annual and perennial growth forms of eelgrass over large areas of the Bay. An unusually high prevalence of annuals would dramatically alter options for restoration and expectations for management as all studies to date are based on perennial growth strategies.

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PERCHED GROUNDWATER BENEATH COSUMNES RIVER MAINTAINS HYPORHEIC ZONE

It is widely accepted that effective river restoration efforts should take advantage of naturally occurring hydrologic and geomorphic processes that support lotic and riparian ecosystem functions. Our ability to develop beneficial management and restoration programs has improved through identification of key processes affecting water movement and exchange between the river, vadose zone and groundwater systems. An important ecotone within the river continuum is the shallow groundwater that interacts with the river, often call the hyporheic zone. Because human reliance on groundwater is continually increasing, especially in California, declining streamflow due to falling water tables is diminishing the hyporheic zones beneath these rivers. Nevertheless, laterally extensive clay units and paleosols can cause infiltrating water to perch beneath the river, potentially maintaining hyporheic zones and even some of the original base flow. We have monitored perched groundwater beneath the Cosumnes River using continuously measuring hydrologic sensors. This study uses hydrologic data collected at the Cosumnes and numerical modeling of surface-groundwater interaction to determine if perched groundwater is persistent enough to support riparian vegetation and function like a hyporheic zone. Numerical modeling is used to quantify the exchange of water between the river and perched groundwater and to determine how susceptible perched groundwater is to drought. The possibility of managing perched groundwater zones may offer an opportunity to mitigate lotic and riparian ecosystems that have become stressed due to falling water tables.

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EVALUATION OF VIDEO MONITORING TO ESTIMATE ESCAPEMENT OF FALL CHINOOK SALMON IN BATTLE CREEK, CALIFORNIA

Accurate estimates of species abundance are essential to determine if the California Bay-Delta Authority is achieving its objective of restoring the Bay-Delta ecosystem. The California Department of Fish and Game and the U.S. Fish and Wildlife Service have cooperated to estimate escapement of fall Chinook salmon Oncorhynchus tshawytscha to Battle Creek since the early 1940's. Abundance estimates have traditionally been developed using a combination of a carcass survey and adult counts at the Coleman National Fish Hatchery (NFH). In recent years, large numbers of fall Chinook salmon returning to Battle Creek have confounded estimates of escapement of fall Chinook salmon. Escapement of fall Chinook salmon to Battle Creek is perennially among the largest of any tributary in California's Central Valley with escapement averaging 124,808 fish from 1997 through 2002 and a high of 397,149 fish in 2002. During years when numbers of salmon are high, carcass surveys are difficult to complete due to constraints of time, personnel, and budget.

In 2003, we constructed a video monitoring station in Battle Creek to estimate fall Chinook abundance and make comparisons to the carcass survey. The migration of salmon was monitored continuously from mid-August through mid-November by a video camera mounted above the stream channel. Videotapes were reviewed and fish larger than 24-inches were enumerated. Counts were adjusted to account for salmon less than 24-inches and steelhead based on observations at the Coleman NFH.

Estimates of fall Chinook escapement to Battle Creek based on video monitoring and the carcass survey were 152,549 and 155,027, respectively. The video monitoring station was constructed for less than $10,000 and generally required maintenance by only one person daily. Based on 2003 results, we believe video monitoring may provide an accurate and substantially less-expensive alternative to estimate escapement of fall Chinook salmon in Battle Creek and other Central Valley tributaries.

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RESPONSE OF AVIAN POPULATIONS TO TIDAL MARSH RESTORATION IN THE SAN FRANCISCO ESTUARY

Significant resources are being spent for acquisition and restoration of baylands to tidal marsh in the San Francisco Estuary. Essential to this process is the development of a set of criteria for assessing the success of restoration projects. Planning for restoration projects will also benefit from an evolving set of goals for critical habitat elements, such as vegetation and tidal channels, that promote target wildlife. To this end we have been conducting bird surveys at 50 natural and restored tidal marsh sites throughout the Bay, to determine bird population sizes and spatio-temporal trends and to determine which marsh habitat features contribute significantly to resident breeding bird abundance. For a subset of sites, we also conduct year-round surveys to assess habitat use by both wintering and resident birds. As part of the BREACH II project, funded by the California Bay/Delta Authority we compared bird use between clusters of restoration and natural, fully-tidal sites in San Pablo and Suisun Bay, including Pond 2A and Petaluma River Marsh restoration sites. We also studied additional restoration sites, including Tubbs Island Levee Setback and Point Edith.

We show that early restoration projects provide mudflats and shallow water habitat used by shorebirds, waterfowl and other waterbirds. As shallow water and mud are replaced by plants adapted to higher marsh elevations, resident passerines and rails replace the waterbirds. We analyze temporal variation (throughout the year and between years) and spatial variation (comparing restoration and fully tidal, mature marshes, and comparing within each category of marsh) in bird use. We contrast marshes in saline condition with those in brackish condition.

Finally, we present a conceptual model of change in bird use in tidal marshes throughout the restoration process, with examples taken from our work with the BREACH II Project.

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MONITORING THE ABILITY OF CONSTRUCTED WETLANDS TO MITIGATE NON-POINT SOURCE POLLUTION IN THE CENTRAL VALLEY

The San Joaquin River (SJR) receives agricultural tail water rich in nutrients and dissolved- and particulate-organic carbon from thousands of acres of irrigated land. The conversion of flood plain agroecosystems into wetlands is becoming a popular land-use practice to mitigate non-point source pollution nation-wide. Natural wetlands are excellent carbon- and nutrient-sinks. There is a critical need to evaluate the function of constructed wetlands as sediment, nutrient and carbon sinks, as well as their capacity to enhance water quality in the San Joaquin River (SJR). With respect to surface water quality, it is necessary to assess whether these seasonally submerged soilscapes act as sources, sinks or transformers of dissolved organic carbon, particulate organic carbon, algae, sediment and nutrients. This study evaluates the efficacy of utilizing constructed wetlands to enhance water quality in the SJR. The objectives are to: (1) determine the effect of constructed wetlands on nutrient and food resource concentrations, including N, P, electrical conductivity, DOC, selenium and dissolved oxygen; (2) identify relationships between algal growth rates and nutrient dynamics in the wetland environment; and (3) estimate input/output fluxes (source/sink) of nutrients, suspended solids, dissolved organic carbon and food resources from constructed wetlands. The project was initiated in March 2004. Preliminary data from three wetlands including input- and output-loads of nutrients, chlorophyll-a, sediment and dissolved organic carbon will be presented. This project is strongly synergistic with the Bay Delta Program's goals and objectives to evaluate solutions for hypoxia in the lower San Joaquin River (dissolved oxygen TMDL). Data from this study will contribute to improved understanding and prediction of: (1) factors regulating algae growth dynamics in the SJR; (2) effects of constructed wetlands on water quality; and (3) management options for addressing hypoxia in the lower SJR and Stockton Ship Channel.

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CHANGES IN RICE PESTICIDE USAGE AND SURFACE WATER CONCENTRATIONS IN THE SACRAMENTO RIVER WATERSHED, CALIFORNIA

Pesticides applied to rice fields in California are transported into the Sacramento River watershed by the release of rice field water. Despite monitoring and mitigation programs, concentrations of two rice pesticides, molinate and thiobencarb, continue to exceed the surface-water-concentration performance goals. There have been major changes in pesticide use over the past decade. Molinate use has declined by nearly half while thiobencarb use has more than doubled; carbofuran has been eliminated entirely and partially replaced by the pyrethroid pesticide lambda-cyhalothrin.

A study was conducted in 2002 and 2003 to determine if the changes in pesticide use on rice resulted in corresponding changes in pesticide concentrations in surface waters. During the rice growing season (May–July), water samples were collected weekly at three sites in 2002 and two sites in 2003. Dissolved pesticides were analyzed using both solid-phase and liquid-liquid extraction in combination with gas chromatography/mass spectrometry. Analytes included lambda-cyhalothrin, molinate, thiobencarb, and two degradation products of molinate: 2-keto-molinate, and 4-keto-molinate.

Molinate, thiobencarb, and 4-keto-molinate were detected in all samples, 2-keto-molinate was detected in less than half of the samples, and lambda-cyhalothrin was not detected in any samples. In 2002, concentrations of molinate were similar at Colusa Basin Drain and Sacramento Slough (maximum concentrations of 11.5 and 11.7 ug/L, respectively) but thiobencarb concentrations differed by a factor of five (maximum concentrations of 7.16 and 1.21 ug/L, respectively). Performance goals were exceeded for either molinate or thiobencarb in six samples from the upstream sites, but not in any samples from the downstream Tower site. In 2003, concentrations at upstream sites were much lower than the previous year with only one sample containing thiobencarb at a concentration above the performance goal. Lower concentrations could be partially due to delays in rice planting and pesticide application caused by spring rainstorms.

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POLYBROMINATED DIPHENYL ETHERS (PBDES) IN WATER, SEDIMENTS, AND TRANSPLANTED BIVALVES FROM THE SAN FRANCISCO ESTUARY

There are several classes of novel environmental organic contaminants that are clearly drawing attention as potential threats to aquatic life in the San Francisco Estuary and elsewhere. These contaminants include a wide variety of persistent and non-persistent chemicals that either have potential to induce toxicity and/or accumulate in marine biota and in higher food chain consumers. One particularly important class of contaminants is polybrominated diphenyl ethers (PBDEs), which are used as flame-retardants in textiles and consumer products. In 2002, the San Francisco Estuary Regional Monitoring Program for Trace Substances (RMP) incorporated the analysis of PBDEs in water, sediment, and transplanted bivalve tissue samples. The first year results showed total PBDE concentrations in water ranging from 1-571 pg/L and in sediments ranging from 1-212 ng/g dry wt. Bivalve total PBDE concentrations (dry wt basis) were as follows: oysters (Crassostrea gigas) 9-64 ng/g, mussels (Mytilus californianus) 13-47 ng/g, and clams (Corbicula fluminea) 85-106 ng/g. This first year of PBDE field monitoring provided preliminary measurements of their distribution. Future research will continue to examine PBDEs in water, sediments, and transplanted bivalves to determine spatial distributions, temporal trends, sources, and transport pathways into the estuary.

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COUPLING RIVER PROCESSES AND PLANT LIFE HISTORY TRAITS TO RESTORE RIPARIAN TREES THROUGH NATURAL RECRUITMENT

Native pioneer riparian tree species, such as Fremont cottonwood (Populus fremontii), depend on key components of natural (unregulated) patterns of flow timing and magnitude to foster recruitment, ensure long-term survival, and reduce competition from other species. River regulation associated with big dams typically alters the physical (hydrogeomorphic) patterns and processes that these species depend upon and consequently decreases their general reproductive success and overall distribution and abundance. In several projects in the San Joaquin Basin, we have taken a combined physical-biological approach to understanding and restoring riparian vegetation using corridor-wide physical processes linked to tree life-history data. We have calibrated a recruitment model for willows and cottonwood seedlings in the San Joaquin Basin, determining seed release timing, root growth rates, and bank elevation zones that foster successful seedling germination and establishment. This approach has allowed us to model areas where successful cottonwood recruitment could occur under different scenarios related to flow release schedules or rehabilitated (reconstructed) channel-floodplain topography. We combine locally-derived hydrogeomorphic and plant tolerance data in a mechanistic, process-based model. In addition, we are monitoring natural recruitment patterns on a variety of substrates (sand to cobbles) to test various hypotheses as part of on-going floodplain restoration projects on the Merced and Tuolumne rivers. These data on plant life-history traits and dependence of recruitment success on physical conditions and processes will provide resource managers throughout the CALFED program area with key information on how to restore native vegetation using natural recruitment processes for site-specific and corridor-wide restoration strategies based on channel-floodplain rehabilitation projects or targeted flow releases. They will also help to identify sites and conditions under which natural recruitment processes may be inadequate to achieve desired restoration objectives and active revegetation using horticultural techniques is likely to be required.

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IMMUNOHISTOCHEMICAL EVALUATION OF P450 EXPRESSION AND TISSUE DISTRIBUTION IN STRIPED BASS EXPERIMENTALLY EXPOSED TO BETA-NAPHTHOFLAVONE

Striped bass are an important sentinel species that reflect the general health of the San Francisco Estuary system. Objectives of this study were to evaluate the expression and tissue distribution of P450 enzymes in striped bass exposed to the P450 inducer Beta-naphthoflavone (BNF) using three anti-P450 antibodies and to develop a routine immunohistochemical biomarker technique for evaluating P450 induction/contaminant exposure in striped bass and related species. Juvenile 14 month old striped bass were segregated into three equal treatment groups: intracoelomic injection with 50 mcg of BNF suspended in 0.5 ml cod liver oil; injection with 0.5 ml cod liver oil; and no injection. Five days post-injection, fish were euthanized and tissues fixed in 10% formalin for 48 hours prior to paraffin embedding. P450 expression was evaluated by standard immunohistochemical methods using an HRP labeled biotin-free polymer linked antibody. Monoclonal antibody CYP2-C10-7 resulted in positive staining of the vascular endothelium of all organs including lamellar capillaries of the gill, reticuloendothelium of the heart, hepatocytes, epithelium of the gall bladder and tubular epithelium and glomerular mesangium of the kidney. Monoclonal antibody CYP3-FA-1 resulted in a similar distribution of staining, although the staining was generally less intense. Polyclonal antibody CYP11-CP-226 resulted in poor staining or an absence of staining. Both control treatments showed no staining/P450 induction. The results of this study indicate that two monoclonal antibodies, but primarily CYP2-C10-7, can be used to determine exposure to P450 inducing toxicants in striped bass using standard immunohistochemical methods. The intense staining of the branchial lamellar vasculature also permits nonlethal collection of samples from wild fish or otherwise valuable fish for evaluation of exposure to environmental toxicants. This study provides a useful technique to determine and evaluate biomarkers of exposure to P450 inducible contaminants in striped bass and related species in the San Francisco Estuary system.

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SACRAMENTO RIVER STRIPED BASS MIGRATION HISTORY DETERMINED BY OTOLITH SR/CA RATIO

Habitat use has been shown to be an important factor in the bioaccumulation of contaminants in striped bass. This study examines migration in striped bass as part of a larger study investigating bioaccumulation and maternal transfer of xenobiotics to progeny in the San Francisco Estuary system. Habitat use, residence time and spawning migration over the life of females (n = 32) was studied. Female striped bass were collected between Knights Landing and Colusa on the Sacramento River during the spawning runs of 1999 and 2001. Otoliths were removed, processed and aged via otolith microstructure. Subsequently, otoliths were analyzed for strontium/calcium (Sr/Ca) ratio using an electron microprobe to measure salinity exposure and to distinguish freshwater, estuary, and marine habitat use. Salinity exposure during the last year before capture was examined more closely for comparision of habitat use by the maternal parent to contaminant burden transferred to progeny. Results were selectively confirmed by ion microprobe analyses for habitat use. The Sr/Ca data demonstrate a wide range of migratory patterns. Age of initial ocean entry differs among individuals before returning to freshwater, presumably to spawn. Some fish reside in freshwater year-round, while others return to more saline habitats and make periodic migrations to freshwater. Frequency of habitat shifts and residence times differs among fish, as well as over the lifetime of individual fish. While at least one fish spent its final year in freshwater, the majority of spawning fish spent their final year in elevated salinity. However, not all fish migrated to freshwater to spawn in the previous year. Results from this investigation concerning migration history in striped bass can be combined with contaminant and histological developmental analyses to better understand the bioaccumulation of contaminants and the subsequent effects they and habitat use have on fish populations in the San Francisco Estuary system.

