Nichols, M.D.
California Air Resources Board, P.O. Box 2815, Sacramento, CA 95812-2815
mnichols@arb.ca.gov

Reducing California's Carbon Footprint - Toward a Clean Energy Future

The Climate Change Draft Scoping Plan is the state's roadmap to reach the greenhouse gas reduction goals required in the Global Warming Solution Act of 2006, better know as AB 32. This Plan calls for an ambitious, but achievable reduction in California's carbon footprint-toward a clean energy future. Reducing greenhouse gas emissions to 1990 levels means cutting approximately 30 percent from business-as-usual emissions levels projected for 2020, or about 10 percent from today's levels. On a per-capita basis, that means reducing our annual emissions of 14 tons of carbon dioxide for everyone in California down to about 10 tons per person by 2020. This challenge presents the opportunity for Californians to transform the economy into one that runs on clean and sustainable technologies so that all Californians can enjoy clean air, clean water, and a healthy and safe environment. This presentation will cover the current status of the Climate Change Draft Scoping Plan. The Plan looks to reduce risks that will be costly to all Californians, such as an increase in the demand and cost of supplying water. Water efficiency will be an important point in The Plan.

SESSION: Plenary, 10/22/2008, 9:10 AM, Rooms 311-315

Dahm, C.N.
CALFED Bay-Delta Program, 650 Capitol Mall, Fifth Floor, Sacramento, CA 95814
cdahm@calwater.ca.gov

Freshwater Ecosystems in a Variable and Changing Climate: Perspectives from New Mexico, Florida, and Queensland Australia

Climate variability, climate change, climate risk, and climate adaptation are topics of great interest worldwide. I will address some of these issues from research on 1) the Rio Grande in central New Mexico, 2) setting minimum flows and levels in Florida rivers and springs, and 3) the healthy waterways initiative in southeast Queensland, Australia. The Rio Grande in central New Mexico is a snowmelt-dominated river that is highly engineered and over allocated. Interannual variability in discharge is linked to Pacific climate forcing in the winter and spring and the North American monsoon in the summer. Warming coupled with drought has caused substantive change in upland vegetation in large areas of the catchment and affected water depletions along the river corridor. Human adaptation to water supply risks involves large shifts from to surface water supplies from historic dependence on ground waters. State statute in Florida requires “the minimum flow for a given watercourse shall be the limit at which further withdrawals would be significantly harmful to the water resources or ecology of the area.” Defining what is meant by “significantly harmful” has led to setting minimum flows and levels (MFLs) that impact less than 15% of habitat along river corridors throughout the annual hydrograph. Climate variability, driven to a large extent by the Atlantic Multidecadal Oscillation (AMO), also is considered when establishing MFLs levels in the Tampa region. An example of the methods and analyses used to establish MFLs will be presented. Integrated assessments of rivers in southeast Queensland has been ongoing since 1999. Measurements of physical conditions, chemical variables, invertebrate communities, fish communities and ecosystem processes are used to produce an integrated assessment that is reported in an annual report card for rivers draining 18 catchments. Stakeholder input of desired conditions for river ecosystems is used in the annual grades assigned to the rivers in these catchments. Many of the indicator variables are sensitive to drought and climate change. Factoring variability and climate change into integrated assessments is an ongoing challenge and effort. Finally, some of the insights from these river ecosystems in New Mexico, Florida, and Australia will be discussed in the context of challenges in the California Bay Delta region.

SESSION: Plenary, 10/22/2008, 9:45 AM, Rooms 311-315

Schlenk, D.
University of California, Riverside, Department of Environmental Sciences, Riverside, CA 92521
daniel.schlenk@ucr.edu

Global Trends of Fish Feminization: Uncovering Regional Causes

Feminization of fish has been reported throughout the world in freshwater and marine systems with recent studies indicating potential population impacts. In spite of the potentially wide-ranging consequences of feminization in fish, there is still great uncertainty about the specific agents causing feminization, their origins, and their reactivity in the environment. There is an urgent management need to reduce this uncertainty, but sufficiently sophisticated ecotoxicological tools are only now becoming available. To date, most studies about the causes of feminization have used variants of toxicity identification evaluations (TIEs) to identify specific feminizing agents. The majority of these evaluations have utilized responses of specialized cell-lines to identify biologically active fractions in municipal wastewater and have concluded that synthetic and natural estrogens are the primary cause for feminization of fish. Newer evidence, however, suggests that these cell-based methods may not be adequate to uncover all feminizing agents particularly in complex natural environments that receive a mixture of urban and agricultural inputs. We evaluated cellular and whole-animal responses in water and sediment samples from the eastern, southern, and western U.S. in a TIE fractionation design. While results from the cell-based method tended to mirror results in whole animals and chemical analyses for steroid estrogens in purely domestic wastewater systems, the cell-based method tended to severely underestimate estrogenic activity in whole animals exposed to more complex systems that receive inputs from many agricultural and urban sources, such as the San Francisco estuary.

CALFED Statement of Relevance
These studies focus on the causes of feminization in fish and the potential to impair fish health.

SESSION: Plenary, 10/22/2008, 10:30 AM, Rooms 311-315

Cloern, J.E.
U.S. Geological Survey, 345 Middlefield Rd., Menlo Park, CA 94025
jecloern@usgs.gov

Think Globally and Think Locally: A Key to Building Future Visions of the Bay-Delta Ecosystem

Biological communities in San Francisco Bay changed dramatically in 1999, the year of a strong El Niño-La Niña transition and shift of the east Pacific from its warm to its cold phase (www.pnas.org_cgi_doi_10.1073_pnas.0706151104). Biological changes occurred across multiple trophic levels, and they illustrate how global processes, including climatically-driven shifts in ocean currents and temperature, can drive changes inside estuaries such as San Francisco Bay. Recent studies in the Delta illustrate the equally powerful influence of local processes. For example, localized water diversions from pumped exports, emplacement of channel barriers, and operation of tidal gates alter regional flow paths and water quality across the Delta (see http://repositories.cdlib.org/jmie/sfews/vol5/iss3/art2/). Our conceptual models of the Bay-Delta ecosystem must consider, then, changes driven by global-scale processes that cascade down, local-scale processes that propagate up, and their interactions. The ecosystem problem becomes even messier as we consider the fact that both global and local processes are changing and will be very different in the future. What tools are available to tackle the enormously challenging question of how the Bay-Delta will respond to a future shaped by global warming, sea level rise, population growth, and new actions to meet demands for water and sustain native communities? CALFED supports a research project (CASCaDE) which was conceived to link models operating at large and small scales as one tool for envisioning Delta futures. Early modeling results will be presented in a special session of the 2008 Science Conference.

SESSION: Plenary, 10/22/2008, 10:55 AM, Rooms 311-315

Luers, A.
Google.Org, Environment, 345 Spear St 4th Floor, San Francisco, CA 94105
amyluers@google.com

The Science and Politics of Managing Climate Risk: A Local and Global Perspective

The recent wildfires and the on-going drought in California are local reminders of the increasing pulse of extreme weather-related disasters across the globe. While these extreme events cannot be directly attributed to climate change, they are omens of what lie ahead and their devastating impacts raise serious questions about society's ability to cope with continued changes in our climate. Fortunately, there is now growing momentum in California and around the world to address climate change by reducing emissions of heat-trapping gases. However, to date much less attention has been given toward climate adaptation. Given the changes ahead, resource managers, regional planners, government and intergovernmental agencies need to consider the changing climate risks in their planning. Among the scientific challenges of managing these risks is understanding and communicating the consequences and uncertainties of the changes underway. The political challenges are centered on questions of justice and equity. Questions such as: Who decides what and who is most vulnerable? How should resources be distributed among the vulnerable populations and regions? How are appropriate actions and associated trade-offs determined? This presentation will explore the challenges and discuss the opportunities around these fundamental questions of climate adaptation: Adaptation to what, by when and for whom?

SESSION: Plenary, 10/22/2008, 11:20 AM, Rooms 311-315

MacFarlane[1], B.R., A.P. Klimley[2], S.L. Lindley[1], A.J. Ammann[1], P.T. Sandstrom[1], C.J. Michel[2], E.D. Chapman[2]
[1]NOAA Fisheries, Southwest Fisheries Science Center, Santa Cruz, CA 95060
[2]University of California, Davis, Dept. of Wildlife, Fish, & Conservation Biology
bruce.macfarlane@noaa.gov

Survival and Migratory Patterns of Central Valley Juvenile Salmonids: Progress Report

We are in the second year of a three-year project describing reach-specific rates of survival and movement of juvenile late-fall Chinook salmon and steelhead. Variation in rates will be related to natural and anthropogenic covariates, such as water flow, water temperature, and riparian habitat use. This CALFED funded project rapidly grew to include other agencies (U.S. Army Corps of Engineers, U.S. Fish & Wildlife Service, East Bay Municipal Utility District, Bay Planning Coalition, and California Department of Water Resources) to address their salmon-related issues. In 2006, the consortium placed 220 acoustic receivers throughout the Sacramento River, Delta, and San Francisco Estuary that will detect the presence of tagged fish. In 2007, 200 late-fall Chinook smolts and 200 juvenile steelhead from Coleman National Fish Hatchery were tagged and released into the system near the hatchery. An additional 194 late-fall Chinook and 49 steelhead were tagged and released near Sacramento for Delta and Estuary related projects. High mortality (> 80%) was recorded between release near the hatchery and Ord Bend, 150 km downstream, for both species. Survival was about 10% at the west end of the Delta. Only 2% of the Chinook and 7% of the steelhead were detected at the Golden Gate. This very low survival may have been related to water conditions; 2007 was a dry year with low river flows, which may have resulted in high predation. Data analysis resulted in changes in release strategies and the number of tagged fish in 2008 to improve survival estimate confidence intervals downstream of the upper river high mortality section. In 2008, 304 Chinook and 300 steelhead were released in the Sacramento at three spatially separated locations, and an additional 471 Chinook and 50 steelhead were released downstream for Delta and Estuary studies. Data from the 2008 releases are currently be checked and added to the database.

CALFED Statement of Relevance
This project is providing for the first time high spatial resolution data on survival and movement of juvenile salmonids, which can be used to assess influences of natural and anthropogenic factors, such as flow, water temperature, diversions, and riparian habitat alteration, on salmonid populations.

SESSION: Migratory Movements and Success of Salmonids (I), 10/22/2008, 1:20 PM, Room 306

Ammann[1], A.J., E. Chapman[2], C. Michel[1], M. Thomas[2]
[1]National Marine Fisheries Service, 110 Shaffer Road, Santa Cruz, CA 95060
[2]UC Davis, One Shields Ave., Davis, CA
arnold.ammann@noaa.gov

Tag Effects in Yearling Salmonids with Implanted Acoustic Transmitters

The use of surgically implanted acoustic transmitters, coupled with an extensive array of receivers, is allowing researchers to track the movement and survival of juvenile salmonids. When implanting a tag it is essential to know that the tag and the tagging procedure do not negatively affect the fish. Additionally, tag expulsion rates should be determined for each tag type, fish species and size class. We performed laboratory trials to test how implanted tags affect the growth and survival of hatchery-raised yearling late-fall Chinook salmon and yearling steelhead. The Chinook were implanted with dummy tags similar to Vemco V7-4Ls, about 3.7% tag to body weight. Steelhead were implanted with tags similar to Vemco V9-1Ls, about 2.8% tag to body weight. Growth and survival rates of tagged fish were compared to untagged controls and surgery controls (25 fish per treatment). For each species, all treatments were held in the same tank, fed daily rations of 2% biomass, and examined, weighed and measured every 30-45 days. Chinook growth rates were similar among treatments. Steelhead growth rates were lower for the tag treatment. Survival was similar among treatments for both species. Tag expulsion did not occur in Chinook after 90 days, while 5 out of 25 steelhead expelled their tags within 30 days. These results suggest that late-fall Chinook yearlings are not greatly affected by tag implantation. In contrast, steelhead growth rates are affected and tag loss is significant. The results of this laboratory study will help interpret results of movement and survival data obtained from tagged fish released into Central Valley and San Francisco Bay systems.

CALFED Statement of Relevance
This study is providing data to support and interpret results of a large-scale salmonid tracking study funded by CALFED.

SESSION: Migratory Movements and Success of Salmonids (I), 10/22/2008, 1:40 PM, Room 306

Lindley[1], S.L., C. Michel[1], P.T. Sandstrom[2]
[1]NOAA Fisheries, Southwest Fisheries Science Center, Santa Cruz, CA 95060
[2]University of California Davis, One Shields Ave. Davis, CA 95616
steve.lindley@noaa.gov

Estimating Reach-specific Smolt Survival Rates and the Factors Influencing them from Acoustic Tagging Data

Our extensive array of acoustic receivers arranged along the Sacramento River between Battle Creek and the Golden Gate, combined with releases of acoustically-tagged chinook and steelhead smolts, allows estimation of reach-specific survival rates. The analysis is complicated by the fact that not all live animals passing a receiver are detected. The Cormack-Jolly-Seber model in Program MARK can be used to obtain maximum likelihood estimates of reach-specific survival rates along linear portions of the river, and some amount of branching can be handled with multi-strata models. The effects of individual covariates (e.g., fork length) can be included to explain variation in survival or detection probabilities among individuals, and the effects of reach-related factors (e.g., bank cover, water velocity) can be included to explain variation in these parameters among reaches, potentially giving insight into the causes of variation in survival. We will present the results of such analyses for smolt release experiments conducted in 2007 and 2008.

CALFED Statement of Relevance
This project is providing for the first time high spatial resolution data on survival and movement of juvenile salmonids, which can be used to assess influences of natural and anthropogenic factors, such as flow, water temperature, diversions, and riparian habitat alteration, on salmonid populations.

SESSION: Migratory Movements and Success of Salmonids (I), 10/22/2008, 2:00 PM, Room 306

Workman[1], M.L., J.E. Merz[2], W.N. Heady[3]
[1]East Bay Municipal Utility District, 1 Winemaster Way Ste K, Lodi, CA 95240
[2]Cramer Fish Sciences, Hedberg Way, Oakdale, CA
[3]UC Santa Cruz, 100 Shaffer Rd., Santa Cruz, CA 95060
mworkman@ebmud.com

Lower Mokelumne River Steelhead Acoustic Study

Development of the Central Valley Fish Tracking Consortium has provided collaborative project opportunities throughout the Sacramento San Joaquin Bay and Delta System. Over the past two years Mokelumne River studies have made use of the extensive acoustic receiver array system deployed as part of this Consortium to track the movement, survival, and habitat use of hatchery origin smolt steelhead *Oncorhynchu mykiss*, hatchery steelhead kelts and multiple life stages (>160mm) of the wild river population of *O. mykiss* . In February and March 2007, East Bay Municipal Utility District (EBMUD) tagged 57 hatchery smolts and released them at New Hope Landing on the lower Mokelumne River. We also tagged 7 re-conditioned hatchery kelts and released them adjacent to the Mokelumne River Fish Hatchery. Concurrently, we collected 64 river-produced and post-yearling residual hatchery steelhead by boat electrofishing, and released them at original capture locations throughout the non-tidal Mokelumne River (within 20 km of Camanche Dam). In 2008 EBMUD tagged 100 yearling hatchery steelhead to be planted in the Bay, Delta, and River, and 10 hatchery kelts released in the river. Concurrently in 2008, 12 actively-migrating steelhead captured by rotary screwtrap near tidewater of the lower Mokelumne River were tagged, and 50 *wild O. mykiss* were tagged for assessment of small scale movements within the LMR. Here, we report information recovered on ten receiver stations deployed from the base of Camanche Dam through the Mokelumne River delta and the station grid located throughout the Sacramento San Joaquin Delta and Estuary. Data from the existing network of approximately 220 hydroacoustic receivers located within the Sacramento-San Joaquin River system, Delta and San Francisco Bay estuary will be used to determine movement patterns, survival, and gross habitat use of hatchery and wild *O. mykiss* from the Mokelumne River.

CALFED Statement of Relevance
Steelhead are important biological components of the Central Valley ecosystem and their abundance is often used to judge the ecological health of the system. Our ability to accurately track steelhead behavior, migration paths, and survival and to accurately assess production origin on these parameters has biological as well as potential regulatory and operational implications throughout the Bay-Delta system.

SESSION: Migratory Movements and Success of Salmonids (I), 10/22/2008, 2:20 PM, Room 306

Bremner[1], A.M., W.N. Brostoff[1], P.E. LaCivita[1], T. Keegan[2], D. Woodbury[3]
[1]U.S. Army Corps of Engineers, 1455 Market Street, 15th Floor, San Francisco, CA 94103
[2]ECORP Consulting, Inc., 2525 Warren Dr., Rocklin, CA 95677
[3]National Marine Fisheries Service, 777 Sonoma Ave. RM 325, Santa Rosa, CA 95404
allison.m.bremner@usace.army.mil

Juvenile Salmonid Outmigration Trends in Relation to Dredging Activity Sites in the San Francisco Estuary

Information on the temporal and spatial distribution of Federally-listed juvenile Chinook salmon and steelhead in San Francisco Bay is needed for assessing potential impacts to these species from dredging activities. Currently, work windows are used that limit dredging activities to periods of time when listed salmonids are thought to be absent in the bay. Through the use of hydroacoustic telemetry we hope to increase our knowledge of juvenile salmonid migratory behavior to better manage dredging operations. Through a collaborative multi-agency effort, Chinook salmon and steelhead smolts implanted with ultrasonic tags are being released each year during the winter months of 2007-2009. As the smolts move from the Sacramento River, through the Estuary, and under the Golden Gate Bridge during their outmigration, they are detected by strategically-located hydrophones placed to better define juvenile salmonid migratory routes, transit times, and distribution relative to dredging and dredged material placement sites, thus providing the information needed to make management decisions. Data from the 2007 field season revealed that the tagged smolts: utilized deeper channels more often than shallow areas during outmigration; traversed the San Francisco Estuary from the release point in Rio Vista, CA to the Golden Gate in an average of 20 days and 41 days for Chinook salmon and steelhead, respectively; and were detected at dredging and dredged material placement sites. This project is coordinated with complementary research conducted by ECORP Consulting, Inc. for the Bay Planning Coalition. This study was designed and funded in collaboration with the San Francisco Bay Region Long Term Management Strategy for the Placement of Dredged Material and the CALFED grant recipients at the NOAA Fisheries Salmon Ecology Laboratory in Santa Cruz and the University of California Davis Department of Fish, Wildlife, and Conservation Biology.