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HABITAT IMPROVEMENT IN THE BATTLE CREEK WATERSHED: WORKING WITH LANDOWNERS, AGENCIES, PG&E AND INTERESTED PARTIES.

The primary factor limiting production of anadromous fish in the Battle Creek watershed is stream flow. Secondary and tertiary limiting factors are upstream passage and entrainment of juveniles at unscreened diversions. Multiple projects are underway or completed in the Battle Ck watershed that will move toward resolving these limiting factors. Ongoing activities reflect the guidance provided in CALFED documents and the Anadromous Fish Restoration Program (AFRP) Plan. These projects will increase the amount of habitat available for use by listed salmonids and could lead to attainment of the AFRP fish population doubling goal. The method to implement restoration of this watershed is enhanced by partnerships and local involvement. Restoration activities include large-scale and small-scale projects that involve many agencies, organizations and funding sources. The primary project, The Battle Creek Salmon and Steelhead Restoration Project, was originally funded by CALFED in 1999 and is considered to be a signature opportunity for the Ecosystem Restoration Program. Embodied in a Memorandum of Understanding among CALFED implementing agencies and PG&E, the project will result in the re-opening of 42 miles of historical anadromous fish habitat. This Project will include flow increases and retrofitting of the hydropower system so that salmonids can access habitat that has been inaccessible for a hundred years. Complementary small-scale projects are also underway. A key component for these activities is the involvement of interested parties and willing partners (e.g. ranchers and PG&E). The partnership approach is valuable to achieve mutual goals and objectives. Additional projects involve the local community (e.g. environmental education), and provide avenues to share information with the local watershed workgroup. Overall, these watershed activities will help to achieve the goals of the Ecosystem Restoration Program and AFRP by providing habitat and rehabilitate natural processes which will maintain and enhance fish populations.

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VEGETATION STRUCTURE AND COMPOSITION IN DIFFERENT AGED BRACKISH TIDAL WETLANDS ALONG THE NAPA RIVER

While plant distribution in brackish tidal marshes is generally controlled by gradients in salinity and tidal inundation, most species appear to have a patchy distribution within any 'zone' they inhabit. Developing effective and efficient methods of sampling requires considerable knowledge of vegetation structure and composition. Our objective was to conduct a detailed vegetation analysis in order to later evaluate a variety of sampling methods. Three islands along the Napa River from the IRWM study were selected for this analysis, Coon's Island, Bull Island, and Pond 2A. Coon's Island is at least a century old, while Bull and Pond 2A are 24 and 8 yr old, respectively. From orthorectified images, random points were generated based on preliminary vegetation maps. At each site, approximately 200 points were visited and percent cover of all plant species within 3 m was recorded. Multivariate and cluster analyses were conducted to identify patterns in species association and distribution within and between marshes. Three principal vegetation groups were indicated: saline high marsh, brackish middle marsh and a freshwater low marsh. Species composition suggests that salinity explained the greatest variation in the multivariate analyses. Richness significantly increased from low to high marsh at Bull Island and Coon's Island, and no difference in species associations were detected between marshes. Total species richness of the two older islands was found to be comparable but distribution patterns differed considerably. Other patterns at all 3 sites related to duration of tidal inundation. Preliminary analyses conclude that three zones of vegetation are found in these brackish tidal marshes with extensive ecotonal intergradation. The patchy distribution of species, especially rare species, creates the greatest problems in developing rapid assessment methods.

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ACUTE AND SUBLETHAL EFFECTS OF LAMBDA-CYHALOTHRIN ON EARLY LIFE STAGES OF CHINOOK SALMON (ONCORHYNCHUS TSHAWYTSCHA)

Little is known about the toxic effects of pyrethroid pesticides on early developmental stages of salmon. In California, pyrethroids are applied to agricultural crops year-round, but storm runoff occurs during winter and spring when Chinook salmon embryos, alevins, and fry are rearing in the Sacramento-San Joaquin watershed. This study is designed to measure the acute and sublethal toxicity of lambda-cyhalothrin (LC), a pyrethroid pesticide, to salmon embryos and fry, and mimic realistic exposure scenarios that may be encountered by early developmental stages of salmon in California. Research objectives are to elucidate and quantify the links of cellular indicators of exposure, stress proteins, and effect, with organism development, growth, and survival.

LC_{50} experiments conducted this winter have revealed that LC was more toxic to fry than to embryos. No effect on mortality, hatching success, and larval survival was observed when embryos were exposed to concentrations ranging from 0.3—5.0 (Mu)g/l (nominal). The LC_{50} for fry was 0.15 (Mu)g/l (nominal). Future experiments will include exposing Chinook fry to multiple pulses of LC at sublethal concentrations. Following exposure and depuration, groups will be maintained in clean water for 6 weeks post-hatching. Subgroups of exposed and control salmon fry will then be exposed to a range of pesticide concentrations to determine if previous exposure affects sensitivity. Condition (CI) and hepatosomatic (HSI) indices will be determined for fry, and stress protein analysis (hsp60, hsp70, hsp90) will be conducted for various tissues using Western blotting techniques.

This study will provide regulatory agencies and resource managers with information to assist in the assessment of environmental risk and the development of improved environmental quality standards thereby reducing the risk of future pesticide exposures to Chinook salmon populations.

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FEASIBILITY OF DUAL MARKING AGE-0 CHINOOK SALMON FOR MARK-RECAPTURE STUDIES

Accurate estimates of juvenile fish production are essential in determining if the California Bay-Delta Authority is meeting its objective of restoring the ecological health of the Bay-Delta.

Therefore, we evaluated the feasibility and latent mortality associated with a dual marking technique used to mark fish for rotary-screw trap efficiency studies at Red Bluff Diversion Dam, Sacramento River, CA. Treatment groups were either spray-dyed with fluorescent pigments, stained with bismark brown or marked with both. Acute mortality was greater for the spray-dye/bismark brown combination (0.48%) and the spray-dye (0.13%) treatment groups than for the bismark brown or control groups. Mean daily mortality was less than 0.15% for all treatment groups through day three. Cumulative mortality was greatest for the spray-dye and the spray-dye/bismark brown groups at 0.19% and 0.18%, respectively. Significant differences in mean mortality between treatment and control groups were not detected ($P = 0.186$). Recognition of fluorescent pigments was 100% during the study. Bismarck brown staining did not obscure the fluorescent pigments, which were easily differentiated among colors. We concluded that our dual marking technique provides researchers a feasible method to differentially mass-mark fish with minimal mortality. Moreover, mark recognition is greatly enhanced.

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CALIBRATION OF SPECIFIC CONDUCTANCE, WATER-TEMPERATURE, AND TURBIDITY INSTRUMENTS

Reliable continuous data enable scientists to identify trends and develop models used for environmental management. These scientific objectives depend on accurate water-quality measurements to establish correlations with physical, chemical, and ecological data. Accurate data are essential to identify ecological trends, which provide an assessment for the improvement of San Francisco Estuary water-quality. The U.S. Geological Survey has established a detailed protocol for maintaining and calibrating instruments used to collect specific conductance, water temperature, and turbidity data in an estuarine environment. Instruments that measure water quality are cleaned and calibrated during each site visit to ensure accurate measurements. Instruments that measure specific conductance are calibrated using conductivity standards; water temperature instrumentation is checked against a calibrated thermistor; and instruments that measure turbidity are calibrated using a formazin standard.

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CONTROLS ON MARSH VERTICAL DEVELOPMENT AT BREACH SITES: SEDIMENTS, VEGETATION AND LOCATION

BREACH conceptual models demonstrate the importance of elevation change in the evolution, or not, from flooded islands to tidal marshes. This component of the BREACH study examined marsh elevation change and basic soil characteristics at 22 locations along the Bay-Delta estuary. The goal was to evaluate the contributions of organic and mineral matter to vertical soil development, and assess the importance of soil character in controlling elevation change.

Studies distributed over a six year period showed that marsh surface processes are adding material at rates in excess of current rates of sea-level rise. There is a trend toward lower surface accretion with higher elevation in the upper estuary supporting the elevation-based conceptual model. However in some areas of the Delta subsurface measurements show that this surface accumulation is being balanced, sometimes exceeded, by compaction. This shallow subsidence is associated with more organic substrates, remote from contemporary sediment sources.

The most organic substrates are not solely associated with tules. Organic matter is higher in pickleweed sites in the upper estuary than in tule marshes in areas of high sediment supply, such as the North Delta and Suisun. Highest organic matter is associated with 'ancient' marshes. In the moderately organic soils, e.g. 10-15% by weight, sediment supply to the site seems to be the dominant control on elevation change. 'Supply' is influenced by sediment availability in the vicinity of the site (e.g., high in North Delta close to Yolo Bypass), connectivity with the source (e.g., interior marshes generally show lower rates in tule marshes) and distance to the sediment source (e.g., Greenpoint Restored is more distant from the Petaluma than Carl's Marsh).

The identification of sediment supply as a crucial control on elevation change even in the Delta provides important information to restoration planners in terms of prioritizing sites and anticipating outcomes.

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WILDLIFE HABITAT OF THE LOWER MOKELUMNE RIVER WATERSHED

A roadside raptor survey was conducted in the lower Mokelumne River watershed in central California from 1998 – 2001 to determine habitat use and activity. This watershed is a landscape with 62% of the land in agriculture production. Habitat description and mapping was essential to this project. ArcGis 8.0 was used to map the 1 urban (2,080 hectares), 6 agricultural (13,719 hectares), and 6 natural (6,201 hectares) habitats described for the watershed. Habitats are described based on the California Wildlife Habitat Relationship (CWHR) system; a subsequent publication by the California Department of Fish and Game (CDFG) – "CWHR Agricultural Habitat Type Descriptions Supplement to A Guide to Wildlife Habitats in California;" and ground-truthing. Three new agriculture habitats are defined and described based on the CDFG Supplement, personal observation, ground-truthing of agricultural land in the watershed, and the San Joaquin County Annual Agricultural Report. This poster visually depicts the 13 habitat types, amount of land each habitat type encompasses, and provides a written description for each habitat.

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TERRESTRIAL VEGETATION COMMUNITIES ALONG THE LOWER MOKELUMNE RIVER

Terrestrial vegetation communities adjacent to the lower Mokelumne River from Camanche Dam downstream to the confluence of the San Joaquin River were classified and mapped between 2001 and 2003 using aerial photographs taken in 2000 and 2002. Sixteen terrestrial vegetation communities and 4 non-vegetated classes, comprising approximately 2,500 hectares of riparian lands, were mapped and quantified. Community composition was analyzed based on reaches and over time. Reach 1 is dominated by agriculture (41%) and grassland (36%); Reach 2 is dominated by tree-dominated communities (38%) and agriculture (34%); Reach 3 is dominated by tree-dominated communities (41%) and grasslands (26%); Reaches 4 and 5 are dominated by agriculture (43%, 51%) and tree-dominated communities (39%, 25%); and, Reach 6 is dominated by grassland (45%) and tree-dominated communities (35%). The vegetation communities in the mapped riparian area are currently (2000 and 2002) dominated by agriculture (40%), followed by grassland (30%) and tree-dominated communities (25%). By comparison, in 1927 the area was dominated by agriculture (41%), followed by tree-dominated communities (31%) and grasslands (20%); and, in 1963 the area was dominated by agriculture (57%), followed by grasslands (29%) and tree-dominated communities (9%). This poster visually depicts the 16 terrestrial vegetation communities and 4 non-vegetated classes; amount of land each community and class encompasses; provides a written description for each community with cross references to the California Native Plant Society vegetation community classification system, and the California Terrestrial Natural Communities, California Natural Diversity Database vegetation classification system; and summarizes the importance of this vegetation mapping for watershed management within the Lower Mokelumne River Watershed Stewardship Plan.

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AN EVALUATION OF 3 TYPES OF DATA USED TO MONITOR THE SUCCESS OF CONSERVATION EASEMENTS

Conservation easements on private ranches are an important strategy for protecting watersheds that harbor critical salmon habitat. Easements are designed to prevent future development and other potentially harmful land uses. With assistance from CALFED's Ecosystem Restoration and Watershed programs, The Nature Conservancy has purchased over 60,000 acres of easements on Battle, Mill, and Deer Creeks. These ranches protect important salmon spawning habitat as well as extensive blue oak woodlands. As part of this project we are developing monitoring tools to evaluate the effectiveness of this conservation strategy. Because the scale of these properties is large and resources are finite, it is not feasible to monitor all species and ecosystem variables. To overcome this limitation, we are focusing on understanding how different elements of blue oak woodlands are related at different spatial scales and determining which variables will be most useful for predicting the overall "health" status of this system. We selected three components of oak woodlands to monitor in 2004: the spatial cover of key plant communities, the composition and abundance of the breeding bird community, and the extent of invasion by non-native plant species in the oak woodlands. We collected data on two conservation easements in the Battle Creek watershed. To map community types at larger spatial scales, we used IKONOS (4 meter, 4 band) imagery. We quantified the abundance of breeding birds using point counts on two transects at each property in the spring. Using the same transects, we quantified understory vegetation in oak woodlands using point intercept methods. We discuss the relationships among these different types of data using multiple regression and evaluate their usefulness in characterizing the long-term status of blue oak woodlands on conservation easements.

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THE EFFECTS OF ESTROGENIC ENDOCRINE DISRUPTING CHEMICALS ON FISH

Evidence is accumulating that documents the occurrence of endocrine disrupting chemicals (EDCs) in surface waters. A partial list of known and suspected EDCs includes pyrethroids, herbicides, cholinesterase inhibitors, various metals, surfactants and synthetic hormones. Previous studies have shown that, upon exposure to estrogenic endocrine disrupting chemicals (EEDCs), reproductive failure, increased levels of aggression among nesting males and, in extreme cases, feminization of males has occurred. Our objective is to develop a method that detects low concentrations of EEDCs in surface waters and apply it to studies on watersheds of the Central Valley and North Coast regions of California. Adult male fathead minnows and larval female rainbow trout have been selected as the warm and cold water test species, respectively. Fish are exposed to treatment water for 24 hours then euthanized and their livers removed for analysis by real-time TaqMan® quantitative polymerase chain reaction analysis (RT-TaqMan® qPCR). Vitellogenin (Vtg) mRNA (a protein precursor to egg-yolk) is quantified by PCR and the estrogenicity of exposure water determined by quantification of Vtg mRNA in negative, solvent and positive control treatments, as well as in ambient samples. In positive control tests, the synthetic estrogen 17(Alpha)-ethinyl estradiol (EE2) was added to control and ambient waters in concentrations of 10, 30 and 90 ng/L. A dose response was observed when comparing these matrix spikes to negative and solvent controls. A statistically significant response in rainbow trout and fathead minnows was observed at 10 ng/L. A comparative study of the sensitivity of fathead minnows and rainbow trout to EE2 is underway. Future studies with unmanipulated ambient samples and additional matrix spikes are planned. Through the development of this method, we hope to determine the extent to which endocrine disruption is occurring in fish species throughout Central Valley and North Coast waterways and better understand their ecological effects.

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METHYLMERCURY PRODUCTION IN EXPERIMENTAL RESERVOIRS INUNDATING BOREAL FORESTS: SENSITIVITY TO LAND COVER AND FLOODING

Hydroelectric reservoir creation increases mercury content in piscivorous fish, which can remain elevated for decades after the initial inundation. We examined the dependence of methylmercury (MeHg) production on storage of organic carbon (OC) in upland soils of three hectare-scale experimental reservoirs of varying OC content (the FLUDEX Experiment). Three years of results indicate that the overall rate of MeHg production is positively correlated with soil OC storage, and that most of the production occurs in the surficial sediments. Methylmercury production increased greatly after inundation, and was particularly stimulated in areas containing specific vegetation types. The medium-OC site exported the most MeHg throughout the study, while the high-OC site retained the majority in its sediments. The low-OC produced and exported the least MeHg at all times. Reservoirs were drawn down each winter, during which the soil MeHg remained stable until the following spring. Methylmercury production rates were greatest in year two, and significantly decreased in all sites in year three. While OC content appears to control the total amount of MeHg formed, most of it was retained within the system in surficial soils. Export fluxes observed from the poor upland soils of FLUDEX were similar in magnitude (27-122 ng MeHg m^{-2} d^{-1}) to those observed in a nearby flooded peatland (5-15 ng m^{-2} d^{-1}), and the Everglades (22-192 ng m^{-2} d^{-1}), suggesting that in the short term, export and subsequent exposure is more a function of specific vegetation type, labile carbon content, and sulfate availability than of total OC stores in soil. Further, rapid increases in porewater MeHg at the onset of each inundation period suggest that the re-oxidation of sulfide through drawdown likely provides a new source of sulfate for subsequent MeHg production. The MeHg content in reservoir food webs generally increased over time, but not in a predictable fashion.

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MICROZOOPLANKTON IN THE SUISUN BAY FOOD WEB: SOURCE OR SINK?

The primary goal of this project is to quantify the role of protistan microzooplankton in the planktonic food web of Suisun Bay in the northern San Francisco Estuary. While recognition of the importance of microzooplankton in pelagic food webs is rapidly increasing within the scientific community, this component of the planktonic system is still largely understudied in many marine and estuarine environments, including San Francisco Bay. In spring 2004 we began a two-year field and experimental program to examine the distribution, abundance, taxonomic composition, grazing rates and contribution to copepod diet of microzooplankton in Suisun Bay. Preliminary results from three sets of seawater dilution experiments conducted monthly between March and May 2004 demonstrated that both phytoplankton growth rates and microzooplankton grazing rates were very low when chlorophyll levels were low (~1.0 micro-g/l). However, during a period of elevated chlorophyll (~3.7 micro-g/l) in April phytoplankton growth rates approached 0.7/day, while microzooplankton grazing rates remained quite low (~0.01/day). Incubation experiments with various mesozooplankton predators feeding on the natural assemblage of microzooplankton prey were also conducted concurrently with the dilution experiments. Moreover, we will soon begin to assess the affect of turbidity on microzooplankton grazing rates. By quantifying the feeding rates and diet composition of both micro- and mesozooplankton grazers in the field and under variable levels of suspended particulate loads, we intend to make predictions about the conditions under which microzooplankton may serve as a source or a sink in the pelagic food web of Suisun Bay.

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USING OTOLITHS TO INVESTIGATE CD-IMPAIRED GROWTH OF LARVAL TOPSMELT (ATHERINOPS AFFINIS)

Otoliths, calcareous concretions in the fish inner ear, are commonly used to determine daily growth rates and ages of fishes. However, their application to toxicological studies is unknown. Our goal was to determine if otoliths were useful for examining cadmium (Cd) impaired growth of larval topsmelt (Atherinops affinis), a species native to California tidal marshes. Eight day post-hatch (dph) larval topsmelt (n=24 per trt) were exposed to Cd (0 – 100 ppb) in seawater for 14 days and Cd concentrations were verified by ICP-MS. Fish were measured and weighed and otoliths (n=8 per trt) extracted. Remaining fish (n=16 per trt) were stored for future analyses of biomarkers of exposure (metallothionein) and effect (DNA cleavage). Otolith daily ring accumulation was analyzed using light microscopy and ImagePro® software. Fish exposed to 50 and 100 ppb Cd ate fewer artemia nauplii ($p=0.006$) and were significantly smaller (length and weight, $p<0.01$) than fish in control and 10 ppb Cd treatments. A significant relationship was measured between otolith and fish growth rates ($R^2=0.99$, $p<0.001$). However, differences in otolith surface areas and radii at 22 dph were not detected among treatments ($p=0.14$). Otolith growth curves varied significantly among individuals within and between Cd treatments ($p<0.001$) and otolith growth rates decreased with increasing Cd concentrations ($R^2==0.18$, $p=0.016$). Otolith analysis was useful for examining the daily growth of Cd-exposed larval topsmelt. A larger sample size may improve the power to detect differences in otolith growth of toxicant-exposed fishes. Results from this study will be used by ecosystem modelers from the Pacific Estuarine Ecosystem Research Consortium (PEEIR) to generate a model of topsmelt population viability under Cd stress.

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EXPLORING LONGFIN SMELT LIFE HISTORY AND MIGRATION BEHAVIOR USING OTOLITH MICROCHEMISTRY

Longfin smelt (LFS) have declined substantially in the San Francisco Estuary. This species requires protection and targeted management; yet little is known about its behavior and ecological tolerances. In an effort to better understand the behavior and ecology of this population, the Interagency Ecological Program initiated a review of data from several long-term community monitoring programs. Analyses of historical patterns in density and distribution suggested that many LFS migrate out of brackish water for some part of their life cycle. We employed laser-ablation sampling of LFS otoliths to determine whether any otolith tissue was deposited in a marine environment. By sampling across the otolith growth-axis, we can determine the duration of marine residence. Preliminary results revealed a sharp increase in Na/Ca and a decrease in Sr/Ca ratios, suggesting a major change in habitat utilization, consistent with a migration from fresh waters to marine environments. As this study continues, we hope to determine what fraction of the LFS population that uses the marine environment and the effect of this marine migration on life history parameters.

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POLYCYCLIC AROMATIC HYDROCARBONS IN SAN FRANCISCO ESTUARY SEDIMENTS: SOURCES, SPATIAL DISTRIBUTIONS, AND TEMPORAL TRENDS (1993-2001)

The San Francisco Estuary Regional Monitoring Program for Trace Substances (RMP) has routinely monitored for PAH in the San Francisco Estuary since 1993. The objectives of this study were to examine surface sediments (top 5 cm) in the San Francisco Estuary for PAH composition over a range of spatial and temporal scales to determine distributions, trends, and possible sources. The mean total PAH concentration in sediments was spatially distributed as Central Bay (230 mg/kg TOC), South Bay (217 mg/kg TOC), North Estuary (96 mg/kg TOC), Extreme South Bay (87 mg/kg TOC), and Delta (31 mg/kg TOC). Overall, the mean total PAH concentrations were significantly higher in the Central and South Bay compared to the North Estuary, Extreme South Bay, and Delta, with the Delta significantly lower than all other segments (Kruskal-Wallis, $H=156.94$, $df=4$, $p=0.000$). This distribution reflects the large amount of urbanized and industrialized area that surround the Central and South Bay compared to the Delta. Linear regression analysis showed a statistically significant temporal trend in total PAH concentration at only 1 of the 26 sites from 1993-2001 (San Pablo Bay, significant decrease, $p =0.024$, $r^2=0.314$, $n=16$). Source analysis using PAH isomer pair ratios as diagnostic indicators showed that PAH are derived primarily from combustion of fossil fuels/petroleum and biomass, with minor amounts of PAH derived from direct petroleum input. Several PAH have mutagenic and genotoxic potential, and long-term exposure to PAH is a potential threat to marine biota and wildlife. This is of special concern in areas like the highly urbanized San Francisco Estuary where there can be chronic and uncontrolled PAH contamination from multiple sources.

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NEW MONITORING TECHNOLOGY TO QUANTIFY HERBICIDE EFFICACY ON EGERIA DENSA: RESULTS FROM BAY-DELTA SITES

Quantifying the efficacy of herbicide treatments to control Egeria densa in the Delta has historically been a challenge due to scale, environment, and sampling logistics. A recently developed technology, applied for the first time in Delta waters in 2003, has helped provide a breakthrough in solving this problem.

Digitally recording acoustic measurements of submerged vegetation yields a very rapid, verifiable characterization of the entire water column beneath the transducer. Coupling DGPS-linked acoustic transects with physical point sampling provides the most complete picture to date of submerged vegetation conditions in the Delta.

Eighteen sites in the central Delta were monitored during 2003 for submerged vegetation species, health, coverage, and biovolume. The goal of the monitoring approach was to better measure the efficacy of aquatic herbicides on Egeria. Fifteen sites were treated with aquatic herbicides and three sites were monitored as controls. Each site was visited two-to-four times throughout the treatment season depending on factors such as active ingredient used (fluridone, copper, diquat), site location, treatment approach, and treatment schedule. Sampling consisted of recording thousands of acoustic measurements along multiple transects during each visit. Acoustic analysis revealed the bottom coverage and biovolume of submerged plants. Sampling also consisted of concurrent physical point sampling at each site to inventory plant species and health.

Efficacy was determined by comparing the suite of acoustic and physical data at each treated site with control sites. The first-year results have already contributed to refinements in treatments and monitoring.

Evaluation of herbicide efficacy is critical to managing invasive, non-native Egeria in the complex aquatic environment of the Delta. Maximizing results while reducing risks, impacts, and expenditures requires increasingly refined and robust analytic tools. The success of this new acoustic technology for quantifying herbicide efficacy in the Delta marks a significant leap forward in achieving this goal.

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EFFECTS OF TOXICANT EXPOSURES ON GENE EXPRESSION IN SEA DUCKS

This research will assess the impact of exposure to toxic contaminants on the ecological health of aquatic bird populations. To date, few studies have examined the effects of long-term exposures to lower levels of contaminants on wildlife. These effects may result in increased vulnerability to additional environmental stressors, such as disease or predation. We will use novel molecular assays to determine whether changes in gene expression result from exposure to contaminants in two types of sea duck: a captive population of Steller's eider (Polysticta stelleri) in Alaska, and wild surf scoters (Melanitta perspicillata), from San Francisco Bay. We will focus on genes associated with the major histocompatibility complex (MHC) of the immune system, using an avian-specific microarray system to test for changes in gene expression levels, and real-time PCR to quantify these changes. We will measure blood contaminant levels and prevalence of infection to test whether increased susceptibility to disease is correlated with contaminant exposure in the ducks. If successful, this assay may be used to assess the health of other avian species exposed to contaminants, in order to help maintain self-sustaining populations of native aquatic birds in the San Francisco Bay-Delta ecosystem.

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AG WATER USE EFFICIENCY AND IRRIGATION SCHEDULING IN THE SOUTHERN SAN JOAQUIN VALLEY

Problem: Agricultural water use efficiency (AgWUE) is generally perceived as being somewhere between 65 to 85% depending on the crop, irrigation system and cost of water; with regional averages often placed around 75%. The assumption, then, is there is still significant room for improvement. However, little documentation exists on a regional basis describing actual AgWUE over a large number of fields and grower receptiveness to "scientific scheduling".

Approach: Starting Winter 2001 an irrigation scheduling demonstration program was initiated in Kern County to instrument grower's fields with soil moisture monitoring equipment and loggers with a visual display. Growers were faxed one page weekly scheduling recommendations with ET, soil moisture and applied water history. Additional fields totaling 7,400 acres were added to this program in 2002 as part of a CalFed AgWUE project; Quantification of Benefits Attributable to Irrigation Scheduling as an On-Farm Water Management Tool. More grower fields were set up in 2003 and 2004.

Results: A total of 110 fields covering 9,000 acres belonging to 24 different growers were instrumented over this time period in 12 different crops, 11 soil textures and 9 different irrigation system types. The frequency of grower use of field loggers and faxed irrigation schedules ranged from almost nil to very high. Many fields using microirrigation were near optimal or deficit irrigated before entering the program; requiring an increase in applied water. AgWUE using weather-based ET averaged 96% and 97% using soil moisture depletion.

Relevance: In the San Joaquin Valley there is less water to be "saved" by improving AgWUE than assumed. As expected, furrow systems in field crops were the most responsive to increased monitoring. Existing micro systems are mostly at maximum efficiency. Growers are receptive to new technology/scheduling but only with regular personal consultation and financial incentives will they adopt these techniques.

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DOES DIETARY METHYLMERCURY ALTER FISH REPRODUCTION?

Little is known of the effects of environmentally realistic concentrations of methylmercury on wild populations of fish. We conducted a series of laboratory experiments with fish to (1) assess the effects of dietary methylmercury on reproduction and (2) to establish the relationship between methylmercury, altered reproduction, and biomarkers that could also be measured in wild populations. We fed juvenile fathead minnows diets contaminated with methylmercury (0.06 to 8.46 (Mu)g Hg g^{-1} dry weight). At sexual maturity, fish were paired, allowed to reproduce and then analyzed for total mercury, plasma testosterone (T), and 17(Beta)-estradiol (E2). Dietary methylmercury reduced reproductive success and delayed spawning, altered spawning behavior, and reduced egg production. Moreover, dietary methylmercury suppressed levels of T in males and E2 in females. It also inhibited gonadal development of females; gonadal development was positively related to plasma levels of T in males and E2 in females. We subsequently quantified sex hormones (T and 11-ketotestosterone) in adult male northern pike from semi-pristine drainage lakes in Voyageurs National Park, USA. The lakes span a narrow range in pH, but vary more than 8-fold in methylmercury concentrations in resident northern pike and have some of the highest concentrations of methylmercury in fish within Minnesota. Fish were sampled shortly before active spawning in early May 2002. Concentrations of reproductive hormones varied greatly among individual fish within each lake. However, mean hormone concentrations decreased markedly with increasing methylmercury exposure among lakes, as reflected by the concentration of total mercury in axial muscle tissue of the fish. Reproduction of wild fishes may be adversely affected by methylmercury, and suppressed hormone levels can be used to indicate diminished reproduction of fish.