CALFED Statement of Relevance
This project is one part of a multi-agency/research institute project which has the common goal to gain knowledge about the migratory behavior of native species so the new information can be used to protect habitat for the native species in the future.

SESSION: Migratory Movements and Success of Salmonids (I), 10/22/2008, 2:40 PM, Room 306

Perry[1], R.W.*, P. Brandes[2], J.R. Skalski[1]
[1]University of Washington, Box 355020, Seattle, WA, 98195-5020
[2]U.S. Fish and Wildlife Service, 4001 N. Wilson Way, Stockton, CA 95295
rwperry@u.washington.edu

Migration Routes and Survival of Juvenile Late-fall Chinook Salmon Migrating through the Sacramento – San Joaquin River Delta

Understanding effects of water management actions on survival of juvenile salmon is critical to management of water and fisheries resources, but the complexity of the Sacramento – San Joaquin River Delta poses challenges in studying such problems. During 2007 and 2008, we acoustically tagged late-fall juvenile Chinook salmon and monitored their migration through the Delta. To better understand how survival among different migration routes contributes to overall survival through the Delta, we developed a mark-recapture model that explicitly estimates both the fraction of tagged fish using specific migration routes and survival within each route. In 2007, an estimated 30%-40% of juvenile salmon migrated through Steamboat and Sutter Slough, a migration route which precludes fish from being entrained into the interior Delta via the Delta Cross Channel or Georgiana Slough. Of fish that remained in the Sacramento River, an estimated 33% of fish entered the Delta Cross Channel when it was open, and approximately 15% entered Georgiana Slough regardless of whether the Delta Cross Channel was open or closed. Accounting for fish distribution among all routes, tagged fish had a 35% probability of being entrained into the interior Delta when the Delta Cross Channel was open and a 9% probability when it was closed. Although standard errors were large, estimated survival for fish migrating through the interior Delta was lower than survival in the Sacramento River, a finding consistent with previous research. However, survival through the interior Delta contributed less than other routes to overall survival through the Delta due to the lower fraction of fish migrating through the interior Delta. Although small sample size limits broad inferences from the 2007 data, this study, ongoing analysis of the 2008 data, and research in 2009 is beginning to shed light on processes affecting survival and movement of juvenile salmon through the Delta.

CALFED Statement of Relevance
Management actions taken under the Water Supply Reliability objective affect distribution of water through the Delta. The Ecosystem Restoration Program is aimed at supporting sustainable animal populations. Our study addresses both objectives by examining how water distribution in the Delta affects routing and survival of migrating juvenile salmon.

SESSION: Migratory Movements and Success of Salmonids (II), 10/22/2008, 3:20 PM, Room 306

Chapman[1], E.D., P.T. Sandstrom[1], A.J. Ammann[2], C. Michel[2], A.P. Klimley[1], R.B. MacFarlane[2], S.L. Lindley[2]
[1]University of California Davis, One Shields Ave., Davis, CA 95616
[2]NOAA, Southwest Fisheries Science Center, 110 Shaffer Rd., Santa Cruz, CA 95060
edchapman@ucdavis.edu

Diel Migrations of Salmon Smolts in the Sacramento River, Delta, and San Francisco Bay Estuary

We have been able to track fine scale movements of chinook salmon, *Onchorhynchus tshawytscha*, and steelhead trout, *Oncorhychus mykiss*, in the Central Valley of California through the use of ultrasonic telemetry. Miniature, ultrasonic coded beacons were implanted within the peritoneum of 500 fish during January of 2007 and released at four locations throughout the Sacramento River and Delta. These fish have been detected by an array of monitors established throughout the watershed extending from Redding to the Golden Gate Bridge in the San Francisco Bay. The detections of chinook over the following months (January, February, and March) exhibited a diel pattern of migration, that is there are few detections during daytime and many during nighttime. This is likely because individuals remain within a confined area during the day moving little, and then become active at night swimming extensively downstream. Furthermore, the difference between the ratio of more frequent nighttime detections to less frequent daytime detections of chinook smolts decreases in the Delta and San Francisco Bay Estuary. Steelhead, which reside upriver longer, do not exhibit the same diel pattern to detections at any point during their out migration. There may be other environmental cues that stimulate migrations of steelhead such as rainfall events (see Sandstrom et al. poster), but it does not appear to be related to day length.

CALFED Statement of Relevance
Late Fall Chinook smolts are exhibiting diel patterns of migration which may help managers determine the use of water in the Sacramento River. These fish are traveling at night in the upper river and by limiting the use of pumps during the day we may be able to reduce mortality.

SESSION: Migratory Movements and Success of Salmonids (II), 10/22/2008, 3:40 PM, Room 306

Michel[1], C.J.*, A. Ammann[2], P. Sandstrom[3], E. Chapman[3], S. Lindley[2], A. Klimley[3], R. MacFarlane[2]
[1]University of California-Santa Cruz/National Marine Fisheries Service, 110 Shaffer Rd, Santa Cruz, CA 95060
[2]National Marine Fisheries Service, 110 Shaffer Rd, Santa Cruz, CA 95060
[3]University of California - Davis, Department of Wildlife, Fish, & Conservation Biology, One Shields Avenue, Davis, CA 95616
michel@biology.ucsc.edu

A High-resolution Account of the Survival and Movement Rates of Acoustically Tagged Juvenile Chinook Salmon (Oncorhyncus tshawytscha) during the 2007 and 2008 Season

Acoustic tagging and tracking has become a very simple, high-resolution way of understanding fish movements. This method is essential in understanding the movements of highly migratory fish such as the late-fall run Chinook salmon (*Oncorhyncus tshawytscha*) smolts as the make their way through the Sacramento River watershed. We are specifically interested in learning more about their survival and timing of their downstream migration using an array of monitors throughout the watershed. This information, coupled with different morphological and environmental variables, will allow us to evaluate and understand their migration patterns. Initial results from 2007 data showed very low survival in the upper Sacramento river, with very few smolts making the 530 kilometer journey from release at the Coleman National Fish Hatchery to the Golden Gate Bridge. The few that did make it to the ocean took an average of 25 days to make the trek. Data from the 2008 season is being analyzed and will also be presented.

CALFED Statement of Relevance
By providing invaluable high-resolution movement and survival information for these economic and ecologically important fish, we will be able to assess the impacts of anthropogenic and natural factors on the population. This could lead to improved management and conservation efforts to help curtail their decline.

SESSION: Migratory Movements and Success of Salmonids (II), 10/22/2008, 4:00 PM, Room 306

Heady[1], W.N.*, M.L. Workman[2], J.E. Merz[3]
[1]Ecology and Evolutionary Biology Department, UC Santa Cruz, Long Marine Laboratory, Santa Cruz, CA 95060
[2]East Bay Municipal Utility District, 1 Winemasters Way Suite K2, Lodi, CA 95240
[3]Cramer Fish Sciences, 636 Hedburg Way # 22, Oakdale, CA 95361
heady@biology.ucsc.edu

Fine Scale Habitat Associations, Movement and Survival of Steelhead Trout of the Mokelumne River, CA using Acoustic Telemetry in Standardized Transects

Steelhead (*Oncorhynchus mykiss*) are highly adaptive with myriad life history trajectories including lifetime freshwater residence and anadromy, and yet populations are in severe decline. In California, all but one steelhead Distinct Population Segment are listed as threatened or endangered. In the Central Valley, declines are clearly linked to water management (McEwan 2001), with dams eliminating approximately 82% of historical spawning and rearing habitat (Yoshiyama et al. 1996 in McEwan 2001). Of particular ecological and management interest are answers to questions related to behavior, movement and survival of wild O. mykiss within the freshwater system prior to, during or instead of seaward migration. In a collaborative effort, the East Bay Municipal Utilities District, University of California and Cramer Fish Sciences have conducted two years of acoustic telemetry of over 300 wild and hatchery *O. mykiss* of the Mokelumne River. In efforts to answer the above questions the locations of acoustically tagged *O. mykiss* were monitored using standardized transects along 39km of the Mokelumne River between the upstream limit to anadromy, Camanche Dam, and tidal influence. Transects were traveled weekly to monthly from February 2007 through March 2009 in a 12ft aluminum skiff using a hand held hydrophone and receiver. For each transect, the time, surface water temperature, habitat parameters, streamflow and weather are associated with specific GPS locations of acoustically tagged fish. In 2008, acoustically tagged wild *O. mykiss* were also tagged with a visual tag to enable snorkel surveys to document behavioral interactions with habitat features and other fish. An angler survey is being conducted to investigate angling effects on *O. mykiss* movement and survival. Results of habitat associations, site fidelity, degree of movement, intraspecific interactions, percent anadromy and survival of approximately 126 acoustically tagged wild *O. mykiss* over a two year period are presented.

CALFED Statement of Relevance
Central Valley *Oncorhynchus mykiss* are listed as threatened under the Endangered Species Act. Knowledge of wild *O. mykiss* habitat associations, movement and survival in relation to managed and altered systems, will enable managers to focus efforts towards more effective restoration, water management, fisheries and wildlife management and recovery.

SESSION: Migratory Movements and Success of Salmonids (II), 10/22/2008, 4:20 PM, Room 306

Sandstrom[1], P.T.*, A.J. Ammann[2], E.D. Chapman[1], A.P. Klimley[1], R.B. MacFarlane[2], S.L. Lindley[2], C. Michel[2]
[1]University of California Davis, One Shields Ave., Davis, CA 95616
[2]NOAA Fisheries, Southwest Fisheries Science Center 110 Shaffer Rd., Santa Cruz, CA 95060
ptsandtrom@ucdavis.edu

Fine-Scale Movement and Depth Distribution of Juvenile Steelhead Trout in the Sacramento River and San Francisco Bay Estuary

Little is known about the movement patterns of juvenile steelhead trout. Four juvenile steelhead trout were tagged and tracked with miniature ultrasonic transmitters that recorded depth. Tagged steelhead made small initial movements for the first 24 hours after release. The two individuals tracked for multiple days exhibited a significant response to tidal flows. Fish moving the greatest distances upstream or downstream were observed in the top 3 m of the water column and closely followed changes in water flow direction. Steelhead trout were observed near the bottom of the water column, where influence of flow is reduced, when making fine-scale movements or ignoring the prevailing water flow. The fish we tracked continuously for five days during the summer showed a diel pattern, moving during the daytime and typically holding in an area of less than 1 km at night. This fish was found at depths ¡Ü3 m 86% of the total daytime detections. The second steelhead tracked during the spring, when juveniles are outmigrating, moved further at night than during the day for the first four days. This fish also exhibited behaviors of holding and localized movements during the daytime rather than at night. 81% of daytime detections were ¡Ý3 m in depth, while 79% of nighttime detections occurred in the top 3 m of the water column. By characterizing movement patterns of smolts we will increase our understanding of the behaviors other juvenile steelhead may exhibit between automated receiver sites along the outmigration corridor at various times of the year.

CALFED Statement of Relevance
The fine-scale movements of juvenile steelhead trout are of importance in the Delta because of predation and responses to water flow.

SESSION: Migratory Movements and Success of Salmonids (II), 10/22/2008, 4:40 PM, Room 306

Enright, C.S.
California Department of Water Resources, 901 P St, Sacramento, CA 95814
cenright@water.ca.gov

Tidal Slough Geometry Filters Estuarine Drivers, Mediates Transport Processes, and Determines Ecosystem Gradients

Problem statement: Transport process and ecosystem gradient variability is considered a key characteristic of resilient estuarine function. Native species compete more effectively for resources and habitat when physiography, hydrodynamics, and chemical/biotic gradients are variable in time and space. While this is a relatively accepted conceptual model, more understanding is needed about the nature of variability, especially as it is influenced by the land-water interface. This presentation suggests that the interaction of tidal motions on the native landscape planform generated spatial variability in the flow field and all scalar quantities. Background: Suisun Marsh is considered to have high ecosystem restoration potential partly because of its non-proximity to water exports, thus solving the water supply/ecosystem conundrum. It is adjacent to the "low salinity zone" where maximums of suspended sediment and organisms have historically been measured. We hypothesize that Suisun Marsh supports high internal biotic productivity, exports nutrients and carbon to Suisun Bay, and plays a key role in the overall aquatic productivity of the estuary. Findings: We deployed an extensive in situ monitoring array for hydrodynamic and water quality parameters across Suisun Marsh (April through August 2004) and measured water and constituent fluxes at various scales. We found wide variability (gradients) of water residence time, and constituent fluxes depending on local channel connectivity, water excursion and exchange, and location vis-à-vis Bay and watershed. We compared tidal sloughs with a range of land-water interface characteristics and found that physiography determines chemical and biological variability and exchange with downstream habitats.

CALFED Statement of Relevance
Several restoration initiatives including BDCP and Delta Vision target Suisun Marsh for tidal marsh restoration. This research supports restoration site selection criteria, informs restoration design, identifies performance measures, and provides a baseline for future adaptive management experiments.

SESSION: Physical Processes (I), 10/22/2008, 1:20 PM, Room 307

Giddings[1], S.N.*, L.J. MacVean[2], M.T. Stacey[2], D.A. Fong[1], S.G. Monismith[1]
[1]Stanford University, Environmental Fluid Mechanics & Hydrology, Stanford, CA 94305
[2]U.C. Berkeley, 202 O'Brien Hall, Berkeley, CA 94720-1718
sarahgid@stanford.edu

Temporal Variability of Shoal/Channel Interactions and Circulations in Far South San Francisco Bay

The hydrodynamic interactions between shoals and channels in estuarine systems are critical drivers of physical processes that impact biological and chemical transport such as the evolution of phytoplankton blooms and transport of scalars such as sediment and pollutants. A month long in-situ experiment at the Dumbarton Narrows in South San Francisco Bay allows us to examine the dynamics of a shoal/channel estuary in detail. Nine moorings were deployed at the Dumbarton Narrows mid-February through mid-March, 2008 in order to examine shoal/channel interactions, transverse circulations, and transport through the Dumbarton Narrows. Moorings included acoustic Doppler current profilers (ADCP); acoustic Doppler velocimeters (ADV); conductivity, temperature, depth (CTD) sensors at several depths; optical backscatter sensors (OBS); and fluorometers. The mooring information was augmented with high resolution ADCP and CTD transects during representative spring and neap tidal periods as well as continuous visual remote sensing. Two events during the period of record exhibit strengthened transverse circulations, enhanced shoal/channel fronts, enhanced turbidity, and greatly altered subtidal circulations. Subtidal circulations reverse from being into the estuary in the channel and out over the shoals to being into the estuary over the shoals and out through the channel. At the same time, transverse circulation cells convergent at the surface near the shoal/channel interface strengthen significantly, forming persistent fronts. Preliminary analysis suggests that wind plays a prominent role in driving these events, but previous storm events and the timing of the spring-neap cycle may also be contributing factors. These events may have important implications to transport mechanisms within South San Francisco Bay and potentially between Central and South Bay. Understanding shoal/channel hydrodynamics more generally allows us to better understand the physics of the system and how the dynamics may respond to morphological alterations due to shoreline restoration and/or development.

CALFED Statement of Relevance
This work leads to a better understanding of shoal/channel estuarine dynamics and transport mechanisms in South San Francisco Bay. An understanding of shoal/channel hydrodynamics will also allow us to better understand how system dynamics may respond to morphological alterations due to dredging, shoreline restoration and/or development.

SESSION: Physical Processes (I), 10/22/2008, 1:40 PM, Room 307

Barnard[1], P.L., L.H. Erikson[1], I.W. Aiello[2]
[1]United States Geological Survey, 400 Natural Bridges Drive, Santa Cruz, CA 95060
[2]Moss Landing Marine Lab, 8272 Moss Landing Road, Moss Landing, CA 95039
pbarnard@usgs.gov

Assessing Sediment Transport in the San Francisco Bay Coastal System using Multibeam Bathymetry, Numerical Modeling and Mineral Provenance

A series of high-resolution multibeam bathymetry surveys between 1997 and 2008 has yielded unprecedented imagery of the Central San Francisco Bay floor and Golden Gate. These data have also allowed precise measurements of sand volume change through time, and detailed measurements of the shapes of over 3000 bedforms indicate the net direction of sediment transport. The multibeam bathymetry analyses were combined with Delft3D numerical modeling and a mineral provenance study stretching from the delta mouth to the bay mouth to infer the dominant sediment transport pathways and to preliminarily assess the impact of human intervention in the San Francisco Bay Coastal System. This collective analysis suggests a loss of at least 130 million cubic meters of sediment in Central Bay and the bay mouth alone in just the last 50 years. Further, the system is ebb-dominated, with net seaward-directed sediment transport. Based on these findings, great caution should be exercised when artificially modifying San Francisco Bay sediment volumes and transport pathways as this could limit the coastal sediment supply and lead to beach erosion. This multi-faceted research approach using state-of-the-art tools has greatly advanced our understanding of sediment budgets, morphology, and sedimentary processes in the San Francisco Bay Coastal System and is a powerful aid to San Francisco Bay sediment management decisions.

CALFED Statement of Relevance
This research provides the first quantitative, multifaceted approach to understanding the sand transport pathways in the San Francisco Bay Coastal System, enabling managers to understand the impact of sediment management practices on the bay floor, adjacent ocean, and local beaches.

SESSION: Physical Processes (I), 10/22/2008, 2:00 PM, Room 307

Fong[1], D.A., S.G. Monismith[1], M.T. Stacey[2], J.R. Burau[3]
[1]Stanford University, 473 Via Ortega, Rm 169, MC:4020, Stanford, CA 94305
[2]University of California, Berkeley, Civil and Environmental Engineering, Berkeley, CA 94720-1710
[3]US Geological Survey, Sacramento State University, Placer Hall, 6000 J Street, Sacramento, CA 95819-6129
dfong@stanford.edu

Turbulent Stresses and Secondary Currents in a Tidal-forced Channel with Significant Curvature

Acoustic Doppler current profilers (ADCP) are deployed to measure both the mean flow and turbulent properties in a channel with significant curvature. Direct measurements of the Reynolds stress show a significant asymmetry over the tidal cycle where stresses are enhanced during the flood tide and less prominent over the ebb tide. This asymmetry is corroborated by logarithmic fits using ten-minute averaged velocity data. A smaller yet similar tendency asymmetry in drag coefficient is inferred by fitting the velocity and estimated large-scale pressure gradient to a 1-D along-channel momentum balance. This smaller asymmetry is consistent with recent modeling work simulating regional flows in the vicinity of the study site. The asymmetry in drag suggests the importance of previously reported bed forms for this channel and demonstrates spatial and temporarily variations in bed stress. Secondary circulation patterns observed in a relatively straight section of channel appear driven by local curvature rather than being remotely forced by the regions of significant curvature only a few hundred meters from the measurement site.