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METHYL MERCURY EXPORT FROM TWO PONDS ON TWITCHELL ISLAND: HABITAT MAKES A DIFFERENCE

Wetlands are known to be major contributors of methyl mercury to the Bay-Delta system. Considering 5,504 hectares of wetland restoration is planned for the Bay-Delta, it is important to evaluate which aspects of wetland design affect methyl mercury production. The sediment-water flux of methyl mercury in two 270-hectare experimental ponds on Twitchell Island was examined from June to December 2003. The ponds had different depths, vegetation densities, water flow patterns, and methyl mercury production rates. The flux of methyl mercury was calculated from water budgets, methyl mercury concentration of import and export waters, and the surface area of the ponds. In June, the flux of methyl mercury from the west pond was 41 ng m^{-2} d^{-1} while the flux from the east pond was 3 ng m^{-2} d^{-1}. In October, the flux from both ponds leveled off to 3 ng m^{-2} d^{-1}. If the planned wetlands are similar to the west pond with respect to methyl mercury production, they could contribute an additional 2.25 g d^{-1} of methyl mercury to the delta. Conversely, wetlands that are similar to the east pond could contribute far less methyl mercury. Investigations to determine why these two similar ponds are producing different amounts of methyl mercury are critical for making restoration decisions.

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THE CALIFORNIA WATER AND ENVIRONMENTAL MODELING FORUM

The California Water and Environmental Modeling Forum (CWEMF) is a non-profit, non-partisan organization whose mission is to increase the usefulness of models for analyzing California's water-related problems, with emphasis in the San Francisco Bay-Delta watershed. The CWEMF, which was formed in 1994, carries out this mission by:

· Providing a consensus-building atmosphere on water-related issues;

· Maintaining a modeling clearinghouse that provides an open forum for the exchange, improvement, and pooling of models, modeling information, and professional resources;

· Assisting in mediating technical disputes involving physical, chemical, biological, and economic modeling;

· Conducting impartial peer reviews of models in order to document strengths and weaknesses, suggest improvements, and identify appropriate applications;

· Seeking input from California water stakeholders and decision makers about their modeling needs; and

· Providing educational opportunities through technical conferences and workshops.

CWEMF activities are guided by a steering committee composed of five officers elected by the membership, representatives from 11 designated governmental water organizations in California, and up to 15 members chosen by the membership to represent universities, environmental organizations, private consultants, water user agencies, and the general public. CWEMF Activities present scientific information and ideas relevant to ecosystem restoration, water quality and water supply reliability.

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EVALUATION OF VEGETATION SAMPLING METHODS FOR BRACKISH TIDAL WETLANDS

Brackish tidal wetlands pose problems for vegetation sampling. They have patchy distribution patterns with a complex influence of tidal channels compared to either tidal salt marshes or tidal freshwater systems. Our objective in this study is to compare two rapid transect-based sampling techniques against an extensive data set of random plots to assess the accuracy and efficiency of these sampling methods. We sampled a large and complex brackish tidal marsh, Coon's Island, along the Napa River. Random plots (n=199) were sampled using 3-m diameter relevé plots. These were used to compare against rapid techniques. For the rapid techniques, ten random points were chosen, and the nearest channel bank was selected as the starting point for a 40-m transect perpendicular to the channel. We used a modified EMAP protocol and a continuous belt transect. For all plots, cover of each plant species was estimated using cover classes. We found that the two more rapid, transect-based techniques gave nearly identical results for cover and frequency and were quite similar to the intense random plot method, even with fewer and smaller areas sampled. The rank order of species for cover or frequency was usually the same. Each technique yielded a unique species list. Randomly subsampling plots or transects from each technique indicates each is robust to smaller sampling sizes. Rapid methods that are appropriately designed can provide similar data to intense random sampling plots. One critical aspect is to randomly choose starting points for the rapid techniques. Because channels are associated with strong vegetation influences, the methods associated with channel banks additionally provided information directly reflecting channel influence lacking in the random sampling technique.

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QUANTIFYING TIDAL MARSH CHANNEL DENSITY AS A TOOL FOR DESCRIBING VEGETATION PATTERNS

Our conceptual model of processes affecting tidal marsh vegetation patterns proposes that geomorphic heterogeneity is a major forcing function on plant community diversity. To test this hypothesis, we needed to quantify both plant diversity and some measure of geomorphic heterogeneity. Because heterogeneity in these marshes is defined primarily by the tidal channel network, several indices of channel density were developed. We assessed these indices to determine which most accurately describes plant diversity patterns.

We created a channel network GIS dataset based on Fall 2003 orthorectified CIR aerial imagery. We then developed a suite of GIS-based methods to quantify channel density across three test parameters (method of quantifying channel density; polygon vs. centerline channel networks; channel type) at one of the six IRWM field sites, Coon Island, Napa River. We quantified plant community composition at 199 randomly generated plant relevé points, and conducted a multivariate analysis using canonical correspondence analysis (CCA) to determine which channel density metric yielded the most ecologically meaningful characterization of geomorphic heterogeneity.

Computational demands varied greatly among channel density estimation methods. The CCA showed that two similar metrics using all channels (inverse weighted and Euclidean distance) fit the model the best, with correlations for both over 0.80 (0.83 and 0.82, respectively). Although these results were significant, considerable variance remained unexplained, which was probably due to other geomorphic characteristics, especially elevation, that were not incorporated in the analysis. These results suggest that metrics can be developed to determine the processes best correlated with tidal marsh vegetation with respect to geomorphic heterogeneity. The results also suggest, however, that more than one factor, such as elevation and pore water salinity, may need to be incorporated into the model for a more accurate representation of field conditions.

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RESTORATION OF THE SACRAMENTO PERCH: GENETIC VARIATION WITHIN AND AMONG REMNANT POPULATIONS

The Sacramento perch (Archoplites interruptus) is the only sunfish (family Centrarchidae) native to the region west of the Rocky Mountains. Today it is extirpated from its native range, the Sacramento-San Joaquin watershed of California. A few transplanted populations remain in other locations, including Pyramid Lake and Stillwater National Wildlife Refuge in Nevada, and Clear Lake Reservoir and Abbott's Lagoon in California. One indigenous population may remain in Clear Lake, CA, although no fish were caught in two attempts in 2003. Much of the potential habitat in the native range of Sacramento perch is now dominated by non-native Centrarchids, such as largemouth bass and bluegill, or has been altered by changing water regimes in the region; these changes limit potential restoration sites for Sacramento perch. As a result, the Sacramento perch is listed as a species of special concern by the California Department of Fish and Game. Plans to restore this species to its native range require a thorough knowledge of the genetic diversity within the remaining transplanted populations. In this study we developed 18 new microsatellite loci for Sacramento perch and used them to describe the variation within and among these transplanted populations. These data will be used to select populations from which to draw individuals for transplantation to habitats within the species' native range. Restoring self-sustaining populations of Sacramento perch to the Sacramento-San Joaquin Delta fulfills an important goal of CALFED to restore native fish to this region.

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JUVENILE SACRAMENTO PERCH, ARCHOPLITES INTERRUPTUS, SHOALING PREFERENCES BETWEEN FAMILIAR AND UNFAMILIAR CONSPECIFIC POPULATIONS

California's only native centrarchid, Sacramento perch (Archoplites interruptus) is extirpated from most of its native habitat in the Sacramento – San Joaquin watershed. Though the exact causes for the species decline are unknown, probable reasons are the alteration and deterioration of habitat quality, and deleterious non-native species interactions. A lack of biological information on this species has stymied restoration and conservation efforts. Shoaling may function as a predator avoidance strategy and/or to increase foraging efficiency. These functions occur optimally if a fish is permitted to shoal with the preferred group. Most captive breeding programs used for restoration fail to consider the impact of behavior on successful population restoration. We tested for an individual's prior experience as an influence on its shoaling preference by conducting a standard binary shoal choice test. We measured the subject fish's distance from familiar and unfamiliar conspecifics over a fifteen-minute period in fifteen-second intervals. Test groups consisted of hatchery raised perch (subject and familiar fish) and two wild populations (unfamiliar). Chemical, visual, and chemical-visual trials were conducted. A repeated measures ANOVA will be used to analyze the development of familiarity over time and test for shoaling preference. This study coincides with the Bay-Delta Program goal of restoring native populations to their natural habitats. It augments the concurrent physiological research being conducted by our laboratory. Our study increases the knowledge on Sacramento perch behavioral preferences and lends insight into the best conditions for effective population restoration.

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CONNECTING WATERSHED SCIENCE AND MANAGEMENT WITH THE CALIFORNIA WATERSHED ASSESSMENT MANUAL

The watershed scale is an appropriate one for assessing the impacts of many land and water-use decisions. Watershed assessment is an integrative approach to assessing impacts of human activities on natural systems at the watershed scale. The California Watershed Assessment Manual (CWAM, http://cwam.ucdavis.edu) is the first of its kind in the state to describe a process for conducting watershed assessments in California. Previous manuals from other states have suitable descriptions for certain assessment needs and approaches, but are incomplete in many important areas (e.g., the use of GIS). The CWAM describes how to organize and plan the assessment, collect and manage data, analyze data, and integrate information to inform watershed management decisions. The Manual is intended primarily for use by watershed groups and member agencies and organizations of these groups. The Manual is currently being updated to respond to users and to include protocols for collecting and analyzing new watershed data during assessments.

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INTEGRATED REGIONAL WETLAND MONITORING PILOT PROJECT – OVERALL PROJECT PURPOSE AND CONCEPTUAL MODELS

Problem Statement: Regional tidal marsh restoration efforts aim to support and recover populations of plant, fish and wildlife species. These ecological support functions follow successful establishment of a variety of ecological processes in restoration projects. In order to understand the effectiveness of tidal marsh restoration efforts regionally, we must determine which processes are in fact important to establish and the means by which we can measure and quantify these processes.

Approach: The Integrated Regional Wetland Monitoring Pilot Project (IRWM) utilizes a five-element strategy. (1) IRWM is multi-disciplinary, intensive monitoring program covering physical processes, landscape ecology, vegetation, birds, fish, invertebrates, primary production, and nutrients. (2) IRWM established a series of core and component conceptual models that describe the current state of knowledge and define a suite of hypotheses. (3) IRWM developed sampling and data QA/QC and management programs to test these hypotheses, to develop data sets to address the ecological process question, and to evaluate different approaches to restoration monitoring. (4) IRWM selected a suite of six sites (four restoration and two natural) spanning the western Delta to San Pablo Bay based on set of criteria tied to the conceptual models. (5) IRWM will integrate results across disciplines and thereby begin to address the fundamental ecological process question.

Results: IRWM initiated field sampling in fall 2003 and will continue into spring 2005. The suite of posters that comprise this Special Poster Session present a variety of results obtained to date. IRWM results are being posted for the public at www.irwm.org as data are finalized.

Conclusions / Relevance: IRWM will contribute an essential strategic element to tidal marsh restoration monitoring in the Bay and Delta in support of ongoing public investment in land acquisition and restoration.

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IRWM PHYSICAL PROCESSES MONITORING IN RESTORED AND REFERENCE TIDAL MARSHLANDS

Problem Statement: The IRWM Physical Processes Team conceptual model serves as one of two core IRWM models. This model proposes: (1) estuarine salinity gradient, inundation regime, sediment supply, and substrate are fundamental external forcing functions on tidal marshes, and (2) these forcing functions, in combination with baseline site conditions, affect tidal marsh restoration trajectories.

Approach: To test this hypothesis and support of work by other IRWM teams, we are installing equipment and instrumentation to measure a number of physical parameters we consider as indicators of physical processes driving abiotic and biotic marsh evolution. We have deployed autonomous monitoring instruments within the main channel entering each site to measure conductivity, temperature, depth, and suspended sediment concentration (CTDS stations), and on the marsh plain at several locations to measure water level and temperature. We are currently deploying piezometers (pore-water salinity) and SETs (marsh accretion) and will conduct topographic surveys and soil sampling (bulk density, N, C, S) to complete the data set.

Results: We have preliminarily begun generating a variety of analytical products to describe hydroperiod (inundation regime), salinity regime and sediment supply. We plan to analyze these data by first analyzing temporal trends in water quality and hydrologic data, and then characterizing physical processes metrics based upon marsh elevation and geomorphology. Statistical analyses will then be used to determine within and between marsh variation and to assess the importance of these different parameters in driving biotic and abiotic marsh evolution. These data are complimentary to other data we are collecting on accretion, geomorphology, and sediment chemistry.

Conclusions: The IRWM physical monitoring will yield a suite of data collection and analytical methods applicable throughout the region and it will support the understanding, in conjunction with all the IRWM teams, of the role of external forcing functions in affecting ecological processes at multiple scales.

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USING STAKEHOLDER PROCESSES TO DRIVE AQUATIC PESTICIDE MONITORING

In 2001, the Talent decision mandated that states in the U.S. Ninth Circuit federal court jurisdiction develop NPDES permits for the discharge of aquatic pesticides to waters of the United States. Development of an NPDES permit in California was contentious because of the lack of aquatic pesticide environmental impact data perceived as unbiased by all parties involved.

To achieve consensus, an open and collaborative stakeholder driven process was established where extensive monitoring of aquatic pesticide applications was conducted for two years and the results of this monitoring used in the development of a science-based NPDES permit. The organization included a steering committee of stakeholder group representatives, several technical workgroups, and an external scientific review panel. The USEPA Triad method (chemical characterization, toxicity testing, and bioassessments) was applied wherever practical.

All chemical characterization data were analyzed using USEPA's Office of Pesticide Programs risk characterization process that compares chemical concentrations to aquatic toxicity data. For at least one application of each pesticide, the risk characterizations indicated the potential for adverse impacts (due to either the pesticide or added surfactant).Our results indicate that toxicity testing is not likely to detect subtle environmental impacts that aquatic pesticides may be causing. Bioassessments are the tool most appropriate to make these kinds of assessments. However, bioassessment require multiple years of data before definitive conclusions can be drawn.

Although the data set yet generated is comparatively small, the SWRCB is using these data as a screening tool to determine the monitoring requirements of the California aquatic pesticides NPDES permit. The SWRCB will also be reopening the permit to add joint or regional monitoring requirements that will allow resources to be pooled to answer the tougher scientific questions identified by our data without unduly financially burdening the individual dischargers.

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IDENTIFICATION OF POM SOURCES IN THE SAN JOAQUIN RIVER USING ISOTOPES OF CARBON AND NITROGEN

Periodic low dissolved oxygen conditions caused by degradation of organic matter, as observed in the San Joaquin River, are now a common occurrence in other freshwater and coastal systems worldwide. It is important to understand the role of the various organic constituents involved in this process for the purpose of developing effective remediation plans.

The importance of particulate organic matter (POM) in nutrient transport and oxygen consumption in surface waters is largely a function of its bioavailability. Soil-derived POM is less bioavailable than freshly produced aquatic POM (mostly algae); therefore, it is important to know the relative proportions of terrestrial and aquatic POM.

POM was collected as part of a CALFED pilot study during the late summer and fall of 2000 and 2001and during three subsequent one-day transects in 2002 and 2003. The purpose of the pilot study was to evaluate the usefulness of carbon and nitrogen isotopes of POM, as well as other constituents, as tracers of the processes leading to low oxygen concentrations in the San Joaquin River at the Stockton deep water channel.

The relatively low carbon isotope values and C:N ratios of POM in all of the data indicate that the majority of POM is composed of algae. A comparison between carbon isotopes of POM in the San Joaquin River and its minor tributaries reveals that the algae is produced mostly in the San Joaquin rather than transported in from its tributaries. A comparison of nitrogen isotopes of POM and nitrate indicates that riverine nitrate is an important nutrient source to algae and supports the hypothesis that algae is produced in the San Joaquin. These preliminary data argue strongly for the usefulness of carbon and nitrogen isotopes as tracers of origin of POM in aquatic systems.

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NEXUS BETWEEN TWO CALFED-FUNDED WETLAND RESTORATION RESEARCH-MONITORING PROJECTS – BREACH AND IRWM

Problem Statement: Promoting support and recovery of tidal marsh dependent plant, fish, and wildlife species in the San Francisco Estuary and Delta depends upon restoration throughout the region. To understand how tidal marsh restoration can contribute desired ecological support functions, it is vital to understand restoration project trajectories and how restoration at various stages contributes to underlying ecological processes that support the target species.

Approach: Breach I and II (BREACH) examined trajectories of eleven restoring and nine reference tidal marshes across the salinity gradient from San Pablo Bay to the central Delta. It collected data on geomorphology, fisheries, invertebrates, vegetation, and birds. The Integrated Regional Wetland Monitoring Pilot Project (IRWM) is examining how tidal marsh restoration projects are affecting ecological processes at different spatial scales. It is collecting intensive data at six sites covering physical processes, geomorphology, landscape ecology, vegetation, birds, fisheries, invertebrates, food web, primary production, and nutrients.

Results: BREACH learned that interactions between landscape position along estuarine salinity gradients, landscape context, geomorphology, antecedent conditions, and local hydrology may be more important in predicting trajectory than age alone. It learned that certain interactions, such as among vegetation patterns and drainage networks, local sediment sources, and subsidence appear more important than simply predicting a single evolutionary pathway. IRWM is building on the BREACH potential with landscape ecology and closely linked vegetation and biota data to help understand these elements better. The overlap of principal investigators between the projects helps to generate unified conceptual models and datasets, with synthetic results interpretation, and in having IRWM build upon lessons learned from BREACH.

Conclusions / Relevance: These nexus of these two projects is now providing new insights into relating tidal marsh restoration progress with their effects on ecological processes and consequently a better understanding of how regional restoration efforts will contribute to species support and recovery.

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BREACH EVIDENCE OF TROPHIC INTERACTIONS AMONG FISHES AND MACROINVERTEBRATES IN RESTORING BAY-DELTA WETLANDS

A leading question about restoration of estuarine wetlands is whether and when they contribute materially to the support of fish and wildlife, particularly through unique habitat associations such as foraging on endemic prey resources. BREACH investigations of fish diet composition in restoring and reference wetlands of the Bay-Delta from 1997 to 2004 were designed to determine: (1) the primary prey linkages for prominent fishes, (2) prey associations with marsh physical and biological attributes, and (3) differences among fish diet compositions and selectivity. Of particular importance was whether, and at what stage, restoring wetlands contributed directly to the support of indigenous, as compared to non-indigenous, fishes. For comparison, fishes were grouped into marsh residents, nursery residents, transient planktivores and predators; we also grouped prey according to their occurrence in benthic, epibenthic, phytal, planktonic or neustonic assemblages. Coincident with other relationships among attributes of restoring wetlands in the Delta and the (northern) Bay, we have found contrasting food web links at the two ends of the salinity gradient. Macroinvertebrates associated with SAV and insects (neuston/drift) account for a greater proportion of the food web support of fishes in the Delta than in the Bay; planktonic organisms are prominent only in the large subsided "lakes" such as Mildred Island. In contrast, restoring wetlands in the Bay tend to provide more benthic and epibenthic prey to fishes, except for obligate planktivores; however, especially in restoring marshes, even epibenthic crustaceans are prominent dietary components in planktivores. In restoring marshes of the Bay, prey selection was surprisingly high for benthic and epibenthic taxa, particularly the amphipod Corophium alienense and mysid Neomysis kadiakensis. Fish species of concern, such as Chinook salmon and California splittail appear to derive considerable support from identifiable marsh production. Biomarkers (e.g., stable isotopes) may enable us to better validate that assertion.

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VEGETATION STRUCTURE ALONG THE BAY-DELTA WETLAND RESTORATION GRADIENT

An essential element of the 1997-2004 BREACH studies in the Bay-Delta was comparison of wetland vegetation structure in the 11 restoration sites and 9 unleveed reference study sites. Many of the issues surrounding wetland restoration concerns the types, rates and patterns of wetland vegetation colonization, and ultimate assemblage structure, that develops over time at restoring wetlands. The pervasive expectation, and that being tested by the BREACH investigations, is that restoring wetland sites will converge toward the structure of reference sites. In addition, understanding associations among vegetation colonization patterns, successional trajectories and other associated functions of these sites, such as provision of important fish, bird and mammal habitat, will be critical to strategic planning of future and more effective restoration. At each of our 20 research sites, we conducted transect sampling and spot samples in conjunction with high-resolution GPS, generating vegetation assemblage-elevation profile and lowest colonization elevation data, respectively. In accordance with our emerging BREACH conceptual model (see D. Reed abstract), we focused on initial colonizing vegetation assemblages because we found many of the restoring sites physical and other ecological attributes assumed more identifiable developmental trajectories after vegetation colonization. Position along the Bay-Delta salinity gradient was the strongest factor on both colonizing and maturing vegetation assemblages, from the colonizing Salicornia europa and Spartina foliosa and Salicornia virginica dominated maturing marsh in the northern Bay, to the Scirpus acutus, S. californicus, S. americanus ("tule") and Typha spp. dominated assemblages of the inner Delta. However, species richness, diversity and complexity of the vegetation assemblages of reference sites were typically higher than any restoring site, suggesting that the structural heterogeneity of the ancient wetlands results from antecedent processes that are not necessarily or yet captured at the restoration sites we examined. Structural complexity should be considered more in future restoration design and monitoring.

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INFLUENCE OF MAJOR DAMS ON HYDROGRAPHS THROUGH A RIVER NETWORK: EXAMPLES FROM THE SACRAMENTO VALLEY, CALIFORNIA

Basinwide patterns in hydrograph alteration were identified by analyzing hydrologic data from a network of long-term streamflow gauges located various distances downstream of major dams in a large river basin. This research was conducted in the Sacramento River basin in California, USA. The 68,000 km^2 basin has many major dams installed between 1940 and 1970 for water supply, irrigation, and flood control. We have selected seven major dams on the mainstem Sacramento and its tributaries to determine their influence on flow at nine downstream gauging stations. Streamflow data were divided into pre- and post-dam hydrologic series of at least 7 years and a flood threshold was defined statistically for each. The data series were statistically analyzed to compare pre- and post-dam hydrographs with respect to annual flood peak, mean annual flow, annual flow volume, flood duration, flood drawdown rate, and annual number of flood days. The results indicate the extent to which: 1) dams affect hydrographs downstream of dams; 2) a dam's influence changes at various distances downstream; and 3) hydrograph alteration from various dams is mixed downstream of confluences near the basin outlet. This research has implications for aquatic and riparian ecosystems and for rehabilitation strategies involving flow alteration and/or manipulation of sediment supplies.

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TRENDS IN METHYLMERCURY EXPOSURE ASSOCIATED WITH A GRAVEL PIT LAKES WETLAND RESTORATION AT CACHE CREEK

Lower Cache Creek in Yolo County is a primary source of gravel used in construction throughout the surrounding region. Gravel mining has been discontinued within the flow channel, with current mining consisting of shallow to deep pit operations in the adjacent floodplain. As these pit regions are exhausted of target rock, long range planning proposes converting them into wetland habitats, resulting ultimately in a series of approximately 17 substantial constructed wetlands along the Capay-Woodland Cache Creek corridor. The concern, in this documented high mercury watershed, is that the habitat and recreational benefits of these new wetlands may be compromised by enhanced methylmercury exposure and export.

Mercury bioaccumulation was investigated over a three year period at a newly constructed pit lakes wetland restoration, the Cache Creek Nature Preserve, as well as in the Gordon Slough inflow and Cache Creek upstream and downstream of the wetlands.

A distinctive spatial pattern of bioaccumulation was found, with identical small fish biosentinels in the constructed wetlands accumulating to more than double the concentrations of methylmercury seen in the inflowing slough habitat, statistically significant at the 95% confidence level. Methylmercury in outflowing water was also elevated. No discernible bioaccumulation increases generally resulted in downstream Cache Creek, possibly due to the relatively low concentrations in Gordon Slough source water. Large, statistically significant seasonal cycles were found in mercury bioaccumulation in both wetland and creek environments, with minimum concentrations in the late winter and spring and maximum concentrations (as much as 5-fold greater) in summer and fall.

This type of converted, vegetated wetlands habitat can be expected to enhance localized methylmercury production and exposure, relative to slough inflow habitats. The magnitude of this effect may be minimized by utilizing low-mercury source water and low-mercury surficial sediments. Export of methylmercury may be minimized by minimizing warm season outflows.

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BIOACCUMULATION OF GOLD-RUSH MERCURY IN REACHES OF THE YUBA RIVER WATERSHED PROPOSED FOR ANADROMOUS FISH REINTRODUCTION

The Middle Yuba and South Yuba rivers are being considered as sites of renewed spawning access for anadromous salmonids, including steelhead and spring-run Chinook salmon. This would require fish passage at Englebright Dam (79 m high), which is being considered for decommissioning or modification. The potential for juvenile anadromous salmonids to be exposed to elevated methylmercury (MeHg) in the upper watershed is of concern.

Biotic mercury was sampled at 13 sites, 10 upstream and 3 downstream of Englebright Lake. Sites spanned the zone of historical gold-mining activity (200-900 m elevation), with additional sites upstream and downstream (30-1,700 m elevation). Adult and juvenile trout, hydropsychid caddisflies, and perlid stoneflies were utilized as biosentinels of relative MeHg exposure. Non-anadromous rainbow trout were sampled from upstream sites as surrogates for potentially reintroduced anadromous salmonids.

All biotic samples showed consistent, statistically significant increases in MeHg and total mercury (THg) within the historical gold mining zone: 4- to 6-fold increases of MeHg in invertebrates, 2- to 4-fold increases of THg in juvenile trout, and 2- to 3-fold increases of THg in adult trout. Mercury bioaccumulation was significantly lower immediately downstream from Englebright Lake, although some higher values were noted further downstream in the lower Yuba River, the site of large-scale historical and ongoing dredging activity. MeHg concentrations in aquatic insects and juvenile trout correlated strongly with each other and with THg concentrations in adult trout, all exhibiting system-wide R^2 correlation coefficients greater than 0.90.

Significant mercury bioaccumulation was found within the historical gold-mining region in the upper Yuba River watershed. If mercury-contaminated stream reaches are re-opened for migration and rearing of anadromous salmonids, juveniles are likely to be exposed to elevated MeHg, with possible adverse effects. This study confirms the utility of young-of-year fish and aquatic insects as biosentinels for MeHg exposure and bioaccumulation.

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THREE-DIMENSIONAL MODELING OF CIRCULATION, STRATIFICATION, AND TURBULENCE IN THE STOCKTON DEEP WATER SHIPPING CHANNEL

A new modeling study is underway to illuminate the physical processes contributing to low dissolved oxygen events in the Stockton Deep Water Shipping Channel (SDWSC). The approach is to use a three-dimensional, fully non-linear, baroclinic, free surface, time-stepping model (SI3D) to simulate circulation in the system. The model domain spans the San Joaquin River just upstream from the Port of Stockton to approximately 15-km downstream of Stockton. Calculations will be done on a set of model grids with 10-m, 20-m, and 30-m horizontal resolution and 1-m vertical resolution. The 10-m grid contains approximately 114,000 horizontal cells and 14 vertical layers (about 1.6 million active cells total). Model bathymetry was obtained from a database prepared by the California Department of Water Resources and developed into grids by the Interagency Ecological Program and the U.S. Geological Survey. The model will be calibrated using detailed month- long observations of velocity and temperature fields obtained from an ongoing field study of the system. Data from this field study will also be used to provide model boundary conditions. Once calibrated, the model runs will be conducted to explore the parameter space of conditions found in the SDWSC (e.g. varying freshwater inflow, tidal forcing, stratification). Circulation fields from the model will be used as input to a water quality model to simulate DO. The combined modeling results should provide guidance on both the physical mechanisms leading to low DO events and how the system can be managed to avoid these conditions.

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SEASONAL AND INTERANNUAL VARIABILITY IN DELTA DISSOLVED ORGANIC MATTER FROM STATISTICAL ANALYSIS OF HISTORICAL DATA

Elevated concentrations of dissolved organic carbon in Delta waters pose a threat to drinking water quality because of the tendency of this material to form carcinogenic disinfection by-products during water treatment process. We used a statistical analysis of historical trends in DOC concentration and inorganic parameters to identify DOC sources and processes controlling Delta DOC in the past. Quarterly averaged DOC data from 1987 to 1999 from the Banks pumping plant, Mallard Island, Green's Landing (Sacramento River), and Vernalis (San Joaquin River) were used to evaluate long-term trends.

At the Banks pumping plant, mean DOC during the first quarter (January-March) remained stable at 4 mg/L from 1987 to 1990, nearly doubled between 1991 and 1995, and returned to ~4 mg/L by 1997. Over the same period, mean DOC in the Sacramento River at Green's Landing declined monotonically from 3 to 2 mg/L, while there was no trend in DOC at Vernalis. At Mallard Island, mean DOC increased steadily by 1.3 mg/L per year, or by >40% over 10 years. The DOC peak at Banks between 1991 and 1995 is consistent with significant winter in-situ production suggested by a three end-member mixing model based on inorganic constituents.

A comparison of wet year versus dry year DOC monthly averaged DOC at Banks shows that in wet years, the winter peak DOC is reached earlier and is sustained for a shorter period than in dry years; however, the average DOC concentration at Banks of wet years is not significantly different from that of dry years within the variability of the data. The increase in DOC at Mallard Island (by ~1.3 mg/L over 10 years), which occurs concurrently with the Sacramento River DOC decrease, suggests that in-situ DOC production in the lower Sacramento River and North Delta may be increasing over time.

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DISTRIBUTION, ABUNDANCE AND MATURITY STATUS OF DELTA SMELT, HYPOMESUS TRANSPACIFICUS, IN THE SAN FRANCISCO ESTUARY

The Department of Fish and Game has conducted the Spring Midwater Trawl survey (SMWT) annually since 1991, to monitor the winter and spring distribution and abundance of delta smelt, Hypomesus transpacificus. The information collected was intended to provide an indication of an adult spawning distribution favoring the eastern or southern delta, which could lead to increased salvage at the south delta pumps and potentially result in high juvenile salvage later in the year.