CALFED Statement of Relevance
Our unique field data and analysis suggest challenges and important considerations for any field scale numerical modeling of the Bay-Delta system. Asymmetric and variation in bed stress need to be carefully considered in order to accurately predict flows.

SESSION: Physical Processes (I), 10/22/2008, 2:20 PM, Room 307

Monismith[1], S.G., J.L. Hench[1], D.A. Fong[1], N.J. Midzieko[1], W.E. Fleenor[2], L.P. Doyle[2], G. Schladow[2]
[1]Stanford University, Dept. Civil and Env. Eng., Stanford, CA 94305
[2]University of California at Davis, Dept Civil and Env. Eng, Davis, CA
monismith@stanford.edu

Thermal Variability in a Tidal River

We discuss observations of temperature variability in the tidal portion of the San Joaquin River. Observations made in August 2004 and August 2005 show significant diurnal variations in temperature in response to surface heat exchange. However, to account for observed changes in heat content a sizeable downstream heat flux (ca. 100 W m-2) must be added to the surface heat flux. To account for this flux via Fickian dispersion, a flow-dependent dispersion coefficient varying from 500 to 4000 m2 s-1 is needed. These values are much larger than would be predicted for a river of this size, suggesting that the complex topology of the Delta greatly enhances longitudinal dispersion. Building on these observations, we present a simple theory that explores how the sub-tidal temperature field varies in response to changes in flow rate, dispersion and heat exchange.

CALFED Statement of Relevance
This work is of general interest to the thermal dynamics of estuaries around the world as well as more specifically understanding of temperature variations and how they can be predicted in the Delta. This work provided the underpinning of the DRERIP conceptual model of temperature in the Delta

SESSION: Physical Processes (I), 10/22/2008, 2:40 PM, Room 307

Williams, P.B., D. Brew
PWA Ltd., 550 Kearny St. #900, San Francisco, CA 94108
p.williams@pwa-ltd.com

Projecting the Future of the Delta: What Morphologic Analysis Tells Us

Decisions on whether, or how many, Delta Islands will be abandoned to tidal action has major implications not just for California's water supply but the functioning and evolution of the entire San Francisco Estuary's tidal habitats. Recent detailed mapping of the Delta combined with estimates of the main components of the Delta's sediment budget, and anticipated sea level rise, allow for the development of 'book-end' scenarios of possible future Delta hypsometry at the estuarine landscape scale. This morphologic analysis addresses key management questions including: the potential increase in tidal prism and tidal volume of the Delta and of the San Francisco Estuary; the relative importance of accelerated sea level rise compared to island abandonment; and the maximum potential extent of passively restored freshwater tidal wetlands. Key findings of this analysis are: 1. The potential accommodation space in the Delta is significantly larger [3.5 million af] than that previously estimated by Mount and Twiss in 2005 [2.0 million af]. 2. Under a hypothetical scenario where all Delta islands are abandoned the tidal volume would increase approximately 4 times and potential tidal prism increases by approximately 6 times. 3. Under this same scenario the tidal volume of the whole estuary would increase by approximately 45%. 4. Only about 20% or 80,000 acres of the Delta is shallow enough for tule marsh to re-establish. 5. Under a hypothetical scenario where all levees were maintained in place for the next 100 years the potential accommodation space in the Delta would double to about 7.0 million af. The potential impacts of these large morphologic changes on estuarine hydrodynamics, sediment dynamics and tidal habitat in the San Francisco is discussed.

CALFED Statement of Relevance
Landscape scale planning for the future of the Delta needs is constrained by, and needs to take into account the long term geomorphic; hydrodynamic, and habitat implications for the whole Estuary, of decisions to abandon or preserve Delta islands.

SESSION: Physical Processes (II), 10/22/2008, 3:20 PM, Room 307

Minear, J.T., G.M. Kondolf
University of California, Berkeley, 202 Wurster Hall, Berkeley, CA 94720
tminear@berkeley.edu

Downstream Geomorphic and Hydrologic Effects of Dams in the Central Valley

Large dams alter downstream flow to varying degrees and completely halt coarse sediment supply to downstream river channels, causing a range of geomorphic effects, ranging from no effect to bed coarsening, incision and loss of topographic variability. The most classic cases of dam-related river incision have been caused on sand-bedded rivers downstream of large dams that halted all sediment supply yet maintained high sediment transport capacity. In contrast, in the Central Valley of California, the rivers below the downstream-most dams are primarily gravel bedded or bedrock, which have a higher sediment transport threshold than sand-bedded rivers. Therefore, we hypothesize that in gravel-bedded rivers, like the Central Valley, the degree of geomorphic response for each river is much more variable and is primarily a function of the degree of hydrologic alteration caused by the dam rather than the simple presence of the dam itself. For this study, we compared the geomorphic threshold and sediment transport data that was available and conducted historical reviews of topographic data to determine the range of likely long-term geomorphic response of gravel-bedded rivers. The results of our study suggest that there is a range of different geomorphic responses below dams that can be expected, ranging from near zero topographic change to several meters of incision. For example, the San Joaquin River has nearly 100% reduction in sediment transport for all years following the construction of Friant Dam in 1942, primarily because no flows are large enough to mobilize the bed. In contrast, the Yuba River downstream of Englebright Dam, is mobile nearly every year. It is our hope that the river restoration community take into account these long-term geomorphic processes that have been operating since the construction of the dams in the Central Valley and to better adapt site-specific restoration designs given the changes that have already occurred.

CALFED Statement of Relevance
Since there has been little research on the downstream effects of dams on gravel-bedded research, this research effort has direct implications for CalFed's central goals of restoration and understanding of it's project area. Our hope is that practioners will be able to use our data to better inform their projects.

SESSION: Physical Processes (II), 10/22/2008, 3:40 PM, Room 307

Constantine, J.A., T. Dunne
University of California - Santa Barbara, Department of Earth Science, Santa Barbara, CA 93106
jconstantine@bren.ucsb.edu

Chute Cutoff and the Controls on Riverbank Incision along the Sacramento River of California

Chute cutoff, which occurs after floods incise a floodplain channel that will evolve into the dominant conveyor of river discharge, is an important mechanism during the evolution of many meandering rivers. In spite of its importance, the mechanism has not been incorporated into theory explaining meandering behavior due to the paucity of observations that are needed to identify the controls on its occurrence, without which it is impossible to deterministically predict when and where chute cutoff will take place. In an effort to determine the controls on chute cutoff, historical incidents of the mechanism were examined along the Sacramento River of California. Our results show that chutes formed within portions of the floodplain that were vegetated lightly by grasses or farmed and often began as embayments in the riverbank. The entrance into each chute paralleled the upstream main-channel, suggesting that momentum of flow within the main channel was an important control on the location of riverbank incision. The location of the chute entrance was also generally located where channel curvature was highest, an observation we attributed to the effects of curvature on the routing of overbank flow. The effects of floodplain vegetation on the incising ability of overbank flow were modeled, the results of which suggested that the grassy vegetated banks typical of the Sacramento River were incapable of preventing riverbank incision. In contrast, banks populated by a dense riparian forest were shown to be nearly impossible to incise. Our approach and results may be applicable to other river valleys and should indicate where more detailed hydraulic studies of the conditions favoring chute cutoffs might be targeted.

CALFED Statement of Relevance
Chute cutoff is an important mechanism for generating off-channel aquatic habitat along the Sacramento River. Our results provide a means for predicting where the creation such habitat is likely and may guide efforts to restore natural floodplain vegetation while managing the behavior of the Sacramento River.

SESSION: Physical Processes (II), 10/22/2008, 4:00 PM, Room 307

Harrison, L.R., C.J. Legleiter, M.A. Wydzga, T. Dunne
UC Santa Barbara, Institute for Computational Earth System Science, Santa Barbara, CA 93106
lharrison@umail.ucsb.edu

Reach-scale Morphologic Response to Restoration in a Simplified Channel-floodplain System

The restructuring and rescaling of river channel-floodplain systems to diminished flows has become a widespread form of river restoration. The practice is largely driven by the concept that restoring physical processes is the best way to restore habitat for native organisms. Here we report results of field and modeling investigations that seek to explain how physical and ecological processes evolve from an initially simplified condition, using a restored gravel-bed reach of the Merced River, CA. Field data exploring the evolution of physical processes revealed an unanticipated sediment pulse moving through the upper four bends, which initiated a series of morphologic and hydraulic responses. Increased sediment storage in the upper reach enhanced bar-building, which lead to a deflection of the high velocity core from the channel center towards the outer bank. The resultant hydraulic adjustments promoted pool scour, cross-sectional asymmetry and bank erosion. Measured bank erosion rates in the upper reach ranged from 1.7 – 3.1 m/yr, following two overbank floods, while negligible bank erosion has been observed during a series of sub-bankfull flows. These channel changes have enhanced spawning and shallow water habitats and have been accompanied by differences in invertebrate communities and resident fish populations. In the lower reach, the cross-sectional form and variability of habitat conditions has remained fairly uniform despite the similarity in flow conditions with the upstream reach. We interpret the disparity in physical and ecological diversity between the upper and lower reaches to be driven largely by the differences in bed-material storage. Collectively, these results highlight the importance of overbank flows and the availability of sediment for bar deposition in driving meander migration and creating channel complexity. Modeling efforts are underway to explore the connections between gravel supply, bar building, the cross-stream balance of forces and bank erosion that lead to the development of high-quality habitat.

CALFED Statement of Relevance
These results are applicable to other restoration projects throughout California, particularly through enhancing our understanding of river mechanics and the degree to which current restoration practices will lead to self-maintaining rivers.

SESSION: Physical Processes (II), 10/22/2008, 4:20 PM, Room 307

Tompkins[1], M.R., G.M. Kondolf[2]
[1]CH2M Hill, 155 Grand Avenue, Oakland, CA 94612
[2]University of California, Berkeley, 202 Wurster Hall, Berkeley, CA 94720-2000
Mark.Tompkins@ch2m.com

Influence of River Channel Complexity on Water Temperature Dynamics: Lower Deer Creek, Tehama County, CA

Despite significant reductions in channel complexity in the lower eleven miles of Deer Creek that have persisted since 1949, local areas of complex channel morphology remain. Recent research on alluvial floodplain rivers similar to lower Deer Creek have shown that hyporheic exchange can influence diurnal water temperature patterns in braided reaches and in reaches where gravel augmentation has occurred. We deployed a network of surface and subsurface water temperature loggers to measure effects of hyporheic exchange on diurnal water temperature fluctuations at sites of varying topographic relief in lower Deer Creek. Comparing hourly temperature of upwelling hyporheic water with downwelling surface water we observed up to 7.19°C reduction in amplitude of daily temperature fluctuation, up to 3.5°C reduction in daily peak temperature, and lag times between downwelling and upwelling peaks of up to 19 hours, all of which were strongly correlated with elevation difference between downwelling and upwelling sites. We also identified flow thresholds below which hyporheic flow paths were disconnected. In addition, we measured surface water temperatures throughout lower Deer Creek to identify spatial and seasonal differences in water temperature dynamics potentially associated with flood control infrastructure and simplified channel morphology. We measured increases in the peak daily warming rate of between 1.3°C and 5.9°C per mile through the highly confined and simplified reach from river mile 4.2 to 5.0 and the reach through the Stanford-Vina Irrigation District dam from river mile 3.6 to 4.2, respectively. In salmonid rivers where water temperature is a critical component of aquatic habitat quality, this link between water temperature and physical habitat complexity should be explored as a new criterion for river restoration efforts. Further, as global climate change continues to alter climatic and hydrologic regimes, the role of hyporheic flow in buffering against changes in river water temperatures should become an important consideration in river management and restoration approaches.

CALFED Statement of Relevance
This research generated new data on the influence of hyporheic flow on water temperature dynamics for lower Deer Creek, a Sacramento River tributary that still supports Spring-run Chinook salmon. In addition, this research provides insights for river restoration, floodplain reconnection, and alternative flood management approaches that are especially relevant in the context of global climate change.

SESSION: Physical Processes (II), 10/22/2008, 4:40 PM, Room 307

Joab, C.M., J. Simi, A. Montgomery
Central Valley Regional Water Quality Control Board, 11020 Sun Center Drive #200, Rancho Cordova, CA 95670
cjoab@waterboards.ca.gov

Low Dissolved Oxygen in the Stockton Deep Water Ship Channel and the Development of a Total Maximum Daily Load (TMDL)

The Stockton Deep Water Ship Channel (DWSC) is located on the San Joaquin River within the Sacramento-San Joaquin River Delta and experiences regular periods of low dissolved oxygen (DO) concentrations. DO is necessary for most aquatic life, with optimum levels for healthy aquatic ecosystems ranging from 5-9 mg/L. DO levels below 5 mg/L are considered unhealthy for fish and other aquatic organisms, and can result in fish mortality, barriers to fish migration, and degraded habitat. In 1967, the CVRWQCB adopted a DO water quality objective of 5 mg/L for all waters of the Delta, and in 1991 the DO objective was revised to 6 mg/L in the DWSC during the period of September 1 to November 30 each year to facilitate the upstream migration of fall run Chinook salmon. In the DWSC, DO levels drop below 5 mg/L in the late summer and fall (June through November) when river temperatures are the highest. In 2005, the CVRWQCB adopted a phased TMDL for the DWSC. Three key factors were identified in the TMDL as contributing to the low DO in the DWSC: (1) upstream inputs of oxygen-demanding substances, (2) modified channel geometry, and (3) reduced net flow. As part of the phased TMDL, further studies on the sources of oxygen-demanding substances that flow into the DWSC were required. A brief description of these on-going studies and the current status of the TMDL will be presented.

CALFED Statement of Relevance
This presentation will provide a perspective on the low DO problem within the DWSC, the development and current status of the TMDL, and act as a platform for the remaining presentations that focus on studies conducted to quantify sources of oxygen-demanding substances and other factors contributing to the DWSC impairment.

SESSION: Low Dissolved Oxygen and Eutrophication in the San Joaquin River: Developing a Scientific Foundation for River Water Quality Mangement (I), 10/22/2008, 1:20 PM, Rooms 308-310

Stringfellow[1], W.T., J. Herr[2], G. Litton[1], M. Brunell[1], S. Borglin[1], J. Hanlon[1], C. Chen[2], R. Dahlgren[3], C. Kendall[4], N. Quinn[5]
[1]University of the Pacific, Ecological Engineering Research Program, Stockton, CA 95211
[2]Systech Water Resources, San Ramon, CA
[3]University of California, Davis, CA
[4]US Geological Survey, Menlo Park, CA
[5]Berkeley National Laboratory, Berkeley, CA
wstringfellow@lbl.gov

Investigation of River Eutrophication as Part of a Low Dissolved Oxygen TMDL Implementation: Three Years of Science in Fifteen Minutes

This Upstream San Joaquin River Dissolved Oxygen Total Maximum Daily Load Project (DO Project) was funded by a grant of funds from Proposition 13 for the purpose of implementing the CALFED Ecosystem Restoration Program (ERP). The project is part of the long-term comprehensive plan to restore the ecological health and improve water management for beneficial uses of the Bay-Delta system. In the tidal estuary of the San Joaquin River (SJR) there occur intermittent low dissolved oxygen (DO) conditions that impair fish-related beneficial uses. Low DO conditions in the SJR estuary are caused in part by excessive phytoplankton growth (eutrophication) in the shallow, upstream portion of the river that create oxygen demand in the deeper estuary. Scientific studies, combing traditional monitoring, watershed modeling, statistical analysis, and directed experiments, were conducted to develop a mass balance on nutrients and phytoplankton and to address outstanding questions concerning how phytoplankton grow and accumulate in the SJR. In this paper we present a summary of the final results for the three-year DO TMDL Project. Water quality and flow were measured using a combination of continuous and instantaneous methods at all major and most minor tributaries of the SJR for a 125 km reach above the Delta and Lagrangian studies were conducted in a 30 km tidal portion upstream of the low DO impacted area of the SJR estuary adjacent to the city of Stockton. A mass balance model on phytoplankton and nutrients was developed using WARMF, a model specifically designed for use in TMDL management applications. Scientific studies, including the measurement of over 70 physical, chemical, and biological parameters at over 100 locations in the watershed, provided a complete picture of spatial and seasonal trends in water quality and sources of oxygen demand in the SJR between Stockton and south of the city of Los Banos. It was demonstrated that phytoplankton biomass accumulates rapidly in a 88 km reach where plankton from small, slow moving tributaries are diluted and combined with fresh nutrient inputs in faster moving water. Plankton load entering the tidal area upstream of the low DO area cease rapid growth and demonstrate a net decay as grazing pressure increases and depths limit light availability. The SJR-WARMF model was demonstrated to accurately predict hydrology and phytoplankton growth in the SJR. Model results suggest that a greater than 80% reduction in nutrient inputs will be required to limit algal growth in the river. Limiting algal biomass loading from tributaries is predicted to significantly limit phytoplankton biomass accumulation in the SJR. The DO TMDL Project has provided the ERP a strong scientific foundation and practical, scientific tools for management of the low dissolved oxygen condition in the SJR estuary.

CALFED Statement of Relevance
This presentation summaries and informs the CALFED community on a $7.8 million Ecosystem Restoration Project. The results of this project will serves as the scientific foundation for the San Joaquin River Dissolved Oxygen TMDL. Ideally, the presentation will be made as part of a special session covering the entire scope of the project, but the presentation can also be made independently to inform the public of how CALFED projects are coming up with real answers to Delta ecosystem problems.