Initially, there was concern that the current gear, a midwater trawl, was not as effective as other gears in capturing the target species. We revisited a special study conducted by IEP in September of 1994 designed to investigate the efficiency of various nets at capturing delta smelt. This study developed evidence strongly suggesting that the current gear and protocol was not as effective as either the United States Fish and Wildlife (USFWS) Chipps Island trawl or a Kodiak trawl. Therefore, beginning with the 2002 sampling season, the use of a larger, surface towed Kodiak trawl was employed to take advantage of its higher catch efficiency. This proved much more effective than the previous midwater trawl and enabled us to better inform water-export facility operators of the potential to entrain adult delta smelt and their offspring. Since 2002, the total catch of delta smelt in the Spring Kodiak Trawl survey (SKT) has increased and the average number of zero-catch stations has decreased, indicating that the Kodiak trawl is in fact more successful at detecting delta smelt, especially in low densities.

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MAPS OF URBAN HYDROLOGY, SAN FRANCISCO BAY AREA, CALIFORNIA

The San Francisco Bay area is a highly urbanized watershed whose streams are both showcased in parks and open space, and relegated to concrete canals or underground storm drains through densely developed areas. Citizens and professionals need a vehicle for understanding this mix of natural and highly engineered streams.

We are developing a series of creek and watershed maps that show, at 1:26,500 scale, both the modern drainage system -- including creeks, engineered channels, underground culverts and storm drains, reservoirs, and watershed boundaries -- and the historical creeks and marshes. The maps dramatically illustrate the extent to which the landscape has changed due to urbanization. Also included are points of interest, regional maps that show historical and/or modern drainage, and local vignettes that enrich the understanding and appreciation of the hydrology of the area. To date, four maps are published, two will be published in late 2004, and eight others are planned for 2005 to 2007.

These maps represent the first-ever published compilation of pre- and post-development hydrology of this area, and will be the only published maps that show the current configuration of the storm drain system on a watershed scale. As each map is completed, we convert the graphic data into a GIS. When completed these GIS files will constitute the only consistent GIS data set of drainage for the Bay Area. Storm drainage data are maintained by over 100 local jurisdictions in the Bay Area typically in widely varying formats and scales.

The four published maps -- of Oakland-Berkeley, Hayward-San Leandro, Fremont and Pleasanton-Dublin, are used by professionals and laypersons alike. Over 8,000 copies have been distributed. Users include professionals charged with managing non-point-source pollution, citizens curious about their watersheds and neighborhood creeks, school teachers, community leaders, creek advocacy groups, stewardship programs, historians, and watershed scientists.

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BEING ADAPTIVE IN THE FIGHT AGAINST WEEDS

Invasive herbaceous weeds including perennial pepperweed (Lepidium latifolium), Johnson grass (Sorghum halepense), Russian knapweed (Acroptilon repens), and yellow star thistle (Centaurea solstitialis) pose an often overlooked threat to habitat and wildlife species recovery. To address this threat, River Partners is utilizing a combination of weed control and native understory plant establishment to limit the infestation of invasive species on the San Joaquin River National Wildlife Refuge (Refuge), where River Partners is restoring approximately 800 acres of riparian vegetation. River Partners is using an adaptive management process to establish and manage a dense native understory to compete with invasive weeds and improve wildlife habitat.

Observations on the Refuge suggest nearly pure stands of mugwort (Artemisia douglasiana) and gumplant (Grindelia camporum var. camporum) occur on a variety of soils and compete well with invasive weeds. In addition to potentially suppressing weeds, these species also provide habitat for nesting birds and serve as important insectary plants. Because little is known about planting and establishing mugwort and gumplant, adaptive management has played an integral role in our understory restoration approach, experimental plantings, and implementing and managing large-scale plantings of these species.

In December 2003, River Partners broadcast seeded approximately 60 acres each of mugwort and gumplant throughout a 2-year-old restoration project. Initial results show excellent germination and seedling establishment of both species. Field preparation, weed control, irrigation, and above all, timing of these activities have been critical to seedling survival and growth. This requires extensive monitoring and weekly management decisions that adapt to changing growing conditions as well as vegetation responses to these management actions. Adapting management practices shows promise for establishing these understory species and similar processes could be used to increase the success of understory plantings and the fight against weeds on other projects.

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METHYLMERCURY EXPORTS FROM WETLANDS IN THE SAN FRANCISCO BAY DELTA--PRELIMINARY DATA

The California Bay-Delta Authority plans to convert large amounts of San Francisco Bay-Delta agricultural land to wetlands. Studies conducted in numerous estuaries including the Bay-Delta have shown wetlands to be major methylmercury production sites. Mass balance calculations suggest that in low flow conditions about 40 percent of the aqueous methylmercury present in the Bay-Delta estuary at any time is produced in situ and an unknown fraction originates from Delta marshes. A concern, expressed by the Authors of the Mercury Strategy for the Bay-Delta Ecosystem, is that the conversion of large tracts of Bay-Delta agricultural land to marsh habitat may exacerbate methylmercury exposure and concentrations in aquatic resources. Several studies were conducted in the Bay-Delta to quantify methyl mercury export from marsh habitat. Methylmercury concentration data from Browns Island indicate methyl mercury is exported from the marsh during the latter half of the ebbing tide cycle. Other studies are ongoing in Suisun Slough and Twitchell Island to determine water and methylmercury exports/imports for the determination of mass loading estimates. The wetlands mass loads are compared to mass loads from riverine inputs for a better understanding of the relative importance of each habitat within the overall Bay-Delta methylmercury budget. Data from several wetland areas are presented.

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QUANTIFYING LANDSCAPE-LEVEL DRIVERS OF TIDAL MARSH RESTORATION IN THE NORTHERN SAN FRANCISCO ESTUARY AND WESTERN DELTA

Indicators of tidal marsh restoration are generally measured at the scale of individual restoration sites. Marsh plain development and plant establishment, channel formation, and the presence or abundance of key wildlife species, are common ways of assessing restoration success. But factors controlling restoration trajectories and outcomes may also operate at larger spatial scales, controlled by physical drivers, such as salinity and sediment availability gradients, as well as anthropogenic patterns of landscape modification. Thus it is important to examine the effects of restoring individual tidal marshes in a larger context, using a multi-scale synoptic landscape approach. The landscape ecology team of the of the Integrated Regional Wetlands Monitoring (IRWM) project, has developed a suite of landscape-scale metrics that may be used to provide context and explanatory power for site-level restoration outcomes.

Using a combination of best-available GIS data layers representing bayland habitats, bayland-adjacent vegetation types, and upland land cover types within surrounding watersheds, we developed a suite of spatial metrics for each wetland patch in the northern estuary and western delta. Patch delineation methods were modified from a previous EMAP effort, and encompassed three nested spatial scales. In addition to patch-level metrics relating to size, shape, and isolation, we used a cost surface analysis to quantify functional landscape connectivity for each patch, recognizing the spectrum of functions provided to different wildlife species by different habitat types and different spatial scales. To address the physical drivers of restoration processes, as well as the factors that are likely to influence aquatic species in tidal marshes, we characterized each wetland patch in terms of estuarine salinity, sediment supply and wave/wind energy. We evaluated IRWM restoration and reference sites with respect to these suites of landscape-scale metrics, and placed them in the context of other wetlands across the Northern Estuary and Western Delta regions.

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COMPARING THE VALUE OF TIDAL MARSH GEOMORPHIC METRICS FOR PREDICTING RESTORATION INDICATOR RESPONSES

The extent and spatial pattern of geomorphic features (i.e., channels, ponds, and pannes) in a tidal marsh is thought to be a product of time, location in the estuary, and human intervention, as well as site-specific characteristics such as slope, substrate, and other antecedent conditions. The development of repeatable, standardized metrics for comparison of these features across sites may help in the evaluation of restoration progress, and the development of specific restoration strategies. As part of two CalFed-funded interdisciplinary restoration monitoring and research projects (BREACH II and IRWM), a team of researchers evaluated and compared the value of tidal marsh geomorphic metrics for the purpose of predicting restoration indicator responses. We compared across restoration and reference marshes located the Northern Estuary and the Western Delta. We compared two channel digitizing methods (fully manual vs. partly automated), several approaches to feature classification, and several density and sinuosity metrics. Metrics for IRWM sites were based on color infrared aerial photos acquired specifically for the project, whereas for BREACH sites we used the best available orthorectified imagery from outside sources.

Based on our marsh-level metrics, we characterized a range of geomorphic conditions across the estuarine salinity gradient, and identified differences between restored and reference marshes. We then calculated these geomorphic metrics at several scales and used the metrics as independent variables in regression models for abundance and diversity of fish and bird species. For birds, results of these analyses suggest that channel width may be a more appropriate classifier than order, and that area-based channel density metrics are more meaningful than linear metrics. For fish, we found important differences in species composition and abundance between high- and low-order drainage networks. From our findings we recommend a suite of geomorphic metrics that may be used to characterize potential restoration endpoints and predict indicator responses.

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MODELING POTENTIAL IMPACTS OF NON-NATIVE SPARTINA SPREAD ON SHOREBIRD POPULATIONS IN SOUTH SAN FRANCISCO BAY

San Francisco Bay holds 70% of California's mudflats and provides habitat to more wintering and migratory shorebirds than any other wetland along the Pacific coast of the contiguous U.S. The Bay's mudflats are currently threatened by the spread of a non-native cordgrass, Spartina alterniflora, and associated hybrids, which grow at lower elevations than the native S. foliosa and can render large mudflat areas effectively unavailable to shorebirds for foraging. Using shorebird and benthic invertebrate survey data, tidal benchmark data, and GIS-based habitat data, we analyzed the potential effect of S. alterniflora on shorebird habitat in the South Bay, creating grid-based spatial models of shorebird habitat value and potential S. alterniflora spread. We developed 12 potential scenarios of habitat value loss for shorebirds, based on assumptions about invertebrate density, inundation tolerance of S. alterniflora, and temporal availability of mudflat resources. Predictions of habitat value loss ranged from 10% to 80%. We identified the upper mudflats, due to their greater exposure time, and the east and south shore mudflats, due to the high numbers of birds detected there, as the areas of highest value to shorebirds in the South Bay. These areas also coincide with the areas of greatest Spartina invasion potential.

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A FRAMEWORK FOR DEFINING AND EVALUATING QUANTITATIVE PERFORMANCE CRITERIA FOR FISH HABITAT RESTORATION PROJECTS

Problem Statement: A key issue in fish habitat restoration concerns the methods and data available to quantify fish production in restored habitats. Such information is essential for improving the scientific basis for determining the necessary spatial and temporal extent of restoration actions, defining restoration goals, and evaluating restoration performance.

Approach: Fish habitat restoration actions are based on the assumption that there will be an increase in the number and biomass of fish in the restored habitat over a given period of time. For this to occur, production of the fish species of interest must be a function of habitat availability and quality. While this assumption is implicit in most fish habitat restoration projects, few projects define restoration goals or evaluate restoration performance in terms of the productive capacity of the habitat type to be restored. With funding from the California Energy Commission, we conducted an extensive review of the methods and data available for estimating rates of fish production in natural and restored habitats, and used this information to develop a framework for evaluating the performance of fish habitat restoration projects. We applied the framework in a case study of fish restoration projects in California.

Results: Research results provide information on fish production in restored habitats for use in defining restoration goals and evaluating restoration performance and also indicate data gaps that are a high priority for future research. Case study application of the framework demonstrated that it is an effective, science-based tool for restoration planning and evaluation.

Conclusions/Relevance: Project results are directly relevant to the CALFED goal of improving the scientific basis of fish restoration activities. Without methods and data for quantifying fish production in restored habitats, it will not be possible to adequately determine the type and amount of restoration required to support sustainable fish populations or to measure restoration performance.

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RAPID EVALUATION OF ALGAL BLOOMS IN AGRICULTURAL DRAINS FOR MEETING DISSOLVED OXYGEN TMDL REQUIREMENTS

A contributing factor to the dissolved oxygen deficit in the Stockton Deep Water Ship Channel is the influx of algal biomass from the San Joaquin River (SJR). As part of the proposed dissolved oxygen total maximum daily load (TMDL), algal biomass production will need to be monitored and managed. The objective of this study was to develop a rapid and inexpensive method for evaluating algal blooms in agricultural drains and to develop models of algal growth kinetics useful for evaluating practices directed at controlling algal growth in the SJR watershed.

A YSI 6600 Multiparameter Water Quality Monitor (MPWQM) was used for rapid field measurements of chlorophyll (a measure of algal biomass), turbidity, and other water quality parameters in a well-defined and hydraulically simple (one input and one output) agricultural drain. Grab samples were collected and analyzed to validate field measurements. The field and laboratory data were compared and modeled to evaluate whether rapid field measurements were sufficient to determine the algal rate of growth and the location of maximum algal biomass accumulation, parameters important to the design and evaluation of algal management actions.

It was determined that a MPWQM could be used to accurately and rapidly locate and assess algal blooms in agricultural drains. The instantaneous chlorophyll measurement was highly correlated with laboratory measurement of chlorophyll using Standard Methods and independent measurements of algal biomass using organic carbon and phospholipid analysis. Algal growth kinetics followed both a descriptive model (Logistic) and a mechanistic model which included functions for nutrients, light, and grazing. The results of this study show that rapid evaluations of agricultural drains using MPWQMs will yield kinetic information that can be used to evaluate problem areas and provide inexpensive data for engineering models used to predict grow-back rates after algal control actions.

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EFFECTS OF MERCURY ON BIRD REPRODUCTION IN THE SAN FRANCISCO BAY-DELTA ECOSYSTEM

The legacy of mining in California, resulting in mercury (Hg) accumulation in the Bay/Delta Ecosystem has resulted in potential Hg bioaccumulation and adverse effects on listed and non-listed wildlife species. A three-year joint U.S. Fish and Wildlife Service and U.S. Geological Survey project is being initiated with funding from CALFED to evaluate the potential effects of Hg on three foraging guilds of birds in the Bay-Delta ecosystem. A field component will build on existing data to evaluate reproduction in diving ducks (surf scoters), recurvirostrids (stilts, avocets) and terns (Caspian and Forsters). We will identify trophic pathways for each foraging guild (using diet, stable isotopes and telemetry), quantify Hg concentrations in adults, eggs and chicks of selected species, and evaluate reproductive success for each foraging guild by quantifying hatchability and chick survival. Laboratory studies will: (1) establish and refine Hg dose-response relationships and threshold concentrations of methyl Hg associated with embryo toxicity to various avian taxa using egg injection studies, and (2) use mallards to conduct a feeding study designed to establish a true NOAEL (No Observed Adverse Effects Level) to which egg injection studies may calibrated.

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HABITAT USE OF SWAINSON'S HAWK IN A VINEYARD LANDSCAPE IN THE LOWER MOKELUMNE RIVER WATERSHED

The Swainson's Hawk (Buteo swainsoni) was listed as a threatened species in California in 1983, after a dramatic decline in population. The highest densities of California nesting pairs at present are in the Central Valley. An increase in vineyards has taken place in these areas, especially in the past 15 years. In the lower Mokelumne River watershed (LMRW), an area dominated by vineyards, preliminary surveys of hawks indicated that the Swainson's Hawk might be declining, prompting a study to assess its habitat use in vineyards.

In 2002 and 2003 systematic surveys of Swainson's Hawk nests were conducted in the LMRW, along with road surveys to record foraging-habitat associations. After the breeding season, nest tree variables were measured at nest sites and at random sites. Arcview GIS technology was used to measure habitat features surrounding these sites. Habitat selection was determined for nesting and foraging, and comparisons were made between use of vineyards and other available habitats. Logistic regression was performed for all variables associated with nest sites to find what features distinguish nest presence.

Analysis concluded that Swainson's Hawks forage and nest in vineyard habitat less than expected by random choice, forage more in irrigated hayfields, and nest more in ag-urban (rural) habitat. Nest sites were distinguished from random sites by larger and taller trees that are located closer to paved roads, and hayfields, and to habitat edges. The area surrounding the nest tree exhibits higher habitat diversity, and a higher perimeter density than random trees. This study reiterates the importance of maintaining landscapes in the Central Valley that are conducive to Swainson's Hawk abundance, shows that vineyards are not preferred, and defines features that increase nest presence.

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FISH-X2 RELATIONSHIPS EXAMINED: A BEHAVIORAL PARTICLE TRACKING MODEL FOR SAN FRANCISCO BAY

Previous work has shown that abundance of starry flounder and Crangon franciscorum shrimp populations correlate with high freshwater flow conditions in the San Francisco Estuary. We are examining the possible physical mechanisms behind this by creating a behavioral particle tracking model to simulate movement of larval fish and shrimp within the estuary. The behavioral model is a Lagrangian computer simulation tracking the advection and dispersion of neutrally buoyant particles with biologically-determined vertical velocities. TRIM-3D hydrodynamic simulations supply the velocities and vertical eddy diffusivity for our model. The results of this model will aid in the design of the next phase of work to examine the mechanisms underlying positive relationships between fish and shrimp abundance or survival and freshwater flows, the "fish-X_2" relationships. This is of vital interest to the managers of California's water resources.

Flounder and shrimp migrate as larvae from outside the Golden Gate up to the Low Salinity Zone to rear. Since tidal currents are strong, we expect that larval swimming in the horizontal plane will have a negligible effect on where they end up. We are interested in how their axial migration may be influenced by gravitational circulation, which is strengthened in the lower estuary by high freshwater flows, or by the vertical swimming behavior of larvae. Vertical migration can influence the axial and lateral movements of larvae within the estuary through the interaction between tidally-varying vertical position of larvae and vertical variability in strength and direction of tidal and residual currents. These results are being compared to a null model in which particles are randomly distributed in the water column, or maintain a constant depth.

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CHRONIC EFFECTS OF DIETARY SELENIUM ON JUVENILE SACRAMENTO SPLITTAIL (POGONICHTHYS MACROLEPIDOTUS)

The chronic effects of dietary selenium (Se) exposure in juvenile Sacramento splittail (Pogonichthys macrolepidotus) were investigated in the laboratory. A total of 960 (40 fish per tank, 3 tanks per diet) 7-month-old juvenile splittail were fed one of eight Purified-Casein diets supplemented with selenized yeast for 9 months in a flow-through system. These diets contained: 0.4 (control), 0.7, 1.4, 2.7, 6.6, 12.6, 26.0, and 57.6 mg Se/kg dry weight. Survival, Se tissue concentration, growth, gross morphology, and liver histopathology were assessed at 5 and 9 months of exposure. Mortalities of splittail fed the two highest Se concentration diets were 8.3 and 18.3 % at 5 months and 10.0 and 34.3% at 9 months, respectively. Liver and muscle Se concentration exhibited a dose-response pattern and were significantly ($r=0.94$-0.96; $P<0.0001$) correlated with the dietary Se concentration. Fish exposed to 0.4-12.6 mg Se/kg diets had reached equilibrium in liver Se concentration after 5 months. Splittail fed diet at concentrations ¡Ý 26.0 mg Se/kg had not reached equilibrium in gonad, liver, and muscle Se concentrations and grew significantly slower ($p<0.05$) at 5 and 9 months of exposure. Se-induced deformities were observed in fish fed ¡Ý 2.7 mg Se/kg diets at 5-month and in fish fed ¡Ý 0.7 mg Se/kg diets at 9-month. Fish fed 26.0 and 57.6 mg Se/kgdiet had higher liver lesion scores at 5-month while fish fed 6.61 and 57.6 mg Se/kg diets had higher liver lesion scores at 9-month. Results indicate that short-term exposure to diet concentrations of 26.0 and 57.6 mg Se/kg significantly affected the growth and survival while chronic exposure to diet concentrations of 6.6 mg Se/kg diet significantly affected the survival of the juvenile splittail.

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A MODEL FOR PROVIDING SCIENTIFIC DATA AND ANALYSIS TO COLLABORATIVE NATURAL RESOURCE DECISION-MAKING PROCESSES

Problem Statement:
Stakeholder-based collaboratives are playing an increasingly important role in natural resource/ecosystem planning processes in California. These collaboratives frequently don't have the ability to utilize high quality scientific data and analysis in their decision-making processes. Assistance is needed to increase the scientific and technical capacity of collaborative groups to ensure the creation of effective, scientifically informed plans and management decisions.

Approach:
UC Davis (UCD) offers a model for effective assistance to collaboratives based on its experience. From 2000 to 2003, UCD provided scientific, technical, and organizational assistance to the Clavey River Ecosystem Project and the Truckee River Watershed Council, two stakeholder-based collaborative watershed-planning processes. Each was provided with a scientific/technical assistance liaison. These liaisons educated stakeholders about the underlying scientific and technical aspects of pertinent watershed issues and provided analytical models and tools to facilitate better decision-making. Liaisons also provided organizational assistance, including planning process facilitation, document creation, and outreach and communication assistance.

Results:
The UCD scientific and technical assistance significantly improved the stakeholder groups' capacity to carry out effective participatory natural resource planning and decision-making. Assistance (1) increased collaboration among stakeholders, (2) increased collaboration between stakeholder and relevant agencies, and (3) increased the level of knowledge about watershed conditions for all involved in the collaborative process. A critical finding was that the provision of organizational assistance was essential to increase the collaboratives' capacity to utilize the scientific data and analysis.

Conclusions/Relevance:
Currently stakeholder-based collaboratives play an important role in natural resource planning and management decisions in California. Increasing such groups' use of credible, high quality science is essential if such efforts are going to create effective policy and management outputs. The UCD assistance model demonstrates the value of and methods for providing scientific information to stakeholder groups participating in Bay-Delta decision-making processes.

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CONTRASTS IN INVERTEBRATE ASSEMBLAGES AT RESTORING AND REFERENCE WETLANDS IN SAN FRANCISCO BAY

As part of the CALFED-funded BREACH research program, we have analyzed historically breached-levee wetlands as a means to predict the feasibility, patterns, and rates of restoration to natural ecological function. Restoring sites were returned to tidal inundation by breaching of levees, between 1925 and 1995. Due to subsidence, the recently breached sites typically have emergent marsh mainly on the fringing remnant levee, while the older sites have more extensive marsh growth and channel formation. An important component of BREACH was invertebrate sampling at reference and restoring tidal wetlands from San Pablo Bay to the Delta, in order to determine invertebrate assemblage response to restoration patterns and rates, and also to provide information on availability of fish prey organisms.

We systematically sampled zooplankton, aquatic benthic invertebrates, and terrestrial insects at all sites. Results indicate both inter-site and inter-season differences in invertebrate assemblages. Zooplankton assemblages varied on the basis of salinity, both along the estuarine gradient and seasonally. Reference sites typically had greater densities of some winged insects, whereas restored sites had some greater densities of wingless insects. Benthic invertebrates mainly consisted of oligochaete and polychaete worms and amphipods, with polychaetes and bivalves typically more numerous at restored sites. Non-indigenous species were abundant in all invertebrate collections, and often had higher densities at restored sites. Overall patterns suggest that while intertidal mudflat benthic communities develop rapidly at restored sites, terrestrial insect communities are more dependent on the formation of emergent marsh vegetation. Analyzing such invertebrate assemblages is an important tool in assessing goals of ecosystem restoration, especially when combined with other interdisciplinary components of our project such as marsh geomorphology, hydrology, fish and bird ecology, and food web interactions.

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WETLAND VEGETATION MAPPING FROM COLOR INFRARED AERIAL IMAGERY

Problem Statement:
The structure and function of vegetation patches across the landscape mosaic affect development of ecosystem processes within a restored wetland. As part of the Integrated Regional Wetland Monitoring Pilot Project, the Landscape Ecology and Plant Teams are collaborating to produce vegetation maps of six study sites by applying remote sensing and other geospatial technologies to color infrared aerial imagery. These vegetation maps will be used to calculate site-scale patch metrics, which quantify wetland composition, structure, and change. The production of accurate vegetation maps is a fundamental part of tracking change during the restoration process and a mandatory precursor to productive sampling design, model development, and spatial metric calculation.

Approach:
Vegetation maps were produced in three phases. In the first phase, automated (unsupervised) classifications were performed to divide unknown plant composition into classes based on spectral properties of the orthorectified color infrared imagery. Random "ground reference" points were assigned to each class and visited by field crews, where percent cover was recorded for every species found within a three-meter radius (relevé). In the second phase, these samples were used to build the training sets for supervised classifications that rendered the finals maps. In the final stage, hundreds of additional points were gathered to assess map accuracy.

Results:
In addition to the vegetation map products, results include map accuracy test results and a comparison of unsupervised and supervised classifications.

Conclusions/Relevance:
We have identified various issues involved in vegetation mapping, including scale, timing and access, sources of error, and plant identification, especially in highly diverse brackish marshes. Therefore, close collaboration with the Plant Team for plant identification and data collection throughout the vegetation mapping process has been a necessary and effective requirement to produce accurate vegetation maps.

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DELTA WATERSHED FISH PROJECT: CHARACTERIZING FISH CONSUMING POPULATIONS AND REDUCING EXPOSURE TO MERCURY

Problem Statement: Elevated levels of mercury have been found in fish species throughout the Sacramento-San Joaquin Delta watershed due to natural sources and historic mining activities. Because mercury is highly toxic to humans, consumption of these fish may pose health risks, particularly to vulnerable populations such as women and children. Fishing is a popular activity in the watershed. Yet little is known about fish consuming populations and their fish consumption patterns. Remediation activities may eventually reduce levels of mercury in fish but will take decades or longer. In the interim, public outreach and education about this problem is the most effective way to reduce human exposure to mercury.

Approach: The California Department of Health Services, with broad support from CBDA, other agencies and community groups, has undertaken a variety of activities to characterize fish consuming populations and raise their awareness about mercury contamination in fish. These activities include three types of fish consumption surveys: interviews of anglers, phone surveys, and interviews of women at health clinics. In addition, outreach and education activities include needs assessments, stakeholder advisory groups, training, and the development of multilingual educational materials.

Results: Limited information gathered to date in the Delta has shown that fish consuming populations are ethnically diverse and have low awareness about fish contamination problems. Summaries of ongoing fish consumption surveys and education activities, including the development of a multilingual poster, a frequently asked questions resource guide, and training for clinic staff, will be described.

Conclusions/Relevance: Surveys to gather information about fish consuming populations will help to identify highly exposed populations and guide future outreach and education activities to reduce exposure to mercury. CBDA remediation, restoration, and fisheries management activities may impact fish populations and mercury levels in fish, and thus these activities need to consider fishing activities and the linkages to human health.

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REPRODUCTION AND EARLY LIFE STAGES OF GREEN STURGEON (ACIPENSER MEDIROSTRIS)

The anadromous green sturgeon is an exceptional and vulnerable species of the Pacific Northwest. Since little is known about the reproduction of green sturgeon, our objectives were to determine the reproductive characteristics of broodstock and to assess the environmental effects on embryo development. Since green sturgeon broodstock are rare in the Sacramento River, our observations were conducted on the still abundant spawning run in the Klamath River. This was also the source of fertilized eggs for laboratory studies. One hundred and twenty-eight broodfish were sampled during the 1999 through the 2002 spawning runs (April-June) in the Klamath River. Females were larger (mean total length 183 cm) and older (age 27 yr) compared with males (163 cm, 19 yr). The average gonadosomatic index was 13% in females and 5% in males. While the average fecundity (152,000) was lower than in white sturgeon, the egg size (diameter 4.32 mm) was larger. All fish were in an advanced stage of gonadal maturity and were close to spawning. The embryos of green sturgeon were obtained by in-vitro fertilization, using gonadotropin-releasing hormone LHRH-A to induce ovulation and spermiation. The embryo development of green sturgeon was similar to white sturgeon. The effects of temperatures (range 16-23.5°C) on survival and development of green sturgeon embryos were examined in different progenies. Egg incubation at 22 and 23.5°C resulted in high mortalities before hatching and neurulation, respectively. Survival to hatch decreased slightly at 20.5°C, but proportions of abnormal embryos significantly increased compared to lower temperatures. The results of our studies indicate a unique reproductive strategy of green sturgeon associated with the trade-off between fecundity and egg size. The regulation of river flow and related changes in water quality appear to be major factors affecting recruitment and abundance of this species.

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GEOGRAPHY OF THE DELTA: A SENSE OF PLACE IN RESOURCE MANAGEMENT

Geographic place names provide meaning and recognition to specific environmental features in a social context; they also serve as important identifiers for scientific data collection. As the characteristics of a particular geographic feature change with time, presumably both formal and vernacular names for the feature change as well.

This poses a problem for geographic information gathering -- especially with regard to the science of ecosystem restoration. Without a solid grasp of the actual names and locations of features being described, the propensity for data loss and overlap becomes high.

We have applied Geographic Information Systems (GIS) tools to the documentation of the changes in geographic place names over time in the Cosumnes River floodplain. The results of our analysis catalog each study location with corresponding data: name, alternate name(s), date of origin, principal function, research activity, location, and unique identifier. The place names used in this catalog include those used by University scientists, agency personnel, and land managers, a cadre whose interests on the landscape vary, as does their vernacular use of place names. The standards we develop, currently restricted to the immediate area around the Cosumnes River Preserve, should provide a prototype which other CALFED projects can use as a framework for cataloging points of scientific interest and organizing geographical identifiers

Our efforts to catalog place names will assist in the management and monitoring of ecological restoration efforts by improving communication through a standardized spatial framework.

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COSUMNES PHOTOGRAPHIC CATALOG: AN OPEN SOURCE APPROACH TO SCIENTIFIC ARCHIVING

Understanding the spatial relationships between restoration efforts and ecosystem results is a critical part of restorative science. Visual communication of these relationships is effectively accomplished with maps and photographic images. We describe here our applied research program to create an online catalog of Cosumnes Research Group photographs and maps, with spatial location and metadata. This information archive is accessible to all, serving as a data repository from which to gauge future restoration successes.