SESSION: Low Dissolved Oxygen and Eutrophication in the San Joaquin River: Developing a Scientific Foundation for River Water Quality Management (I), 10/22/2008, 1:40 PM, Rooms 308-310

Herr[1], J.W., W.T. Stringfellow[2], N.W. Quinn[3], R. Brown[4]
[1]Systech Water Resources, Inc., 1200 Mount Diablo Blvd., Suite 102, Walnut Creek, CA 94507
[2]Environmental Engineering Research Program, University of the Pacific, School of Engineering & Computer Sciences, Sears Hall, 3601 Pacific Ave, Stockton, CA 95211
[3]Berkeley National Laboratory, 1 Cyclotron Road , Bld. 70A-3317H, Berkeley, CA 94720
[4]Jones & Stokes, 2600 V Street, Sacramento, CA 95818
joel@systechwater.com

Evaluating the Effect of Phytoplankton Seed Removal on San Joaquin River Organic Loading

The Stockton Deep Water Ship Channel (DWSC) in California's Sacramento / San Joaquin delta is a tidal reach which experiences episodes of low dissolved oxygen impeding the passage of fish. An important cause of dissolved oxygen depletion is decay of phytoplankton produced upstream in the San Joaquin River. The Watershed Analysis Risk Management Framework (WARMF) model was applied to the San Joaquin River to determine the sources of phytoplankton and the effectiveness of various means to control its growth. WARMF uses meteorology, land use, measured inflows, diversion data, and irrigation practices to calculate nonpoint source load including agricultural drainage. The model uses properties of various species of floating algae and simulated river travel time, temperature, nutrients, and light to determine phytoplankton concentration in the San Joaquin River. WARMF has been calibrated to flow and water quality data collected in the San Joaquin River. Simulations indicated that phytoplankton growth was exponential and not nutrient limited, in agreement with field investigations. Preliminary simulations showed that reducing the load of phytoplankton seed in the upper reaches of the San Joaquin River would reduce the load of organic matter entering the Sacramento / San Joaquin delta. A field experiment was conducted in July 2007 shutting off the San Luis Drain, a significant source of phytoplankton seed at the upper end of the San Joaquin River. Flow and water quality data collected before, during, and after the planned shutoff was used to simulate the events as they occurred. The WARMF model also was used to simulate a hypothetical "do nothing" scenario, under which the San Luis Drain continued to discharge normally during the time period of the experiment. The difference between the two scenarios demonstrated the change in organic loading and the applicability of the phytoplankton seed reduction strategy on a short-term and long-term basis.

CALFED Statement of Relevance
Excessive organic loading to the Delta is a cause of water quality impairment in the Stockton Deep Water Ship Channel. A 3 year scientific study including field investigation and modeling has been applied to determine the effectiveness of a proposed organic loading control strategy.

SESSION: Low Dissolved Oxygen and Eutrophication in the San Joaquin River: Developing a Scientific Foundation for River Water Quality Management (I), 10/22/2008, 2:00 PM, Rooms 308-310

Kendall[1], C., M.B. Young[1], S.R. Silva[1], C.R. Kratzer[1], R.A. Dahlgren[2], W.T. Stringfellow[3]
[1]USGS, 345 Middlefield Road, Menlo Park, CA 94025
[2]UC Davis
[3]LBNL and UoP
ckendall@usgs.gov

Synthesis of Stable Isotope Data for Tracing Sources of Nitrate and Organic Matter to the San Joaquin River

As part of two projects aimed at identifying sources of nutrients and organics in the San Joaquin River (SJR), water and particulate organic matter (POM) samples were collected bi-weekly to monthly from March 2005 through December 2007 from mainstem and tributary sites. All samples were analyzed for d13C, d15N, and C:N of POM, d18O and d2H of water, and d15N and d18O of NO3. Subsets were also analyzed for DOC, SO4, and PO4 isotopes. In a parallel project, groundwater samples were also analyzed for NO3 and DOC isotopes. NO3 isotopes provided a classification scheme for evaluating the dominant source of nitrate (e.g., fertilizer, soil, or waste) at each site and date, as well as the dominant process controlling the composition (e.g., mixing, denitrification, nitrification, or uptake). The NO3 isotopic signatures of many groundwater samples are consistent with a waste source, but the nitrate concentrations are generally low. West-side creeks had different NO3 isotope signatures than east-side tributaries or upstream wetlands. During low-flow conditions in the mainstem SJR in 2007, the d15N of the SJR increased downstream, in contrast to the normal pattern of a downstream decrease in d15N associated with input of low-d15N water from the major tributaries. The high d15N values cannot be explained by known inputs and strongly suggests that there was addition of waste-derived NO3 from unsampled sources along this reach. A POM source classification scheme developed using isotope, pigment, and BOD data showed that the relative proportions of fresh and older algae decreased downstream at mainstem sites while the relative contributions of refractory POM derived mainly from east-side tributaries increased. We find that the temporal and spatial variation in isotopic compositions provides unique insights into sources of NO3, organics, water, and other salts that could not have been gained with standard chemical and hydrological measurements.

CALFED Statement of Relevance
This study evaluates the usefulness of a multi-isotopic approach for investigating the sources of nutrients and organic matter that contribute to low dissolved oxygen levels in the SJR, a major concern of the Ecosystem Restoration Program of the CALFED Drinking Water Quality Program.

SESSION: Low Dissolved Oxygen and Eutrophication in the San Joaquin River: Developing a Scientific Foundation for River Water Quality Management (I), 10/22/2008, 2:20 PM, Rooms 308-310

Quinn[1], N.W., T. Heinzer[2], L.M. Gary[3]
[1]Berkeley National Laboratory/ USBR, 1 Cyclotron Road, Bld 90-1089, Berkeley, CA 94720
[2]US Bureau of Reclamation, 2800 Cottage Way, Sacramento, CA 95825
[3]University of the Pacific, 3601 Pacific Ave., Stockton, CA 95211
nwquinn@lbl.gov

2-D Hydrodynamic Model Analog of Algae Transport in the Lower San Joaquin River Based on Dye Tracer Studies

During late summer of 2005 through 2007 dye tracer studies were conducted in conjunction with a Lagrangian algal fate study to improve understanding of algal dynamics between Vernalis and the Deep Water Ship Channel. Previous studies had shown a reduction in algal biomass in this reach of the river which was not explained by the flow bifurcation at Old River or by riparian diversions from the river at Banta Carbona Irrigation District or the private pumping stations along the river serving delta agriculture. The dye study was conducted in both Lagrangian and Eulerian modes – the Lagrangian study followed the peak dye concentration as it moved downstream in a moving boat that was fitted with instruments capable of simultaneous GPS positioning and real-time dye measurement – the Eulerian study was conducted from a boat moored at a fixed location that measured the dye pulse as it swept past. To develop an understanding of the influence of river morphology on conservative dye transport and retardation - a two dimensional hydrodynamic flow model was developed to account for such phenomena as eddying, which is caused by river sinuosity and that is a primary causal factor in longitudinal dispersion of both dye and algae in the River. The Danish Hydrologic Institute's Mike 21c code was chosen to perform the model simulations. This paper describes the development of the model, use of GIS to visualize the river bathymetry and the simulation experiments performed to date.

CALFED Statement of Relevance
Derived from Task 8 of the final report on algal fate and transport between Vernalis and the Deep Water Ship Channel for the CALFED -sponsored San Joaquin Dissolved Oxygen TMDL

SESSION: Low Dissolved Oxygen and Eutrophication in the San Joaquin River: Developing a Scientific Foundation for River Water Quality Management (I), 10/22/2008, 2:40 PM, Rooms 308-310

Dahlgren[1], R.A., C.R. Kratzer[2], B.A. Bergamaschi[2], P.D. Dileanis[2], C. Kendall[2], S.P. Phillips[2], A. Russell[1], M. Young[2]
[1]University of California - Davis, One Shields Ave., Davis, CA 95616
[2]U.S. Geological Survey, Sacramento, CA
radahlgren@ucdavis.edu

Water Quality Characteristics of Riparian-zone Groundwater of the Lower San Joaquin River, California

The influence of groundwater on surface water quality in the San Joaquin River (SJR), California was examined for a 59 mile reach from the confluence with Salt Slough to Vernalis. Previous studies have estimated that groundwater may contribute 5-10% of downstream flow during the summer. However, there is a paucity of information concerning the chemical composition of groundwater accretions in the lower SJR, which hinders the estimation of nutrient loads from groundwater sources. A synoptic study making measurements at 30 sites using temporary drive-points (0.25 and 1 m depths) was conducted by boat along the 59 mile reach. The sampling at each site included measurements of hydraulic and temperature gradients within the stream bed, and general water quality characterization of groundwater samples. Median concentrations for the 30 sites were: E.C. = 1.7 dS/m (range 0.5-15.9 dS/m), nitrate-N = <0.01 mg/L (range <0.01-10 mg/L), ammonium-N = 0.31 mg/L (<0.01-32 mg/L), and soluble-reactive phosphate = 0.21 mg/L (range 0.01-3.66 mg/L). Anoxic conditions and low nitrate concentrations suggest that denitrification is a prevalent process leading to the loss of nitrate from groundwater at many sites. However, many of the anoxic wells displayed high ammonium concentrations that could be oxidized to nitrate upon entering the river. Hydraulic gradient and temperature data will be used to model rates of groundwater flow into the river. These flux rates will be combined with water quality data to estimate nutrient loads contributed to the river from groundwater. This study will provide important information on nutrient inputs to the SJR which are of concern due to eutrophication and hypoxia in the lower SJR.

CALFED Statement of Relevance
This study will provide important information on the water quality of groundwaters input into the San Joaquin River, which contribute nutrients that affect eutrophication and hypoxia, dissolved organic carbon that affects drinking water quality, and salts and boron that affect irrigation water quality.

SESSION: Low Dissolved Oxygen and Eutrophication in the San Joaquin River: Developing a Scientific Foundation for River Water Quality Management (II), 10/22/2008, 3:20 PM, Rooms 308-310

Young[1], M.B., C. Kendall[1], W.T. Stringfellow[2], S.R. Silva[1], J. Hanlon[2]
[1]U.S. Geological Survey, 345 Middlefield Rd. MS434, Menlo Park, CA 94025
[2]University of the Pacific Ecological Engineering Program, 3601 Pacific Avenue, Stockton, CA 95211
mbyoung@usgs.gov

Linking Land Use with Stable Isotope Source Signatures of Nutrients and Particulate Organic Matter in San Joaquin River Tributaries

Land use patterns are changing rapidly in certain areas around the lower San Joaquin River (SJR), and population growth is expected to alter the delivery of nutrients into the SJR and its many tributaries. Identifying sources of nutrients and organic matter is critical to understanding ecosystem health, but can be difficult in large, mixed land use systems such as the San Joaquin. For this study, we are using three years of stable isotope data collected from the San Joaquin River and its tributaries to investigate relationships between land use and stable isotope signatures of various constituents, primarily nitrate and particulate organic matter (POM). Our results show that the types of mixed land use, rather than just the dominant land use, exert a strong control on the isotope signatures in the tributaries. In tributaries dominated by agricultural uses, it was expected that the nitrate stable isotope values would fall into the common isotope range previously determined for nitrate and ammonia- based fertilizers (Kendall 1998). However, the isotope signatures of SJR tributaries containing both major and minor contributions of wetland discharge tended to have distinct POM and nitrate isotope signatures (most likely due to nitrification of organic compounds) compared to other tributaries, regardless of whether or not agriculture was the dominant land use. Nitrate isotope values in the Merced River and several minor eastside tributaries suggest a major contribution of nitrate from human or animal waste, even for the tributaries where fertilizer was expected to be the dominant source of nitrate. This information is critical for evaluating nitrate isotope patterns in the mainstem SJR as tracers of nutrient sources and cycling, and will also contribute to our general understanding of nitrate isotope source signatures in other large mixed agricultural and urbanizing basins.

CALFED Statement of Relevance
Nitrogen compounds and organic carbon discharging from the SJR can contribute to periods of low dissolved oxygen in the Stockton Ship Channel (Lehman et al 2004), inhibiting fish migration. This research will help to link land use patterns with the processes controlling nutrients and organic matter distribution in the SJR.

SESSION: Low Dissolved Oxygen and Eutrophication in the San Joaquin River: Developing a Scientific Foundation for River Water Quality Management (II), 10/22/2008, 3:40 PM, Rooms 308-310

Kendall[1], C., S.E. Borglin[2], S.R. Silva[1], M.B. Young[1], W.T. Stringfellow[2,3]
[1]USGS, 345 Middlefield Road, Menlo Park, CA 94025
[2]LBNL
[3] UoP
ckendall@usgs.gov

A POM-classification Scheme Developed using Stable Isotope, Algal Pigment, and BOD Measurements

Temporal and spatial variations in the source and bioavailability of particulate organic matter (POM) in the San Joaquin River (SJR) and tributaries were assessed in 2005-2007 as part of two projects, with ~1500 samples analyzed for d15N, d13C, C:N, algal pigments (AP), and Biological Oxygen Demand (BOD). Using these data, we have developed a simple preliminary scheme for estimating the relative contributions of several different types of POM to each site and date. This classification scheme was intended to take advantage of the usefulness of C:N in distinguishing algae and terrestrial POM sources, use AP data to distinguish between new and old algae, use BOD to distinguish relatively refractory organic matter, and then use d15N and d13C to constrain the sources of C and N and the biogeochemical processes responsible for the isotopic signatures. Observations from this model include: Mainstem SJR sites showed decreasing relative contributions of fresh and older algae downstream, while the relative contributions of an unknown, mainly terrestrial, source of POM with low BOD derived mainly from the major east-side tributaries but also from some of the minor east-side tributaries (e.g., MID L5 and Westport) increased downstream. POM from the upstream wetlands sites (e.g., Los Banos, San Luis Drain, Mud Slough) was dominated (~80%) by fresh and old algae, whereas POM from Salt Slough, like Del Puerto Creek, was dominated by old algae and more refractory sources of POM. The average POM in the minor east and west-side tributaries showed a wide range of average compositions, with sites ranging from fresh algae-dominated (e.g., Ramona Lake) to ones dominated by refractory and terrestrial POM sources similar to the POM in the major tributaries (e.g., MID L5). POM from Harding Drain and MID L5 has unusually high d13C values, suggestive of C4 plants.

CALFED Statement of Relevance
This study evaluates the usefulness of a multi-tracer approach for investigating the sources of particulate organic matter that contribute to low dissolved oxygen levels in the SJR, a major concern of the Ecosystem Restoration Program of the CALFED Drinking Water Quality Program.

SESSION: Low Dissolved Oxygen and Eutrophication in the San Joaquin River: Developing a Scientific Foundation for River Water Quality Management (II), 10/22/2008, 4:00 PM, Rooms 308-310

Brunell[1], M.S., G.M. Litton[1], N.W. Quinn[2]
[1]University of the Pacific, Department of Biological Sciences, Stockton, CA 95211
[2]Lawrence Berkeley National Laboratory, 1 Cyclotron Road, Bld 70A-3317H, Berkeley, CA 94720
mbrunell@pacific.edu

Zooplankton Dynamics in the Non-tidal to Tidal Transition Zone of the San Joaquin River

As part of a larger study investigating algal dynamics in the San Joaquin River, an analysis of zooplankton was coordinated with a dye monitoring study during the summers of 2005 - 2007. Zooplankton were collected from the dye plume along a tidal freshwater reach of the river spanning 30 miles above the Stockton Deep Water Ship Channel (DWSC). During low flow periods samples were taken longitudinally along the reach. Rotifera comprised the most diverse group with 42 species. Rotifer diversity over the study reach varied greatly with several species exhibiting site preferences. Copepoda followed rotifers in diversity however their biomass was generally higher, especially downstream. Approximately four species of copepods occur; all three major orders are represented. The introduced *Pseudodiaptomus forbesi* was the dominant copepod. Nauplii occur throughout the reach, their numbers increasing downstream during periods of high to moderate flow. Cladocera are represented by six species, but abundance is low and distribution inconsistent. During high flow periods, peaks in zooplankton biomass occurred sporadically over the study period: in 2005 peaks occurred about 15 miles above the DWSC; in 2006 they occur in the five mile reach above the DWSC. In 2006, peaks are strongly correlated with reversal in flow during flood tides. In June 2007, the DWSC maintained the highest levels of biomass in the entire study. During the low flow conditions starting in July 2007, biomass peaks were predictably between eight and twelve miles above the DWSC. With the installation of the Head of Old River Barrier in late October 2007, biomass levels fell drastically and abundance peaks moved into the DWSC. In the majority of sampling runs, rotifer biomass increases or dominates upstream of river mile 48, with copepods dominating downstream of this point. During most of the sampling periods, zooplankton biomass was highest during night hours.

CALFED Statement of Relevance
Fate of algae entering the Stockton Deep Water Ship Channel (DWSC) has been linked to low dissolved oxygen concentrations. Characterization of the zooplankton community in this reach indicates the importance of grazing in controlling algae populations flowing to the DWSC.

SESSION: Low Dissolved Oxygen and Eutrophication in the San Joaquin River: Developing a Scientific Foundation for River Water Quality Management (II), 10/22/2008, 4:20 PM, Rooms 308-310

Litton[1], G.M., M.S. Brunell[1], J.C. Monroe[1], N.W. Quinn[2]
[1]University of the Pacific, Department of Civil Engineering, Stockton, CA 95211
[2]Lawrence Berkeley National Laboratory, 1 Cyclotron Road, Bld 70A-3317H, Berkeley, CA 94720
glitton@pacific.edu

Modeling Algae and Zooplankton Interactions in the San Joaquin River

A three-year effort to characterize the presence, transport and fate of algae in the San Joaquin River (SJR) was performed during the summers of 2005 to 2007 as part of a larger study investigating low dissolved oxygen in the Stockton Deep Water Ship Channel (DWSC). The freshwater 31-mile study reach upstream of the DWSC transitions from non-tidal to a tidally-influenced river. As algae are known to significantly contribute to oxygen demands entering the DWSC, influences on algal populations were investigated using a Lagrangian monitoring scheme. Mechanisms controlling algal fate in the SJR were investigated by characterizing changes in water quality parameters and by assessing the magnitude of grazing effects. Algal productivity and respiration, zooplankton grazing rates, and biochemical oxygen demands (BOD) were independently determined with batch microcosms. A plug-flow reactor model was developed to identify mechanisms responsible for the decline of algal populations upon entry into the DWSC. Results show a decline in chlorophyll with a concomitant increase in phaeophytin and zooplankton. Modelling simulations indicate that zooplankton grazing and light attenuation are the dominant mechanisms influencing algal populations flowing into the DWSC. In addition, measured biochemical oxygen demands entering the DWSC were also well correlated to the algae decline during periods of low net flows. Observed dissolved oxygen concentrations in the DWSC responded favourably when the decrease in algae concentration and its associated oxygen demand were significant. These results and identified mechanisms that control algae populations above the DWSC can be integrated into a comprehensive watershed model to evaluate land use practices, pollutant control strategies, and water routing operations in the San Joaquin River watershed.

CALFED Statement of Relevance
Algae and its associated oxygen demand entering the Stockton Deep Water Ship Channel (DWSC) has been linked to critically low dissolved oxygen concentrations. The mechanisms controlling algae populations flowing to the DWSC have been identified with field studies and modelling efforts.

SESSION: Low Dissolved Oxygen and Eutrophication in the San Joaquin River: Developing a Scientific Foundation for River Water Quality Management (II), 10/22/2008, 4:40 PM, Rooms 308-310

Holmes[1], R.W., B.S. Anderson[2], B.M. Phillips[2], J.W. Hunt[2], A. Mekebri[3], D.B. Crane[3], V. Connor[4]
[1]CA Dept. Fish and Game - Water Branch, 830, Sacramento, CA 95811
[2]Marine Pollution Studies Laboratory, 34500 Highway 1, Monterey CA 93940
[3]CA Dept. Fish Game - Water Pollution Control Lab, 2005 Nimbus Rd., Rancho Cordova, CA 95670
[4]State Water Resources Control Board, 1001 I Street, Sacramento CA 95814
rholmes@dfg.ca.gov

Statewide Investigation of the Role of Pyrethroid Pesticides in Sediment Toxicity in California's Urban Waterways

A statewide investigation of urban creek sediment toxicity was conducted in recognition of increased incidences of toxicity linked to pyrethroid pesticides. The goals were to examine the spatial occurrence and magnitude of sediment toxicity in California urban creeks, and to examine the role of pyrethroids in toxic urban creek sediment samples. After a preliminary screening of ninety sites, thirty creeks were sampled in eight geographical regions. Sediment toxicity was assessed using 10-d bioassays with the resident amphipod (*Hyalella azteca*). Bioassays were conducted at two test temperatures of 23C and at 15C to provide evidence of the cause of toxicity, and to more accurately reflect ambient environmental temperatures. Twenty-five of thirty samples were toxic when tested at 23C, and all thirty samples were toxic when tested at 15C. The magnitude of toxicity increased in samples tested at 15C suggesting the influence of pyrethroids, which are more toxic at colder temperatures. Pyrethroids were present in all sediment samples and were the only compounds detected at concentrations toxic to *H. azteca*. Bifenthrin was the pyrethroid of greatest toxicological concern, occurring in all 30 samples at concentrations up to 219 ng/g. Pyrethroid contamination of urban creeks was most severe in the Los Angeles, Central Valley, and San Diego regions, respectively. However, pyrethroids were also linked to urban creek aquatic toxicity in all regions sampled, including the less urbanized areas of the North Coast and Lake Tahoe.

CALFED Statement of Relevance
This study evaluated the statewide significance of pyrethroid pesticides and the significance of ambient creek temperatures in assessing the toxicity of pyrethroids on a resident amphipod. The findings provide important information relevant to Water Quality Program objectives.

SESSION: Pesticides: Sources and Toxicity to Aquatic Organisms (I), 10/22/2008, 1:20 PM, Rooms 311-313

Weston[1], D.P., R. Holmes[2], M. Lydy[3]
[1]University of California, Dept. Integrative Biology, Berkeley, CA 94720-3140
[2]California Department of Fish and Game
[3]Southern Illinois University
dweston@berkeley.edu

Residential Runoff as a Source of Pyrethroid Insecticides to Surface Waters

The use of pyrethroid insecticides in urban areas has grown rapidly over the past several years following restrictions on previously widely used insecticides like diazinon and chlorpyrifos. Monitoring has generally shown an improvement in surface water quality with respect to these earlier compounds as their use has diminished, however there has been a concurrent emergence of pyrethroids as a water quality concern. Recent studies have documented the presence of pyrethroids in the sediments of urban creeks at concentrations toxic to sensitive aquatic life, particularly in residential areas, though there has been little study of potential sources. Two residential storm drains in suburbs surrounding Sacramento were monitored over the course of a year to determine if pyrethroids were present at analytically measurable levels. Pyrethroids were measurable in residential runoff, and in fact were present in every sample collected. Although toxicity was not directly evaluated in this study, the thresholds of toxicity to sensitive standard monitoring species were determined, and most samples exceeded these thresholds. Patterns of runoff contamination provided insight on the specific compounds of greatest concern, appropriate monitoring approaches, the dominant transport mechanisms (stormwater vs. lawn irrigation runoff), and specific practices that may be leading to off-site movement of these pesticides.

CALFED Statement of Relevance
There are no data available on the concentrations of pyrethroid insecticides in urban runoff, or even if their measurement is analytically feasible. This presentation demonstrates the feasibility of measuring pyrethroids in runoff from residential areas, and shows the need to do so to protect surface water quality.

SESSION: Pesticides: Sources and Toxicity to Aquatic Organisms (I), 10/22/2008, 1:40 PM, Rooms 311-313

Brander[1], S.M.*, I. Werner[2], L.A. Deanovic[3]
[1]UC Davis, Department of Environmental Toxicology, Bodega Bay Marine Lab, Bodega Bay, CA 94923
[2]UC Davis, School of Veterinary Medicine & Dept. of Anatomy, Physiology, and Cell Biology, One Shields Avenue, Davis, CA 95616
[3]UC Davis, Aquatic Toxicology Laboratory, One Shields Avenue, Davis, CA 95616
smbrander@ucdavis.edu

The Toxicity of a Pyrethroid Mixture to an Amphipod at Environmentally Relevant Concentrations

The pyrethroid pesticides cyfluthrin and permethrin were detected in Sacramento-San Joaquin Delta water in the summer of 2006. In order to gauge the toxicity of pyrethroids at these concentrations, elucidate any additive, synergistic, or antagonistic effects between the two pyrethroids, and to determine whether pyrethroid exposure upregulated heat shock proteins (HSP60 & 70) or reduced total protein content, a ten-day laboratory exposure was performed with 7-14 day-old amphipods (*Hyalella azteca*) in 2007 and again in 2008. In both exposures, cyfluthrin and permethrin were tested both singly and in combination at detected levels, and also at one-half and twice the detected levels. Concurrent treatments were tested with the addition of 25 ppb piperonyl butoxide (PBO), a commonly used pesticide synergist. Mortality in all treatments was significantly higher than controls, with LC50s for permethrin and cyfluthrin with and without PBO at or below levels measured in SSJ Delta water samples. To evaluate the combination treatments from 2007 and 2008 tests, models containing terms for cyfluthrin concentration, permethrin concentration, and presence of PBO as well as models containing all possible combinations of these terms and their interactions were run and compared using Akaikeâ€™s Information Criterion (AICc). The most parsimonious model indicates a pattern of slight antagonism between cyfluthrin and permethrin. Because concentration-based LC50s could not be calculated for the cyfluthrin / permethrin mixture treatments, we used a dilution index to estimate the combined concentrations that would be required to cause a specific proportion mortality. Results from both years indicate that cyfluthrin and permethrin are toxic to amphipods, both individually and in combination, at low pptr (part per trillion) concentrations.

CALFED Statement of Relevance
Determining the extent of the impact of commonly used pyrethroid pesticides and their mixtures on aquatic habitats will contribute to establishing better pesticide regulation and enhanced water quality.

SESSION: Pesticides: Sources and Toxicity to Aquatic Organisms (I), 10/22/2008, 2:00 PM, Rooms 311-313

Nillos, M.G.*, D. Schlenk, J. Gan
University of California, Riverside, Department of Environmental Sciences, 2258 Geology Bldg., Riverside, CA 92521
mnill001@student.ucr.edu

Stereoselectivity in the Estrogenic Effects of Pyrethroid Insecticides in Fish

The occurrence of chirality and its implication on the environmental fate and toxicity of a number of current-use pesticides has increasingly attracted attention in recent years. Among the modern-use pesticides, chirality exists in all pyrethroids. At present, contamination of aquatic ecosystems by pyrethroids is a major environmental concern. Their widespread use in California has resulted in detections in agricultural and urban streams throughout the state. Pyrethroids have been shown to be highly toxic to fish and aquatic invertebrates. Several studies also reported estrogenic activity by certain pyrethroids and their major metabolites. Because biomolecules such as receptors and enzymes are generally stereoselective, enantiomers of the same chiral chemical may have different activities in a number of environmental processes including biotransformation and toxicity. Recent studies have shown that only 1 or 2 enantiomers of the 2 to 8 enantiomers constituting consisting most pyrethroids are acutely toxic to aquatic invertebrates, indicating that their over-all ecotoxicological risk depends on the fate and behavior of the individual enantiomers, rather than the total chemical concentration. Currently, information on the enantioselectivity in biotransformation and estrogenic effects of pyrethroids is still limited. The present study investigated the stereoselective estrogenic activity of pyrethroids, and the potential importance of stereoselective biotransformation in this effect. Chiral selective HPLC techniques were developed and used to prepare enantiopure pyrethroid compounds for biotransformation and toxicity evaluation. Results of the in vivo (Japanese Medaka ELISA) and in vitro (primary rainbow trout hepatocyte) estrogenic activity assays indicate stereoselective estrogenic activity by pyrethroids at levels significantly higher (p ¡Ü 0.05) than the controls. The S- enantiomers of both cis and trans-permethrin were observed to have higher estrogenic activity than the corresponding R- enantiomers. In addition, a dose-related response in the primary hepatocytes was observed for permethrin and cypermethrin metabolites (3-phenoxybenzyl alcohol and 3-(4-hydroxy-3-phenoxy)benzyl alcohol). Interpretation of risks associated with pyrethroid use can clearly benefit from a better understanding of stereoselectivity in their environmental fate and effects. The outcomes of the present study have important implications for many stakeholders including regulators and the agrochemical industry.

CALFED Statement of Relevance
Contamination of aquatic ecosystems by pyrethroids is a major environmental concern. Their widespread use in California has resulted in detections in agricultural and urban streams throughout the state. Among the modern-use pesticides, chirality exists in all pyrethroids. Interpretation of risks associated with pyrethroid use can benefit from a better understanding of stereoselectivity in their environmental fate and effects.

SESSION: Pesticides: Sources and Toxicity to Aquatic Organisms (I), 10/22/2008, 2:20 PM, Rooms 311-313

Connon[1], R.E., J. Geist[2], H. Wintz[3], A.V. Loguinov[3], V. Chris[3], I. Werner[1]
[1]University of California, Davis, School of Veterinary Medicine: Anatomy, Physiology and Cell Biology, Davis, CA 95616
[2]Technische Universität München, Fish Biology Unit, Department of Animal Science, Technische Universität München, D-85350 Freising, Germany
[3]University of California, Berkeley, Nutritional Sciences and Toxicology, Berkeley, California 94720, USA.
reconnon@ucdavis.edu

Molecular Responses in the Delta Smelt (Hypomesus transpacificus), Microarray Assessments of Copper and Esfenvalerate Exposures

The Delta smelt (*Hypomesus transpacificus*) is a pelagic fish species endemic to the Northern California Delta, and considered a major "indicator" for ecosystem health in the Sacramento-San Joaquin watersheds and estuary. Abundance has dramatically declined since the 1980s and it was listed as threatened in 1993, under both the Federal Endangered Species Act (ESA) and California Endangered Species Act (CESA). Delta smelt have been reared since 1992 at the Fish Conservation and Culture Laboratory (FCCL), UC Davis, providing a refuge population as well as a supply for research. Microarrays are increasingly used in ecotoxicology to measure the impact of stressors on organisms, identifying pathways that are altered due to exposure. To better understand the effects of contaminants upon H. transpacificus we constructed a microarray with over 8,000 Expressed Sequence Tags (ESTs). Gene fragments were obtained using a normalized cDNA library of fish exposed to a variety of stressors and ambient water samples. Our initial research focused on two contaminants of concern; esfenvalerate, a pyrethroid insecticide widely used in agriculture and residential pest control, and copper, used to control pests, weeds, and bacterial/fungal diseases. Larval and juvenile delta smelt were exposed to 35 and 50 µgL-1 copper, for 48 h and 7 days, (21- and 60-day old respectively), and to 0.625 and 0.125µgL-1 esfenvalerate, for 24 h (52-day old). Acute effects such as mortality and altered swimming behavior were recorded. We measured gene responses to sublethal concentrations of copper and esfenvalerate and further investigated a suite of responding genes with quantitative PCR. Here we present our information on acute toxicity, and specific differentially expressed genes following copper and esfenvalerate exposure, and suggest how a multi-biomarker approach can be used to measure stress responses and aid the determination of causative factors for the decline in numbers of this species.

CALFED Statement of Relevance
This research is directed towards the development of comprehensive biomarkers on the delta smelt, assessing the impact of delta-bay contaminants.

SESSION: Pesticides: Sources and Toxicity to Aquatic Organisms (I), 10/22/2008, 2:40 PM, Rooms 311-313

Haver[1], D.L., L. Oki[2], S. Bondarenko[2], R. Holmes[3], R. Mazalewski[2], T. Majcherek[2], J. Kabashima[1], I. Werner[4], J. Gan[5]
[1]University of California Cooperative Extension, 1045 Arlington Drive, Costa Mesa, CA 92626
[2]University of California, Dept. of Plant Sciences, MS6, Davis, CA 95616
[3]Water Branch, California Dept. of Fish and Game, 830 S. Street, Sacramento, CA 95811
[4]University of California, Aquatic Toxicology Lab, Davis, CA 95616
[5]University of California, Dept. of Environmental Sciences, Riverside, CA 92521
dlhaver@ucdavis.edu

Detection of Pesticides in Residential Runoff

In a statewide collaborative project characterizing the runoff from single family residences, 4 neighborhoods in Sacramento and Orange Counties were selected for monitoring based on their size, type and age of homes, drainage conditions, and lack of other land-use types. Runoff samples are being collected every 1-2 weeks at drainage outfall sites in those neighborhoods that contain a total of more than 2,000 homes. Runoff samples from the first few storms of the season are also collected. Sample collection began in Sacramento County in July 2006, in October 2006 in Orange County, and will continue through 2008. All samples are analyzed for pesticides that include two organophosphates, eight (8) pyrethroids, and fipronil. In addition, at two of the Sacramento sites toxicity assessments were conducted on a select few samples. Pesticides selected for analysis are those typically used to control ants and termites. Surveys have consistently shown that more than 60% of all pesticides used in urban applications are for ant control. Pyrethroids have been the most widely used materials recently, but the use of fipronil, a newer pesticide, is rapidly increasing. Fipronil is known for its aquatic toxicity to certain aquatic invertebrates. In addition, degradation of fipronil produces three metabolites that all have higher acute toxicities than fipronil. The pyrethroids, bifenthrin, permethrin, and cyfluthrin are consistently found in the runoff samples, with cypermethrin and cyhalothrin detected less frequently. Higher concentrations are found in storm runoff samples than in dry season and non-storm runoff samples as the levels of these pesticides appear to correlate with suspended solid content in runoff water. Although there was 100% survival of *C. dubia* in the samples collected, *H. azteca* suffered 100% mortality.

CALFED Statement of Relevance
Given the increasing use of pyrethroids and fipronil for landscape maintenance and structural pest management, these findings may have significant implications for water quality protection in urban and coastal watersheds.

SESSION: Pesticides: Sources and Toxicity to Aquatic Organisms (II), 10/22/2008, 3:20 PM, Rooms 311-313

Smalling, K.L., J.L. Orlando, M.L. Hladik, K.M. Kuivila
US Geological Survey, 6000 J Street, Sacramento, CA 95819
ksmall@usgs.gov

Fungicides: Changing Use, Occurrence, and Potential Effects on Aquatic Organisms

Fungicides are pesticides designed to control fungal diseases, but tend to be understudied or even ignored during routine monitoring of contaminants in aquatic environments. Chlorothalonil, a broad spectrum fungicide, has been applied for various uses for over 50 years, but recently the use of other new fungicides has been increasing. In California, the registered use of azole and strobilurin fungicides has increased from 90 to 300 thousand kilograms (active ingredient) over the past 5 years. Fungicides are moderately hydrophobic (log Kow 3-4), and are considered to be relatively persistent in water and sediments. Because fungicides are not included in environmental monitoring studies, little is known about their occurrence, transport, and fate in aquatic environments. In this study, water and sediments were sampled from a variety of pesticide-use settings throughout California. Nine fungicides were detected in both water and sediments, including boscalid, chlorothalonil, 5 azoles (cyproconazole, myclobutanil, propiconazole, tebuconazole, tetraconazole), and 2 strobilurins (azoxystrobin and pyraclostrobin). Maximum concentrations of individual fungicides were 850 ng/L in water and 60 µg/kg, dry weight, in sediment. Fungicides were detected throughout California in agricultural drains, urban creeks, rivers, and estuaries, but concentrations were generally higher in areas receiving agricultural inputs. There are limited environmental data available for many of these compounds, and the aquatic toxicity of the newer fungicides, especially in sediment, is still unknown. Additive toxicity should be considered since most samples (water and sediment) contained multiple fungicides with similar modes of action. As the use and occurrence of these newer fungicides continues to increase, it is critical to assess their potential effects on aquatic organisms.

CALFED Statement of Relevance
Current-use pesticides are of concern for the ecological health of the Bay-Delta watershed. As the use of pesticides changes over time, so does their occurrence and effects. This study documents the frequent occurrence of the newer fungicides (azoles and strobiliurins), and identifies the need for corresponding toxicity information.