Our strategy employs Open Source software, to minimize costs. We modify existing Open Source code (e.g., PHP, MySQL, Coppermine, ImageMagick and Mapserver) to support the data management needs of the Cosumnes Research Group. Our modifications permit the collection and storage of image metadata, consistent with standards of the National Biological Information Infrastructure (NBII). These collected data include and extend the Dublin Core metadata framework, in order to facilitate sharing within the scientific community and beyond.

Numerous high-resolution digital images in several categories, printable maps and scholarly posters are collected in a modified Coppermine photo catalog -- currently hosted at http://watershed.ucdavis.edu/photographs/index.php. All metadata elements, including spatial identifiers, are stored in an underlying MySQL database. Most notable data are individual biological taxa identified in the images, which are cross-referenced to the USDA's Integrated Taxonomic Information System; this feature provides an additional reference for the image user. Record level spatial coordinates are integrated into various online mapping systems, including a custom Mapserver application showing locations in the Cosumnes River research area.

Obtaining project images and maps, sharing critical information among collaborators, and providing consistent attribution of data are necessary elements in supporting ecosystem science. Our Open Source data archive, which integrates photographic images, spatial location, and core metadata, serves as a relevant and timely framework from which to capture restorative science in the Cosumnes River floodplain.

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TEMPERATURE TOLERANCE AND THE HEAT-SHOCK PROTEIN RESPONSE IN LARVAL GREEN STURGEON (ACIPENSER MEDIROSTRIS)

Although the ability to tolerate and adapt to a range of water temperatures can be of great importance for the success of wild populations of green sturgeon, little is known about temperature stress in these fish. To detect and quantify thermal stress, this study investigated heat-shock protein (hsp) expression levels in newly hatched larval sturgeon exposed to a range of water temperatures during yolk-sac absorption. Hsps are intracellular proteins important in protecting organisms against the cytotoxic consequences of protein denaturation and play a major role in thermotolerance and thermoprotection. Wild broodfish were obtained from the Yurok Tribe gillnet fishery on the lower Klamath River, transported to the University of California, Davis, within 24 hour of capture, and placed into 4 m diameter circular flow-through tanks. After ovulation, spermiation and fertilization, eggs were incubated to hatching at 16.5±1°C in upwelling incubating jars. Hatched larvae were exposed to 18, 20, 22, 24, 26, and 28°C in 4 replicate flow-through tanks per treatment using six water recirculating systems. Mortality was recorded daily, and samples (10 larvae) for hsp analysis were collected and snap-frozen before, 24 h and 96 h after begin of temperature exposure and immediately after yolk sack absorption. Heat-shock proteins were analyzed by Western blotting. Exposure to 22°C and above caused increased levels of hsps as well as increased numbers of larvae with abnormal morphology.

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BIOMARKER RESPONSES AND GROWTH IN MACOMA SPEC. OUTPLANTED AT FIELD SITES IN CALIFORNIA MARSHES.

Clams of the genus Macoma are surface deposit feeders living in mud or silt in marshes and estuaries along the coast of California. As part of an effort to identify and characterize indicators of environmental stress in estuarine ecosystems (Pacific Estuarine Ecosystem Indicator Research Consortium – PEEIR), field experiments were conducted to determine whether growth in Macoma petalum and Macoma nasuta was linked to biomarkers of cellular stress (stress proteins, lysosome membrane damage). To measure growth during the field exposures, clams were stained for 24 h in a 100mg/L calcein solution prior to outplanting experiments. Clams were then transported to field locations in San Francisco Bay, Tomales Bay and Carpinteria Marsh (Santa Barbara) and outplanted in leached cages (3-4 clams per cage) in three blocks consisting of eight cages. Two rows of 4 cages were aligned parallel to the channel, and cages were spaced 0.5 m apart. Blocks were spaced 1m apart. Cages were constructed of 3-in diameter PVC, 20 1-cm holes were drilled to aid water circulation and the top end was covered with 0.5-cm plastic mesh. Samples were retrieved from each block after 2, 4 and 11 weeks, and snap-frozen. Clams were analyzed for growth, stress proteins and lysosomal membrane damage. Preliminary data indicates that growth was reduced, and stress protein levels were significantly elevated at several field sites. Data is related to dominant contaminants present in sediments and clams.

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WHITE STURGEON, ACIPENSER TRANSMONTANUS, SWIMMING ABILITY AND BEHAVIOR ASSOCIATED WITH FISHWAY DESIGN

A goal of the California Bay-Delta Program is to modify the existing conveyance system for water supply, water quality, flood protection and ecosystem benefits. One potential conveyance improvement proposed in the CALFED Programmatic Record of Decision (CALFED ROD) is a screened through-Delta facility (TDF) on the Sacramento River of up to 4,000 cfs. The CALFED ROD recognized the fish passage problem that would be created by a proposed TDF, as migratory species such as sturgeon, salmon, and splittail, cued by Sacramento River water in the interior Delta, approached a screened TDF from downstream. Little is known about the swimming ability and behavior of white sturgeon, Acipenser transmontanus, one of the migratory species that would be impacted by a screened TDF and would need to be passed back into the Sacramento River with an associated fishway. We tested the swimming ability and behavior of wild, adult, white sturgeon in a flume at the UC Davis J. Amorocho Hydraulics Laboratory in 2003 and 2004. Faster velocities (0.76 – 1.07 m/s), in general, cued fish to swim upstream, sooner. In 2003, vertical and horizontal baffles were tested at three velocities. Among the baffle types, percentages of successful passage were mixed, with no statistically significant pattern detected. However, pilot tests showed that white sturgeon tended not to pass horizontal baffles more than 30 cm high. In 2004, tests indicated that sturgeon were able to pass over ramps with 4 and 8 percent slopes, but that flow turbulence tended to inhibit passage. During the final phase of the study, in 2005, burst, sustained and prolonged swimming speeds will be determined and attraction flow characteristics will be evaluated. Results of the study will help develop design criteria for accommodating white sturgeon in fishways at a proposed TDF or other conveyance structures built in the Bay-Delta.

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DIFFERENTIAL EFFECTS OF SALINITY AND INUNDATION ON PICKLEWEED (SALICORNIA VIRGINICA) ADULTS AND SEEDLINGS

We examined the influence of water salinity and inundation duration of common pickleweed (Saliconia virginica). We subjected pickleweed adults (1-year old) and seedlings (less than 1 month old) to four levels of inundation (following a sinusoidal tide cycle) and four levels of salinity in a greenhouse. For adults, we found increased plant height with increased inundation, but growth in the late growing season decreased with increasing salinity. We did not find any interaction between salinity and inundation in adult plants. Seedling mortality was greatest with the least inundation, but height of the survivors was not significantly different. Higher salinities caused significant seedling mortality and decreased height. For seedlings, there was an interaction of salinity and inundation. We compared results from the greenhouse to vegetation at the Guadalcanal Village Project, a 22 ha wetland restoration with engineered elevations located 5 km nw of Vallejo, California, along State Highway 37. At Guadalcanal Village, we related soil elevation and inundation duration to plant height. A digital cone penetrometer revealed highly compacted soils in the high marsh. Our results suggest that soil compaction may exacerbate environmental stressors of salinity and inundation on plant growth.

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THE EFFECTS OF TEMPERATURE AND DISSOLVED OXYGEN ON LARVAL SACRAMENTO PERCH: IMPLICATIONS FOR RESTORATION

California's only native centrarchid, Sacramento perch (Archoplites interruptus) is now extirpated from most of its native habitat in the Sacramento – San Joaquin watershed. Though the exact causes for the species decline are unknown, the probable reasons are the alteration and deterioration of habitat quality, and deleterious non-native species interactions. This CALFED sponsored project investigates the physiological tolerances and behavioral preferences of Sacramento perch at various life stages. The determination of the physiological optima and sub-optima to temperature and dissolved oxygen is useful for the habitat delineation and conservation of Sacramento perch. We propose that larval Sacramento perch physiology and ecology are often subjected to different selective pressure than the juvenile and adult Sacramento perch. High temperature and hypoxic environments may have a greater detrimental affect on larval Sacramento perch as larval fish have few mechanisms to compensate. To determine these effects on larval Sacramento perch, we measured 1) the critical temperatures and P_{O2}, 2) gill ventilation and oxygen consumption at 10-day intervals using larval fish reared at the Putah Creek Aquaculture Facility. Finally, we incorporated these results into an environmentally sensitive bioenergetic model for Sacramento perch to predict growth changes. Knowing the temperature and dissolved oxygen effects on these sensitive larval stages are important for the restoration of Sacramento perch populations.

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COMPARISON OF SAMPLING METHODS FOR TRACE ORGANIC COMPOUNDS IN ESTUARINE WATERS

Trace organic compounds in water may affect estuarine biota (and their human consumers) at concentrations well below detection limits typical for standard methods approved for regulatory compliance monitoring. Methods for improving method sensitivity through collection of larger samples and preconcentration have been used in order to obtain more quantitative measurements of these compounds in natural waters. A method using larger 4 liter samples with conventional in-laboratory extraction was compared to in-field solid-phase extraction (SPE) for analysis of PCBs and PCDD/Fs in samples from San Francisco Bay. Concentrations of PCDD/Fs in whole water samples were typically higher than those measured in SPE examples. PCBs congeners were also not found at 1:1 ratios in a comparison of whole-water and SPE samples. For both groups of compounds, many isomers were not detectable in the 4 liter samples. Biases in quantitation and sensitivity limits arising from sampling and analtyical methods have implications for evaluating risks posed by these organic compounds.

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MCCORMACK-WILLIAMSON TRACT ECOLOGICAL RESTORATION

Problem Statement: The North Delta Ecosystem Restoration and Flood Control Project will restore ecological values and improve flood control in the region. The project will incorporate McCormack-Williamson Tract and Staten Island, properties purchased by The Nature Conservancy with CALFED grants totaling over $42 million. McCormack-Williamson Tract presents unique restoration opportunities because it is adjacent to valuable ecological areas such as the Cosumnes River Preserve and has elevations conducive to intertidal habitat.

Approach: The project Team includes Department of Water Resources, The Nature Conservancy, Department of Fish and Game, the UC Davis Center for Integrated Watershed Research and Management and California Bay-Delta Authority staff. A North Delta Science Panel, convened by Dr. Jeff Mount of UC Davis, reviewed the project in November 2003 and April 2004 meetings. The panelists provided critical comments and highlighted important scientific uncertainties. Restoration alternatives, developed before and after the Science Panel meetings, were modeled by UC Davis modelers.

Results: Three conceptual ecological restoration alternatives have been developed that address ecological and flood control goals. The alternatives are 1) Fluvial maximum (with minimal control), 2) Floodplain (with maximum control) and 3) Floodplain with Subsidence Reversal Demonstration Project. In-depth analysis of these alternatives including sediment and high-flow hydraulic modeling will be conducted. As recommended by the Science Panel, an exotic species management plan, and methylmercury and organic carbon monitoring and research efforts will be developed.

Conclusions/Relevance: The project planning process, involving extensive science review and iterative restoration idea development and modeling, has resulted in three potential restoration alternatives. The project is relevant to the CALFED Ecosystem Restoration Program because project actions address CALFED ERP strategic goals and objectives: restoring ecological processes (including flooding and sediment deposition), restoring habitat, supporting special status species and limiting exotics, and address scientific uncertainties common to all Delta ERP actions.

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SPATIAL AND TEMPORAL ELEMENTAL FINGERPRINTING IN JUVENILE SACRAMENTO SPLITTAIL OTOLITHS AS IMPLICATION FOR MIGRATORY PATTERNS

The rim, middle and core across the section of juvenile splittail otolith from Big Break (BB), Nurse Slough (NS) and Sherman Island (SI) in the Sacramento and San Joaquin Rivers were chosen as the representatives of time of capture, time between capture and birth, and natal time respectively. Elements such as Li, Mg, Ca, Cr, Mn, Fe, Co, Cu, Zn, Rb, Sr, Ba and Pb were detected in otoliths using Laser Ablation Inductively-Coupled Plasma Mass Spectrometry (LA-ICP-MS). Significant differences of microchemistry in rims of otoliths collected from the three locations revealed the existence of spatial differences while significant differences in the cores inferred the different natal origins. No significantly different patterns of otolith microchemistry between the rim and the middle area were detected between NS and SI, suggesting that elemental compositions in splittail otoliths are rather stable within a certain period and some fish reside in same area for a pretty long time. Although fish collected from the three locations (BB, NS, and SI) had significantly different patterns of otolith microchemistry between the core and the rim which may indicate separations of nursery and spawning grounds. However, we are not sure because the differences can also be caused by seasonal changes, further investigation is needed. In summary, elemental signatures in otoliths have the potential for revealing the migratory history of splittail.

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SE-POLLUTED ENVIRONMENT? FISH OTOLITH CAN TELL

Selenium contamination and its effects on ecosystem and wildlife is one of the primary concerns in California. A key question is whether we can use a simple indicator to determine if the level of selenium in the environment may be harmful to fish and wildlife and furthermore to trace the pollution history. Otoliths were obtained from juvenile Sacramento splittail exposed to 0.4 (control), 0.7, 1.4, 2.7, 6.6, 12.6, 26.0 and 57.6 mg Se kg-1 Se dry weight for 9 months. Selenium analysis was conducted using Laser-Ablation Collision/Reaction Cell Inductively-Coupled Plasma Mass Spectrometry. Se/Ca ratios in otoliths of fish exposed to diet concentrations of 6.6 mg kg-1 and above were significantly higher than those of 2.7 mg kg-1 and below. Result of this study indicates that 6.6. mg kg-1 is considered as the dietary toxicity threshold for splittail. Therefore, a significantly elevated Se/Ca ratio in fish otolith over the Se/Ca ratio from reference places indicates that the fish may be exposed to a toxic level of Se. Results suggest that Se/Ca ratio of otolith is applicable in screening for environmental Se contamination.

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ASSESSING MIGRATORY PATTERNS OF SPLITTAIL USING OTOLITH ELEMENTAL FINGERPRINTING

The use of migratory pattern in coordinated environmental monitoring programs can be avaluable, cost-effective approach for assessing the exposure and effects of metal contaminants and can help in evaluating restoration efforts. Otoliths (earstones) have been used by State and Federal fish biologist as indicators of metabolically inert timekeeper (fish aging) and environmental recorder. Because of their metabolically inert nature, otoliths combine time-keeping properties with storage of geochemical information. They are therefore ideal material to track the movements of individual fish exposure to different environments. Trace metals are of biological interest because of their role as micronutrients and toxicants. Trace metals enter the San Francisco estuary from a wide variety of urban and agricultural runoff, industrial effluents, old mines, and from weathering of soils and rocks within the watershed; thus metal bioaccumulation patterns are complicated. Report of CVRWQB, 1998 has shown that there can be high regional differences in the chemical environment within the Sacramento/San Joaquin Delta with concentration differences of 27-300X between the lowest and highest sites; temporal differences at the same site vary only 2-15X, much lower than regional differences (Table 1). These differences in metallic contaminant concentrations among various sites in the Sacramento-San Joaquin Rivers and Delta provide a sound foundation for using otolith as indicator of past metal exposure in the fish.