SESSION: Pesticides: Sources and Toxicity to Aquatic Organisms (II), 10/22/2008, 3:40 PM, Rooms 311-313

Denton[1], D.L., M. Moore[2], J. Wrysinski[3], C. Cooper[2], I. Werner[4], L. Deanovic[4], J. Miller[5], D. Crane[6], M. Williams[7], M. Huddleston[8]
[1]USEPA, 1001 I Street , Sacramento, CA 95814
[2]USDA, Oxford, MS
[3]Yolo RCD, Woodland, CA
[4]UCD, Davis, CA
[5]AQUA-Science, Davis, CA
[6]CDFG, Sacramento, CA
[7]Waterborne, Inc, Leesburg, VA
[8]ENTRIX, Pendleton, SC
denton.debra@epa.gov

Benefits of Vegetated Agricultural Drainage Ditches for Water Quality Improvement

Vegetated agricultural drainage ditches have been proposed as a potential management practice to improve the quality of agricultural runoff waters by reducing both pesticide and suspended sediment loading at edge of farm field. The ditches have been shown to be effective in mitigating simulated pyrethroid runoff storm events in the Mississippi Delta. However, California poses a different scenario in field management practices, winter storm vs. summer irrigation runoff, rainfall intensity, and ditch vegetation and soil types. Farm field demonstrations were conducted to validate the effectiveness of the ditches to reduce pesticides and suspended sediment loadings at the farm level. Results indicate that the vegetated ditch demonstrated a 20% reduction of chlorpyrifos and a 68% reduction of permethrin from an alfalfa and tomato field, respectively. A laboratory mesocosm simulation study was conducted to further evaluate the plant species effectiveness. This practice can be an economical and environmentally successful management practice for landowners a viable on-farm option for water quality improvement.

CALFED Statement of Relevance
Project demonstrates the vegetative BMP as an water quality improvement to reducing concentration of pesticides from edge of farms.

SESSION: Pesticides: Sources and Toxicity to Aquatic Organisms (II), 10/22/2008, 4:00 PM, Rooms 311-313

Rogers[1], M.R.*, W.T. Stringfellow[2]
[1]Department of Civil and Environmental Engineering, UC Berkeley, 69 Glen Suite #101, Oakland, CA 94611
[2]Environmental Engineering Research Program, University of the Pacific, 3601 Pacific Ave, Sears Hall Rm 117, Stockton, CA 95211
mrrogers@berkeley.edu

Sorption of Chlorpyrifos in Vegetated Agricultural Drainage Ditches

Constructed wetlands and vegetated agricultural drainage ditches have been proposed as structural best management practices (BMPs) for the control of non-point source chlorpyrifos in agriculturally dominated watersheds. There are currently several pilot projects examining the applicability of natural treatment systems as agricultural pesticide BMPs in the San Joaquin River Valley, but research is needed to enhance removal. Partitioning processes dominate the short-term fate of chlorpyrifos in aquatic ecosystems. Sorption to soil and aquatic plants has been measured as an important sink for chlorpyrifos, however, sorption to soils of the San Joaquin River Valley and plants used in structural BMPs has not been characterized. Sorption isotherms to three soils and five plants were determined by batch equilibrium technique. Linear partitioning coefficients of whole plant stems (Kd = 571.1 to 1303.4 Lâˆ™kg-1) was more than 10 times higher than for soil (Kd = 40.0 to 71.4 Lâˆ™kg-1). Chopped plant material had Kd values 7.6 to 96.2 percent greater than whole stems. Wetland plants with high internal surface area due to porous tissues had greater linear partitioning coefficients than terrestrial plants with a hollow tubular structure. Chlorpyrifos sorption reached a pseudo-equilibrium in less than 8 hours, more rapidly than the reaction rates for biotic or abiotic degradation reactions. While sediment-associated chlorpyrifos is a small portion of total chlorpyrifos in the water column, but plant biomass provides greatly increased surface area for enhanced adsorptive removal. Plants with higher adsorptive capacity and growth density should be chosen to optimize chlorpyrifos removal in BMPs. Partitioning to plant surfaces in natural treatment systems is an important mechanism in vegetated agricultural drainage ditches for mitigating peak concentrations of chlorpyrifos in irrigation or stormwater, allowing time for attenuation by slower degradation reactions.

CALFED Statement of Relevance
Measurements of the pesticide adsorptive capacity of soils and plants to be used in structural BMPs aids in the selection of optimal sites and plant communities to achieve removal objectives for improved water quality and reduced stress in zooplankton and insect communities for improved ecosystem health.

SESSION: Pesticides: Sources and Toxicity to Aquatic Organisms (II), 10/22/2008, 4:20 PM, Rooms 311-313

Werner[1], I., L.A. Deanovic[2], J. Wrysinski[3], P. Robbins[3], D. Denton[4], J. Miller[5]
[1]UC Davis, Aquatic Toxicology Laboratory, Davis, CA 95616
[2]Aquatic Toxicology Laboratory, UC Davis, Davis, CA
[3]Yolo County Resource Conservation District, Woodland, CA
[4]US EPA Region 9, Sacramento, CA
[5]AquaScience, Davis, CA
iwerner@ucdavis.edu

Effectiveness of Vegetated Agricultural Ditches in Removing Pesticide Toxicity from Irrigation Runoff from Tomato and Alfalfa Fields in Yolo County, California

This study was performed to test the hypothesis that vegetated drainage ditches may reduce the toxicity of agricultural irrigation runoff on aquatic organisms. Runoff toxicity from three fields (tomato, alfalfa) was monitored using a continuous flow in situ exposure apparatus containing larval fathead minnow (*Pimephales promelas*), and juvenile amphipods (*Hyalella azteca*), located at the top and bottom of the ditches. An identical control system was set up with laboratory control water. Organism survival was recorded every two hours. When irrigation runoff ended (or after 12 h), surviving organisms were transported to the laboratory and held under control conditions for the remainder of the 48-h experimental period. Sediment samples were collected before and after irrigation runoff occurred and tested using *H. azteca*. Results show that irrigation runoff was not toxic to larval fathead minnow during the exposure period. However, runoff from all three fields was highly toxic to *H. azteca*. Our results indicate that toxicity of irrigation runoff from an alfalfa field and concentrations of the organophosphate insecticide chlorpyrifos were reduced after passage through the vegetated ditch. The toxicity of irrigation runoff from tomato fields treated with pyrethroids was not reduced after passage through the vegetated ditch, in part potentially due to release of toxic contaminants from the ditch itself. Toxicity of ditch sediments increased with time after runoff ended at two sites, while sediments from one site were highly toxic to *H. azteca* before and after the runoff event.

CALFED Statement of Relevance
This study provides important information on the effectiveness of vegetated ditches as a best management practice for removing insecticide toxicity from irrigation runoff.

SESSION: Pesticides: Sources and Toxicity to Aquatic Organisms (II), 10/22/2008, 4:40 PM, Rooms 311-313

Edwards[1], K.P., K.A. Rose[2], W.J. Kimmerer[3], W.A. Bennett[4]
[1]National Centre for Ocean Forecasting, Met Office, Exeter, UK, EX1 3PB
[2]Louisiana State University, Baton Rouge, LA 70803
[3]Romberg Tiburon Center for Environmental Studies, Tiburon, CA 94920
[4]Bodega Marine Lab, Bodega Bay, CA 94923
karen.edwards@metoffice.gov.uk

Delta Smelt Population Dynamics I: Development of a Spatially-explicit, Individual-based, Full-life Cycle Model

Delta smelt (*Hypomesus transpacificus*) has become the focus of attention due to its long-term decline and its more recent decline as part of the pelagic organism decline (POD). To address some of the questions related to the causes for the decline, we developed an individual-based population dynamics model. The model tracks thousands of individuals on the same spatial grid as used by Department of Water Resource's DSM2 hydrodynamics model. A coarser set of spatial boxes is superimposed on the spatial grid for outputting and analyzing field data. Daily water temperature, salinity, turbidity, and the densities of eleven zooplankton prey types are represented on the spatial grid. The model follows the reproduction, growth, mortality, and movement of individuals over their entire life cycle. Reproduction is evaluated daily and egg cohorts are tracked until hatching. New model individuals are introduced as individual yolk-sac larvae. Growth of later stages is based on bioenergetics and zooplankton densities. Mortality includes a constant rate plus mortality due to starvation, turbidity, and entrainment. Movement of individuals is particle tracking for the larval stages and behavioral for juveniles and adults. We first calibrated growth and mortality rates using conditions for 1999, which we judged to be a relatively good recent year for delta smelt. We then compared four 15-year simulations that each started with a 3-year spin-up of 1999 conditions: 1999 repeated, 1995 to 2005, the worst year from this period (2002) repeated, and 2005 to 1999 (i.e., reverse historical order). These simulations are being refined, but preliminary results suggest that the decline was due conditions that have progressively gotten worse for delta smelt. In a companion paper, Kimmerer et al. describe the results of using the model to examine the relative influence of historical changes in food, entrainment, turbidity, and female size on delta smelt population dynamics.

CALFED Statement of Relevance
Increased understanding of how environmental conditions and pumping-related entrainment affect delta smelt population dynamics will inform the ecosystem restoration objective of restoring and protecting the habitats of native species. The modeling can be used to filter the many possible management actions that could be taken to help identify effective and efficient options from an ecological perspective.

SESSION: Modeling (I), 10/22/2008, 1:20 PM, Room 314

Kimmerer[1], W.J., K.A. Rose[2], K. Edwards[3], W.A. Bennett[4]
[1]San Francisco State University, Romberg Tiburon Center, Tiburon, CA 94920
[2]Louisiana State University, Baton Rouge, LA 70803
[3]National Centre for Ocean Forecasting, Exeter Devon EX1 3PB United Kingdom
[4]Bodega Marine Lab, UC Davis, P.O Box 247, Bodega Bay, CA 94923
kimmerer@sfsu.edu

Delta Smelt Population Dynamics II: Preliminary Results of Simulations with an Individual-Based Model

The long-term decline in abundance of delta smelt, *Hypomesus transpacificus*, has prompted investigations of this species including monitoring, laboratory studies, and statistical analyses of trends and environmental influences. It is clear that multiple factors are affecting the trajectory of delta smelt. Simulation modeling is a suitable method for distinguishing the magnitudes of these different effects, and the available data on this species provides an excellent basis for modeling. We have developed an Individual-Based Model (IBM) of the population of delta smelt in the San Francisco Estuary. This model tracks fish through each life stage over multiple years, using the output from a hydrodynamic model (DSM2) to provide flow conditions, and field measurements of salinity, temperature, turbidity, and zooplankton abundance to provide other environmental conditions. The baseline model is described in the companion paper by Edwards et al. Here we present results of simulations designed to investigate the effects of environmental variation on the long-term population trajectory. The simulations are designed to isolate the effects of single environmental influences by contrasting model behavior with alternative levels of each condition. These include: 1) food, in which pre-1987 and post-1993 conditions are contrasted; 2) direct losses at the export facilities, in which 100% mortality of fish at the facilities is contrasted with 100% successful salvage and return to the estuary; 3) reductions in turbidity, which affects feeding success and mortality; and 4) the joint effect of female size at spawning, fecundity, and export pumping on production of young fish. Simulations indicate that all of these factors have an effect on delta smelt. Future simulations will examine how sampling may obscure these effects, and potential effects of alternative management scenarios.

CALFED Statement of Relevance
Increased understanding of how environmental conditions and pumping-related entrainment affect delta smelt population dynamics will inform the ecosystem restoration objective of restoring and protecting the habitats of native species. The modeling can be used to filter the many possible management actions that could be taken to help identify effective and efficient options from an ecological perspective.

SESSION: Modeling (I), 10/22/2008, 1:40 PM, Room 314

Sridharan, V.*, D.A. Fong, S.G. Monismith, J.L. Hench
Environmental Fluid Mechanics Laboratory, Department of Civil and Environmental Engineering, Stanford University, Y2E2 Building, Room M18, Stanford, CA 94305
vamsiks@stanford.edu

Delta Smelt Modeling Project: The Development of a Particle Tracking Model to Study Discontinuous Scalar Fields in the Delta

A particle tracking model (PTM) has been developed in FORTAN 95 to study the effects of hydrodynamics on the transport of Delta Smelt eggs and larvae in the Sacramento – San Joaquin delta. The system under consideration is treated as a 1–D network of 3–D channels. The advection and the random walk based cross–channel and vertical diffusion are solved using the fourth order Runge–Kutta (RK–4) time marching scheme. The model uses stages and flows in the grid of the Delta obtained from DWR's DSM2–HYDRO 1–D tide solver. The PTM incorporates the ability to model a large number (~O(1 million)) of particles, non-prismatic geometries through different effective cross–sections within channels at different times, a completely mixed flow reactor model for reservoirs in order to recover the residence times, and includes two models of achieving mixing at the grid nodes by either randomly mixing and reassigning particles to different channels, or by tracking the streamlines of the particles. In addition, the PTM models gates and agricultural and consumptive use diversions by dynamically removing particles from the domain. This model is an update to the existing DWR PTM written in JAVA, which can only model about 5000 particles and lacks the aforementioned features. The movement of Delta Smelt eggs and larvae are studied during different water years from 1990 to 2006. As Delta Smelt are affected adversely by gate operations, a detailed sensitivity analysis of the role of the gates, particularly the Delta Cross Channel will be discussed. In order to understand the role of mixing at channel confluences, and to accurately determine the effective dispersion of discontinuous scalars in the delta, the two models of nodal mixing will be compared and discussed.

CALFED Statement of Relevance
A more capable PTM than the existing Java-based PTM will improve understanding of how environmental conditions and pumping-related entrainment affect Delta Smelt population dynamics. This model, coupled with DSM2 and our collaborators' Individual Based Model, will inform the ecosystem restoration objective of restoring and protecting the habitats of native species.

SESSION: Modeling (I), 10/22/2008, 2:00 PM, Room 314

Sitts[1], R., P. Unger[2], B. Adams[3], A. Huber[3], B. Manly[4]
[1]Metropolitan Water District of Southern California, 1121 L St., Suite 900, Sacramento, CA 95814
[2]WaterWise Consulting, Sacramento, CA
[3]ICF/Jones & Stokes, San Antonio, TX
[4]Western Ecosystems Technology, Inc., Laramie, WY
rsitts@mwdh2o.com

Modeling Effects of Water Project Operations on Delta Smelt Abundance

Population effects of pumping restrictions imposed in December 2007 by Judge Wanger to protect delta smelt from losses at the Delta export pumps, and the associated water costs, were evaluated to see what difference they might make to the population and at what water costs. We estimated effects and costs with a delta smelt population model that was integrated with hydrologies with and without these restrictions. Losses at the pumps are based on equations predicting daily salvage of adult delta smelt, or the percent of the larval/juvenile population near the pumps. We adjusted losses with life-stage-specific survival rates developed from agency field survey data, and with year-specific larval/juvenile survival rates. The difference between historic and restricted exports during December-June exports is the water cost. Results depend on assumptions for sampling efficiencies, seeding, flows and other specifications. For a 1996-2005 run, modeled increases in abundance predictions among years for juvenile delta smelt ranged from 0 to 14M (26%), while water costs ranged from 234 to 1,720 taf, depending on the year; however, considerable uncertainty is involved. Thus, population modeling indicates in some cases and with some uncertainty, potential increases in delta smelt abundance and water cost given a specified flow regime.

CALFED Statement of Relevance
Relevance lies in relating water supply reliability to ecosystem restoration, especially in regard to evaluating potential benefits for listed fish species of changes in water project operations in the Delta, particularly through quantitative tools.

SESSION: Modeling (I), 10/22/2008, 2:20 PM, Room 314

Satterthwaite[1], W.H., M. Beakes[2], E. Collins[3], D. Swank[2], J. Merz[4], R. Titus[3], S. Sogard[2], M. Mangel[1]
[1]UC Santa Cruz, Applied Math and Statistics, Santa Cruz, CA 95064
[2]National Marine Fisheries Service
[3]California Department of Fish and Game
[4]Cramer Fish Sciences
satterth@darwin.ucsc.edu

Insights from A State Dependent Model of Steelhead Life History

Steelhead/rainbow trout (*Oncorhyncus mykiss*) are a falcutatively anadromous, potentially iterporarous species with a highly variable life history. This highly plastic life history presents management challenges, particularly with regards to conserving life history diversity and predicting the demographic impacts of altered life histories. We use a state-dependent life history model to predict the effects of changes in the juvenile growth environment on steelhead life histories, and applied this model to data collected on the lower American and Mokelumne Rivers. We characterize optimal state-dependent strategies as a function of fish size and growth rate during decision windows preceding the actual smolting and spawning events, allowing the identification of threshold sizes and growth rates at which fish are predicted to adopt alternate life history pathways. Using these thresholds, we predict the strategies taken by individual fish growing along trajectories in the current and in altered growth environments. We predict that under current conditions, all lower American River steelhead will smolt as 1 year old fish; scale analysis of returning spawners suggests that over 90% emigrated at age 1, and we have no evidence for resident fish in this system. For the Mokelumne River, we both predict and observe a mix of resident and anadromous fish. We can use this model to predict the short- and long-term impacts on life history diversity of changes in the juvenile growth environment that might be caused by various water management decisions. Over the short-term, we predict that changes in growth rate can easily change the mix of life histories in a river such as the Mokelumne but larger changes would be required to change life histories in the lower American. Over the long-term, we predict that maintaining passage for emigrating and returning fish is most important for the preservation of anadromy.

CALFED Statement of Relevance
Our model provides predictions of the impacts changes in river conditions will have on the diversity of life histories displayed by steelhead/rainbow trout.

SESSION: Modeling (I), 10/22/2008, 2:40 PM, Room 314

Alexander[1], C.A., D.R. Marmorek[1], R. Luster[2], M. Roberts[3]
[1]ESSA Technologies Ltd., 1479 Aspen Court, Kelowna, BC Canada, V6J 5C6
[2]The Nature Conservancy, 500 Main St., Chico, CA 95928
[3]The Nature Conservancy, Salt Lake City, UT 84102
calexander@essa.com

The Sacramento Ecological Flows Tool (SacEFT): Ecological Modeling to Support River Management Decisions that Meet Multiple Objectives

Water planning efforts on Sacramento River currently consider few ecosystem components, such as maintaining minimum in-stream flows and temperature requirements, or influencing Delta exports to reduce entrainment losses. Most of these in-stream flows have been developed with a focus on few species. Results of the Sacramento River Ecological Flows Study (the "Study"), a 3-year study initiated by The Nature Conservancy (TNC) and partners, are now available (www.delta.dfg.ca.gov/erp/sacriverecoflows.asp). The Study synthesizes two decades of restoration work by TNC and its partners in the riparian corridor of the Sacramento River from Keswick Dam to Colusa. The Sacramento Ecological Flows Tool (SacEFT) component of this project links management actions (flow, water temperature, gravel, and channel revetment) to the habitats for six focal species (chinook salmon, steelhead, green sturgeon, western pond turtle, bank swallow, and Fremont cottonwood), with the objective of improving the ecological value of water operations. The system leverages existing physical datasets from accepted planning tools like CALSIM-SRWQM-HEC5Q rather than reinventing wheels, and selectively "builds-in" functional relationships for focal species performance measures. SacEFT can provide guidance on both target flows (to maximize ecological benefits) and avoidance flows (to minimize negative consequences), bracketing the range of discharges to be evaluated experimentally. Ultimately, the long-term goal is to work with leaders in water planning forums to continue the development of SacEFT to best meet the needs of these groups. SacEFT provides for multiple levels of communication of information ranging from simplified multi-year rollups for managers and decision-makers to in-depth displays of functional relationships and within-year variation for review by technical experts.

CALFED Statement of Relevance
SacEFT permits managers and technical scientists to greatly extend the ecological considerations used in management decisions along the Sacramento River between Keswick and Colusa, including such projects as Sites Reservoir and raising Shasta Dam. This is consistent with CALFED's Ecosystem Restoration Plan recommendation to restore the variability of the flow regime and associated river processes "as an important component of restoring ecological function and supporting native habitats and species in the Bay-Delta ecosystem."

SESSION: Modeling (II), 10/22/2008, 3:20 PM, Room 314

Turner, C.R., P.S. Bergman, B.J. Cavallo
Cramer Fish Sciences, 126 East Street, Auburn, CA 95603
cturner@fishsciences.net

The IOS Model: A Simulation Tool for Salmonid Conservation and Water Supply Management

Effective conservation and management of natural resources requires simultaneous consideration of multiple factors to inform policy decisions. This process is often complex and benefits from modeling approaches that integrate disparate effects. However, the utility of any model as a management tool depends on its transparency to users. To address the conservation needs of a federally endangered winter-run Chinook population on the Sacramento River we developed a life cycle model that integrates environmental and anthropogenic effects across different salmon life stages. It was designed to receive hydrologic data produced by the CalSim-II Water Resources Planning Model and related temperature models. The salmonid life cycle model was constructed in a software platform that allows users to easily examine and/or adjust the model structure, functional relationships, and assumptions. Results of testing in historical simulations demonstrate the model's ability to accurately reproduce past population trends at both adult and juvenile life stages. Results of testing in non-historical simulations demonstrate the model's ability to respond appropriately to environmental and anthropogenic changes. Results of simulations to evaluate proposed CVP/SWP management scenarios demonstrate the model's utility for informing water policy decisions. The transparent model platform provides a user-friendly interface while facilitating continued improvement of the management tool by allowing reviewers to examine all aspects of the model. This model, the Interactive Object-oriented Salmonid Simulation (IOS) model, represents an important advance in the management strategy for salmonids in the Sacramento River system. The IOS model builds on advances made with other salmon models and provides a tool that performs well using the best available science, facilitates user understanding, and can be readily adapted to incorporate new data or address new management scenarios.

CALFED Statement of Relevance
The Interactive Object-oriented Salmonid Simulation (IOS) model is a new tool to assist conservation efforts for native salmonids and to help water managers effectively balance ecosystem and water supply needs.

SESSION: Modeling (II), 10/22/2008, 3:40 PM, Room 314

Schwartz[1], P.O., E.S. Ateljevich[2], P. Colella[1], Q. Shu[2]
[1]LBL, 1 Cyclotron Rd, Berkeley, CA 94720
[2]DWR, 1416 Ninth St, Sacramento, CA 95814
poschwartz@lbl.gov

REALM: Large, Multi-scale Flow Modeling for Decision Support in the Bay-Delta

Water resource management in the Sacramento-San Joaquin Delta increasingly requires hydrodynamic and water quality simulation over large, multi-scale domains with complex geometry over a variety of hydrologic conditions. REALM is a high performance, parallel, adaptive model amenable to emerging flood and climate change applications involving moving boundaries. We present our 2D hydrodynamic model for a shallow water estuary that is designed for multi-processor computation using a Cartesian mesh, embedded boundaries (Cartesian cut cells) to conform to bathymetry and the natural boundaries of the system, and adaptive mesh refinement (AMR) for efficient handling of multi-scale problems. The Cartesian solver is based on a second order Godunov algorithm with a Corner Transport Upwind correction of fluxes. We present the formulation of our model, testing results, geometry processing techniques and an application in the Bay Delta. We also describe the institutional setting in which we intend to use and further develop the model and how this affects our design. Collaborators at UC Berkeley are working on data assimilation using the model. In the future, our work will be extended to moving boundary problems such as intertidal wetting and drying and flooding, particle transport and three dimensional modeling.

CALFED Statement of Relevance
REALM is a computational model being developed for decision support in the Bay-Delta. It represents a significant advance in computational technique and architecture, and is being developed for the region that is of greatest direct interest to CALFED. We are also working directly on decision support tools for the model that are particularly relevant to this years themes.

SESSION: Modeling (II), 10/22/2008, 4:00 PM, Room 314

Zamora, C., C.R. Kratzer, S.P. Phillips, P.D. Dileanis
U.S. Geological Survey, 6000 J Street, Sacramento, CA 95819
czamora@usgs.gov

Estimating Ground-water Accretions to the Lower San Joaquin River, California using Heat Flux and MODFLOW

Ground water may be a significant source of nitrate to the San Joaquin River (SJR), which contributes to algae growth and low dissolved oxygen in the Stockton, California deep water ship channel. Previous studies have estimated ground-water inputs to the SJR on the order of 1-3 ft3/second/river mile, which could account for up to 15 percent of downstream flow during the summer. However, there is a paucity of information concerning the chemical composition of ground-water accretions in the lower SJR. As a result, the importance of ground-water inputs to downstream chemical loads is not known. The objective of this study is to quantify both the amount of ground water entering the lower SJR, and the associated ground-water nitrate load. The study area is a 60-mile reach of the SJR from the confluence with Salt Slough to Vernalis. Nested monitoring wells on both banks at three sites monitor water levels for modeling ground-water inputs. At each of these sites, two-dimensional steady-state flow models representing vertical cross-sections orientated perpendicular to flow were created using the U.S. Geological Survey (USGS) modular finite-difference ground-water flow model (MODFLOW). Additionally, temperature is used as a tracer to estimate rates of exchange between the SJR and ground water. Paired in-stream monitoring wells screened at two depths (approximately 5-7 and 20-28 ft.) below the streambed at six sites continuously monitor water levels and temperature above and below the sediment-water interface. Measured temperature and water-level data constrain the upper and lower boundary conditions for a numerical model of the streambed using the USGS Variably Saturated 2-Dimensional Heat (VS2DH) model. VS2DH uses an energy transport approach by way of the advection-dispersion equation to simulate the transport of heat and water. All monitoring wells are sampled monthly and analyzed for nitrate concentration to provide temporal data on associated nitrate loads.

CALFED Statement of Relevance
This study is relevant to the objectives of both the Water Quality and Ecosystem Restoration programs. The findings of this study will advance the understanding of sources and processes involved with the occurrence and transport of nitrate (ultimately affecting dissolved oxygen) in the lower San Joaquin River watershed.

SESSION: Modeling (II), 10/22/2008, 4:20 PM, Room 314

MacWilliams, M.L., E.S. Gross
Environmental Consultant, PO Box 225174, San Francisco, CA 94122
michael@rivermodeling.com

Three-Dimensional Hydrodynamic Simulations of San Francisco Bay and the Sacramento-San Joaquin Delta

Three-dimensional processes play an important role in the transport of salt and organisms in San Francisco Bay and the Sacramento-San Joaquin Delta. Important three-dimensional processes include gravitational circulation, lateral mixing due to secondary circulation, and wind driven circulation. One-and two-dimensional models typically rely on the calibration of dispersion coefficients to parameterize these processes, however these coefficients may not be appropriate under changing conditions in the Delta resulting from sea level rise, levee failures, channel deepening, or changes to Delta conveyance. As a result, there is an increasing need for a high resolution three-dimensional hydrodynamic model which is suitable for detailed assessment of the potential impacts of complex future changes which are likely to occur in the Sacramento-San Joaquin Delta. As part of the Pelagic Organism Decline (POD) program, the three-dimensional unstructured UnTRIM Bay-Delta model developed for the Delta Risk Management Strategy (DRMS) project has been extended throughout the entire Sacramento-San Joaquin Delta as part of a project funded through the California Department of Water Resources. The resulting model encompasses the entire San Francisco Estuary, from the coastal Pacific Ocean at Point Reyes through the entire legal Delta. The UnTRIM model is an ideal three-dimensional model for simulations in the Sacramento-San Joaquin Delta due to the flexible grid structure allowed by the model, similar to the grid structure of finite element models, and the highly efficient and stable finite difference numerical method and matrix solver of UnTRIM. This combination of flexibility and efficiency allows the model to use high resolution where it is needed to accurately describe the bathymetry of small Delta channels, while using coarser resolution in other portions of the Bay and coastal ocean. The resulting UnTRIM Bay-Delta model is suitable to predict a large range of processes including hydrodynamics, sea level rise, salt intrusion, movement of organisms and sediment transport. The UnTRIM model has been coupled with a particle tracking model and applied to help increase the current level of understanding of the Pelagic Organism Decline (POD) in the Delta. The three-dimensional unstructured grid model (UnTRIM) of San Francisco Bay and the Sacramento-San Joaquin Delta was developed and calibrated to resolve water levels, salinity, and flows throughout San Francisco Bay and the Sacramento-San Joaquin Delta. The model results have been used to assess the transport of particles and tracers throughout the Delta, and to increase the understanding of hydrodynamics, flow pathways, mixing at junctions and in open water bodies, and residence time in Clifton Court Forebay. Ongoing efforts include evaluating the impact of alternative Delta operations on entrainment in the South Delta. This application of UnTRIM provides the first fully three-dimensional model which extends from the Pacific Ocean through the entire Sacramento San-Joaquin Delta. The results demonstrate the importance of three-dimensional processes in flow and transport in the Sacramento-San Joaquin Delta. This model is suitable for detailed studies of Delta hydrodynamics, including but not limited to: Investigating the potential impacts of sea level rise or channel deepening on salinity intrusion into the Delta; Predicting salt entrainment into the Delta resulting from Delta levee failure(s); Evaluating the three-dimensional effects which impact the effectiveness of flushing flows aimed at pushing salt out of the Delta; Assessing the suitability alternative conveyance strategies for Delta water supply; and Quantifying potential impacts of alternative conveyance strategies on Delta hydrodynamics and water quality.

CALFED Statement of Relevance
The Pelagic Organism Decline program (POD) is part of the Interagency Ecological Program (IEP) which is part of the CALFED Science program. The hydrodynamic and particle tracking models described in this presentation are being applied to allow refinement of hypothesis to explain the observed decline of pelagic organism populations.

SESSION: Modeling (II), 10/22/2008, 4:40 PM, Room 314

Whitton, K.S., J.M. Newton
U.S. Fish and Wildlife Service - Red Bluff FWO, 10950 Tyler Road, Red Bluff, CA 96080
kellie_whitton@fws.gov

Rotary Screw Trap Efficiency Trials: Can Hatchery Fish be used as Surrogates for Naturally Produced Chinook Salmon?

Rotary screw traps are widely used to estimate downstream passage of juvenile salmonids in tributaries to the Sacramento River and rivers throughout the Pacific Northwest. However, estimating the downstream passage of naturally produced Chinook salmon can be difficult when insufficient numbers are available to conduct mark-recapture trials to estimate trap capture efficiency. Hatchery produced Chinook salmon are often used as surrogates with little or no testing for behavioral differences, which may affect the results of mark-recapture trials. To determine whether behavioral differences may preclude or limit the use of hatchery fish as surrogates in Battle Creek, a tributary to the Sacramento River, we conducted paired mark-recapture trials at various flows using hatchery and naturally produced fall-run Chinook salmon. Trap efficiency of naturally produced Chinook salmon was higher in 14 of 19-paired trials. Standard t-test results showed trap efficiencies were significantly different between groups (P=0.029). Mean trap efficiency was 2.9 and 3.9% for hatchery and naturally produced Chinook salmon, respectively. To explain apparent differences in trap efficiency, we explored a variety of biological and environmental variables. Preliminary analyses suggest that flow at the time of release and fork length influenced trap efficiency of hatchery fish, but no single variable appeared to strongly influence trap efficiency of naturally produced Chinook salmon. Passage estimates for spring-run Chinook salmon on Battle Creek would have been 28% higher if they were calculated using hatchery rather than naturally produced weekly trap efficiencies. Our study was conducted during a low-flow year; therefore, we recommend this study be continued a second year to ensure complete coverage of the flow-range over which the trap can be operated. We conclude that hatchery fish should not be used as surrogates in other areas without first testing to determine whether trap efficiencies for hatchery and naturally produced Chinook salmon are similar.

CALFED Statement of Relevance
Exploring methods that may reduce our impacts to threatened salmonids as well as improve the accuracy of our passage estimates is critical for adaptive management. This study is funded by CALFED and is linked to the Battle Creek Salmon and Steelhead Restoration Project, an Ecosystem Restoration Program (ERP) monitoring project.

SESSION: Salmon Management, 10/23/2008, 8:20 AM, Room 306

Ericksen, R.P., S.P. Cramer
Cramer Fish Sciences, 600 NW Fariss Rd, Gresham, OR, 97030
ericksen@fishsciences.net

Weak Stock Ocean Fishery Management: What Does it Mean to Central Valley Chinook?

We review CWT and genetic stock identification data to determine which Chinook stocks are caught off California and how their distribution affects ocean fishery management and Central Valley Chinook stocks. Ocean fisheries off California and Oregon are managed on a weak stock basis, where harvest is allowed only to the point that the weakest stock is projected to meet its conservation and allocation objectives. With the collapse of Central Valley Chinook returns in 2007, fisherman are faced with the possibility that little or no ocean salmon fishing will be allowed in California and Oregon for the next several years. A similar collapse of the Klamath River Chinook stock resulted in a $60.4 million disaster relief fund appropriation to affected communities in 2006, and relief funds are expected to be far greater for 2008. Recoveries of CWTs show that stock distributions vary annually, and sometimes result in substantial harvest outside of protected zones. By marking all hatchery fish and restricting harvest to marked fish only, the dependence could be reduced on time-and-area closures that sometimes miss align with the stocks targeted for protection. New data indicates that up to 90% of Chinook in the ocean off California are hatchery fish, so most fish captured could be retained. Given the observed ocean populations of Chinook during 2001-2007, assuming 80% of fish were hatchery origin, and allowing harvest seasons that would have captured 60% of those marked hatchery fish, the total landings of Central Valley Chinook would have increased by an average 120,000 fish annually, while escapements of natural-origin spawners would have increased by about 30,000 fish annually. Further, the frequency and magnitude of harvest cutbacks, which have frequently been implemented to protect weak stocks, could be substantially reduced.

CALFED Statement of Relevance
Fish Protection - We evaluate management strategies to protect fish populations through new fishery management strategies

SESSION: Salmon Management, 10/23/2008, 8:40 AM, Room 306

Cramer[1], S.P., R. Sitts[2]
[1]Cramer Fish Sciences, 600 NW Fariss Rd, Gresham, OR, 97030
[2]Metropolitan Water District
stevec@fishsciences.net

Harvest the Hatchery Fish: A Promising Recovery Strategy for ESA Listed California Chinook Salmon

We address the problem of how to recover listed wild Central Valley Chinook salmon while providing Chinook fishing opportunities, especially in the face of Chinook declines on the Sacramento and Klamath Rivers. An option useful in other regions but untried in California is mark-selective fisheries, in which all hatchery Chinook receive a readily discernable mark (e.g., adipose fin removal) and can be retained in commercial and sport fisheries, while unmarked (natural-origin) fish are returned to the ocean. We estimated potential changes in harvests and natural spawner abundances (escapements) under mark-selective fisheries (using simulations for Sacramento River winter spring Chinook salmon. We simulated a number of restoration strategies, and found that mark-selective fisheries resulted in far greater future gains in wild spawner abundances of winter and spring Chinook, while at the same time allowing harvests of up to several hundred thousand hatchery Chinook. For example, simulation of population growth for winter-run Chinook indicated that spawner abundance would increase by 6% within 30 years if all take of winter-run smolts at the Delta export pumps were eliminated, but would increase 90% if mark-selective fisheries were implemented in the ocean. From a coast-wide perspective, mark-selective fisheries in California may provide a flexible and cost-effective management tool for maintaining fisheries while accelerating the recovery of ESA-listed stocks. Although costs to implement mass marking and monitor the fisheries are substantial, analyses of cost effectiveness indicate this strategy will produce the highest return-on-investment of any restoration strategy under consideration for Central Valley Chinook.

CALFED Statement of Relevance
Fish Protection - We evaluate management strategies to protect fish populations through new fishery management strategies

SESSION: Salmon Management, 10/23/2008, 9:00 AM, Room 306

Cavallo[1], B.J., D.P. Lee[2]
[1]Cramer Fish Sciences, 126 East Street, Auburn, CA 95603
[2]Fishery Management Consulting, PO Box 2244, Folsom, CA 95763
bcavallo@fishsciences.net

Central Valley Salmonid Hatcheries: Fish factories or tools to facilate recovery and conservation of ESA species?

Five Central Valley (CV) salmon hatcheries mitigate for habitat lost to dam construction and water diversions. Collectively, these hatcheries annually produce more than 31 million juvenile fall-run Chinook salmon. During recent decades, fall-run Chinook populations have fluctuated dramatically, and the most recent decline (2008) necessitated closure of major California commercial and recreational fisheries. The high economic and intrinsic value of CV salmon emphasizes the need for effective, science-based hatchery monitoring and management. The recent development of Hatchery and Genetic Management Plans (HGMP) for some CV hatcheries, along with emerging research on hatchery effects, highlights the need for increased focus on how hatcheries are contributing to the recovery or decline of CV Chinook stocks. Our HGMP reviews found that additional consideration with regard to how CV hatcheries may affect wild origin stocks is warranted. More importantly, managers have not considered hatchery practices or strategies by which negative hatchery effects may be minimized. For example, 100% external marking of hatchery fish would make it possible to protect wild origin fish from harvest, simplify restoration project assessment, and allow introgression between wild and hatchery stocks to be minimized. Yet 100% external marking of hatchery fish is not presently an action advocated by CV salmon managers. Properly managed, financially supported, and performance accountable hatcheries could (and should) serve as key data sources and management tools to aid the in the recovery ESA listed CV salmonids.

CALFED Statement of Relevance
Anadromous fish hatcheries are central, but often overlooked, components of the Sacramento-San Joaquin ecosystem. This presentation summarizes findings from recent reviews of Central Valley salmon hatcheries as it relates to how monitoring and management can facilitate resource efficient recovery of ESA salmonid species.

SESSION: Salmon Management, 10/23/2008, 9:20 AM, Room 306

Kormos, B.J., A. Grover
California Department of Fish and Game/PSMFC, 475 Aviation Blvd Suite 130, Santa Rosa, CA 95403
bkormos@dfg.ca.gov

Age-Specific Escapement for Chinook in California's Central Valley

In past years the Central Valley Index (CVI) was used as an indicator of the abundance of all Central Valley Chinook. The CVI was a sum of ocean harvest south of Point Arena and escapement for all Central Valley Chinook adults in the same year. Until recently, management of Central Valley Fall Chinook relied upon the accuracy of this abundance estimate. As of 2007, a new index called the Sacramento Index now specifically estimates abundance of Sacramento Fall Chinook. Length-frequency derived estimates of jack escapement from the previous year are used to forecast the following year's index of ocean abundance. While this method is an improvement over the CVI, it is not age specific, and a more accurate and comprehensive estimate of overall escapement and abundance at age is needed. Through scale aging, this study produces age structured hatchery and natural escapement estimates for all principal reaches in the Central Valley. Sampling methods employed by hatcheries and escapement surveys reflect spatial and temporal differences among fish present throughout the escapement periods. State of the art digital imaging and reading techniques are being used. A modified maximum likelihood estimator based on the work of Kimura and Chikuni (1987) is being utilized. This method uses known aged coded wire tagged (CWT) scale samples in conjunction with those of unknown aged (non-CWT) fish to create bias-corrected age specific estimates of escapement for each major reach and run in the Central Valley. This statistical approach allows for reader assigned ages of CWT fish to validate those of non-CWT fish by using reader accuracies to assign bias corrected age specific proportions to the overall escapement estimates. While actual cohort reconstructions will require estimates from future escapement years, preliminary results indicate differences in the age structure of hatchery and natural escapements. In addition results of this study have shown that scale aging is a valid method for deriving age specific escapement, however it can be difficult during poor escapement years. In accordance with the CALFED Ecosystem Restoration Program directed actions, this project represents the first attempt at assessing age-specific escapement for all Central Valley Chinook salmon based on scale aging. Through the use of age specific escapement data and CWT recoveries with known mark rates, estimates of natural and hatchery abundance may be derived. Once the entire 2006 brood (marked at a constant 25% rate) has reached completion in 2011, age specific ocean harvest rates, maturation rates, and stray rates, can be calculated. Consequently, both the methods employed and results presented may have broad implications for the future of Chinook salmon management and restoration in the Central Valley.

CALFED Statement of Relevance
In accordance with the CALFED Ecosystem Restoration Program directed actions, this project represents the first attempt at assessing age-specific escapement for all Central Valley Chinook salmon through scale aging. Both the methods employed and results presented have broad implications for future Chinook salmon management and restoration in the Central Valley.

SESSION: Salmon Management, 10/23/2008, 9:40 AM, Room 306

Beakes[1], M.P., E. Collins[2,3], W. Satterthwaite[3], D. Swank[1], M. Mangel[3], J. Merz[4], S. Sogard[5], R. Titus[2]
[1]NMFS/UCSC, 110 Shaffer Road, Santa Cruz, CA 95060
[2]California Department of Fish and Game
[3]UC Santa Cruz
[4]Cramer Fish Sciences
[5]NMFS
Michael.Beakes@noaa.gov

Smolt Transformation and Decision Windows in Two California Populations of Steelhead: Effects of Temporal Variability in Growth.

Steelhead from different populations exhibit disparate life history pathways, presumably as a function of local adaptations to contrasting environments. Food availability, through its effect on growth, is thought to be a primary factor influencing the decision to undergo smolt transformation in salmonids. In other salmonids, temporal windows have been identified, during which fish appear to decide whether or not to undergo smolt transformation the following spring based on their current growth rate and expected size at emigration. In laboratory experiments, we tested the effect of temporal patterns in growth on smolting decisions in steelhead from a central California coastal population (Scott Creek) and the northernmost Central Valley population (upper Sacramento River). Fish were maintained on moderate rations to restrict growth, except for an 8 week period of ad libitum rations. We varied the timing of high food availability across four treatment groups to identify when growth potential has its greatest influence on the decision to smolt in the following spring. We conducted a seawater challenge to assay osmoregulatory capacity as a function of the timing of high food availability. In addition, the change in condition index over time was used to assess morphological signs of smolt transformation. Size upon seawater entry was significantly correlated with seawater survival and the threshold for survival was smaller for Scott Creek fish than for upper Sacramento fish. Although the timing of ad libitum rations did not affect seawater survival, a significant divergence in condition index between seawater challenge survivors and mortalities in December suggests that the decision to smolt occurs prior to winter. These results provide insight into the applicability of life history models and management strategies to California steelhead.

CALFED Statement of Relevance
Maintaining viable salmon populations is integral in the efforts to establish optimally functioning ecosystems. Our research is focused on understanding critical stages of salmon life history development.

SESSION: Fish Ecology, 10/23/2008, 10:20 AM, Room 306

Collins, E.M., R.G. Titus
California Department of Fish & Game, 6708 Orleans Way, Sacramento, CA 95831
ecollins@dfg.ca.gov

Comparative Feeding and Drift Ecology of Juvenile Steelhead in Central California

Benthic and drift macro-invertebrate samples were taken to provide data for a steelhead life-history modeling effort. The model will be used to determine the environmental conditions, such as flow and food availability, that underlie the possible life-history pathways available to steelhead in their first year. Samples were taken on two reservoir-controlled Central Valley rivers and on two mostly unimpaired central coast streams. Monthly drift samples and seasonal benthic samples were taken at each site. In addition, a seasonal diel drift sample was taken on each stream. Juvenile steelhead were sampled seasonally by seining; stomachs were lavaged in a sub-sample of the catch. The contents of the gastric lavage samples were then compared to the contents of the drift and benthic samples. Steelhead consumed Ephemeropterans, Dipterans, Trichopterans and Plecopterans as primary food items. Steelhead on the central coast feed primarily on drift due to the size and life stage of their prey items, which most closely mirrored that of the drift. Central Valley steelhead feed equally from the benthos and drift. Drift Density comparisons between the Central Valley and the central coast clearly suggest that Central Valley rivers below dams have much higher drift densities than small central coast streams, a factor that likely explains the higher growth rates of Central Valley steelhead.

CALFED Statement of Relevance
The availability of food is an important factor in the steelhead life-history decision making process. Flow fluctuations influence steelhead foraging by altering the abundance of colonizing and drifting invertebrates in the stream, which may ultimately have an affect on the growth rate and survival of juvenile steelhead.

SESSION: Fish Ecology, 10/23/2008, 10:40 AM, Room 306

Swank[1], D.R., M. Beakes[1], E. Collins[2], M. Mangel[1], J. Merz[3], W. Satterthwaite[1], S. Sogard[4], R. Titus[2]
[1]UC Santa Cruz, 110 Shaffer Rd, Santa Cruz, CA 95060
[2]California Department of Fish and Game
[3]SP Cramer Fish Sciences
[4]National Marine Fisheries Service
david.swank@noaa.gov

Growth Trajectories of Wild California Steelhead Parr

While relatively well studied, much of the basic behavioral ecology of salmonids is still poorly understood, and therefore our understanding our how habitat alterations affect salmonid populations is incomplete. Steelhead (*Oncorhynchus mykiss*) are an especially challenging species to understand, as they express a wide array of life-history pathways, such as a range of smolt ages and ages at first maturity, and the occurrence of resident and anadromous individuals in the same population. We hypothesized that *O. mykiss* follow life-history decision rules similar to those known to exist in Atlantic salmon, specifically that there are decision windows for smolting and maturity based upon genetically determined size thresholds and growth rates. We surmised that stream temperature, flows and food availability should differ between coastal California and Central Valley streams, and the resulting differences in growth rates should result in significant differences in life-histories among these populations. Using PIT tags, we measured individual growth rates and life-history pathways of juvenile steelhead in two coastal California populations and two Central Valley populations. Central Valley steelhead populations were found to have much higher growth rates than coastal populations. Steelhead parr were found to commonly reach smolt size in only one year on the American and Mokelumne Rivers, while this is rare in the coastal streams, where successful smolts spend several months growing in the lagoons at the stream mouth. Significant growth in coastal California steelhead occurs mostly during the winter and spring, and many fish actually lose weight over the summer and fall when streamflow is very low. Temperatures do not appear to be a limiting factor in any of the populations. Female resident rainbow trout are common in the Mokelumne River, but are extremely rare below barriers in the coastal streams.

CALFED Statement of Relevance
We will incorporate these data in a model that predicts how changes in stream flows on managed rivers can affect growth rates and therefore life-histories of wild steelhead populations, giving managers a tool to help them better understand how stream flow and water quality will impact threatened salmonid populations.

SESSION: Fish Ecology, 10/23/2008, 11:00 AM, Room 306

Lindberg[1], J.C., J. Adib-Sami[2], L. Ellison[1], T. Rettinghouse[1], B. Baskerville-Bridges[1]
[1]UC Davis, FCCL, Biological and Ag Engineering, Davis, CA 95616
[2]California Department of Fish and Game, 4001 Wilson Way, Stockton, CA
lindberg@steeper.us

Factors Influencing Sexual Maturation and Reproductive Output in Delta Smelt

Delta smelt are a small native fish species endemic to the Sacramento-San Joaquin Delta, and listed as threatened in 1993. The Fish Conservation & Culture Laboratory (FCCL), a satellite facility of University of California, Davis (UC Davis) has begun to document sexual maturation and reproductive output of delta smelt at several ages or held under two temperature regimes. Laboratory studies help to define species responses to variables seen in nature. Effect of age at spawning was tested within and between year class; gonadal development was assessed in natural origin (NOR) and hatchery origin (HOR) fish from birth year 2006 and 2007 (BY2006 or BY2007) and in HOR fish hatched early and late in 2006. Influence of seasonal-temperature regimes on gonadal development was also tested. Fish were sampled monthly and indicators of maturation recorded (weight, fork length, stage of gonad maturation, gonad weight and liver weight); comparisons were drawn in terms of these measures and ratios of organ to body weight. After spawning, fish were held to determine if they could spawn more than once in a season. Results indicate that hatchery-reared fish are similar in size and reproductive stage to sexually-maturing wild fish in 2007. Differences in size and the other measures of sexual maturation do occur due to age and water-temperature regime, and these are discussed. NOR fish were found to spawn more than once, and up to three times in one season when held under hatchery conditions. Variables were found which influence sexual maturation and reproductive output and these findings are discussed in terms of the wild population.

CALFED Statement of Relevance
Delta smelt are a key species of special concern in the Bay-Delta. Developing a better understanding of the effects of age and temperature regimes on reproductive development in the smelt has species-management and population-modeling applications.

SESSION: Fish Ecology, 10/23/2008, 11:20 AM, Room 306

Kaufman, R.C.*, A.G. Houck, J.J. Cech, Jr.
Wildlife, Fish, and Conservation Biology, University of California Davis, One Shields Avenue, Davis, CA 95616-8751
rckaufman@ucdavis.edu

Effects of Dietary Selenium and Methylmercury on Green and White Sturgeon Bioenergetics in Response to Changed Environmental Conditions

The southern population of green sturgeon has recently been listed as threatened, and one of the goals of this project is to assess the feasibility of using the more common white sturgeon as a surrogate species for toxicity testing and extrapolation of those results to the threatened green sturgeon. Green and white sturgeon were exposed, to two toxicants of concern (i.e., selenium or methylmercury) in the SF Bay-Delta in our laboratory. After dietary exposure to either selenomethionine (0,20,40,& 80 ppm) or to methylmercury (0,25,50, & 100 ppm) for a 56-day growth period, we measured individual sturgeon's routine and active metabolic rates, swimming performance, and avoidance of a simulated predator. These measurements were conducted at three environmental conditions: ambient temperature-freshwater (19 C, 0 ppt), elevated salinity (19 C, 18 ppt), and elevated temperature (25 C, 0 ppt). Our results show that green sturgeon were more sensitive to methylmercury than their white sturgeon counterparts with methylmercury having a negative impact on the bioenergetic responses at all tested conditions and exposures. Additionally, green sturgeon were found to be much more sensitive to selenium than white sturgeon at levels currently found (20 ppm) in the SF Bay-Delta. Using our current experimental design and treatment regimes we were unable to determine a "no effect" concentration (NOEC) for selenomethionine for the threatened green sturgeon. These results may have serious implications for the management and recovery of the listed southern green sturgeon population given their sensitivity to this common toxicant, selenomethionine, at levels currently found within the SF Bay-Delta. Furthermore, our experiments demonstrated that white sturgeon are not a suitable surrogate species for use in predicting the effects of toxicants and environmental variability on green sturgeon bioenergetics. Research funded by CALFED agreement no. science psp 2006-1035.

CALFED Statement of Relevance
Management and recovery of threatened and/or endangered species is predicated upon establishing an environment suitable for successful reproduction and rearing of these species. Green sturgeon are more sensitive to the effects of selenomethionine than are white sturgeon precluding the use of the white sturgeon as a surrogate species for toxicity testing.

SESSION: Fish Ecology, 10/23/2008, 11:40 AM, Room 306

Fujimura, R.W., J. Morinaka, G. Aasen, V. Afentoulis
California Department of Fish and Game, Bay Delta Region, Stockton, CA 95205
bfujimura@dfg.ca.gov

CHTR Program Overview: Six Years Later

Integrated studies on the terminal phase of fish salvage operations at the Central Valley and State Water Projects were proposed in 2002 to address critical data gaps on the survival and health of salvaged delta smelt. High losses or injuries of delta smelt during the collection, handling, transport, and release (CHTR) phases were thought to limit the benefits of new state-of-the-art fish screening facilities in the south Delta. From the initial concept proposal, five study elements were eventually implemented; three elements examining the existing CHTR impacts at the State fish salvage facility and two elements examining impacts associated with the State and Federal release sites. We report the major findings of the first three studies on 1) the mortality and injury rates of salvaged delta smelt, 2) fish predation during CHTR, and 3) evaluation of stress indicators. We summarize the status of the two release site studies and other related CHTR investigations. This presentation will also discuss the current knowledge and monitoring of direct impacts of the south Delta exports facilities on entrained delta smelt.

CALFED Statement of Relevance
These studies were funded by the CALFED Conveyance Program and this presentation is part of the planned dissemination of our results to the local scientific community.

SESSION: Delta Fish Protection, 10/23/2008, 1:35 PM, Room 306

Clark[1], K.W., M.D. Bowen[2], K.P. Zehfuss[3], R.B. Mayfield[4]
[1]California Department of Water Resources, 1416 9th Street, Room 252-35, Sacramento, CA 95814
[2]United States Bureau of Reclamation, PO Box 25007, 6th and Kipling, Bld. 56, Denver, CO 80225
[3]Science Applications International Corporation, PO Box 25007, 6th and Kipling, Bld. 56, Denver, CO 80225
[4]California Dept. of Fish and Game, 4001 N. Wilson Way, Stockton, CA 95205
kclark@water.ca.gov

Pre-Screen Loss of Steelhead within Clifton Court Forebay

In response to the 2004 National Oceanic and Atmospheric Administration Fisheries Service biological opinion, the California Department of Water Resources conducted a study in 2007 to assess and quantify steelhead pre-screen losses within Clifton Court Forebay. Two tagging technologies, acoustic and Passive Integrated Transponders (PIT) tags, were utilized. Pre-screen loss rate was estimated by using multiple, small releases of PIT tagged steelhead immediately upstream of the radial gates. Concurrently, movement patterns of steelhead and striped bass were examined using acoustic telemetry. Steelhead pre-screen loss rate was estimated to be 82 ±3% (mean ±95% Confidence Interval) within Clifton Court Forebay. Time to salvage was different among release months. However, pre-screen loss rate did not differ by month of release. Radial gate operations may contribute to these losses as avian predators and striped bass were consistently present near the radial gates and were foraging. Additionally, striped bass spent long periods of time in the intake canal leading to the John E. Skinner Delta Fish Protective Facility potentially foraging on fish. Results and observations of this study will be used to develop a management action plan for predator control to reduce the loss of juvenile steelhead and other fish entrained in Clifton Court Forebay.

CALFED Statement of Relevance
The steelhead pre-screen loss study is included in the CALFED Conveyance Program and is intended to evaluate and improve existing SWP facilities to increase the survival of fish.

SESSION: Delta Fish Protection, 10/23/2008, 1:55 PM, Room 306

Castillo[1], G.C., J. Morinaka[2], B. Baskerville-Bridges[3], J. Lindberg[3], R. Fujimura[2], J. DuBois[2], G. Tigan[3], V. Poage[1]
[1]U.S. Fish & Wildlife Service, 4001 N Wilson Way, Stockton, CA 95205
[2]Department of Fish & Game, 4001 N Wilson Way, Stockton, CA 95205
[3]Fish Conservation & Culture Lab, UC Davis, 5280 Bruns Rd, Byron, CA 94514
gonzalo_castillo@fws.gov

Pilot Mark-Recapture Study to Estimate Delta Smelt Pre-screen Loss and Salvage Efficiency

The goals of this pilot study are to provide initial estimates of delta smelt's prescreen loss at Clifton Court Forebay (CCF, a water reservoir), and salvage efficiency at the adjacent Skinner Fish Facility, State Water Project (SWP). The SWP and the Central Valley Project (CVP) export Delta water year-round for agricultural and urban use and both have fish salvage facilities to reduce fish entrainment losses. Yet, pre-screen loss and salvage efficiency at the SWP remain critical unknowns for most fish species. To address these questions, we refined methods to be used in mark-recapture experiments for cultured delta smelt. We conducted five laboratory tests in winter-spring 2008 to evaluate the use of the fluorochrome calcein (SE-Mark calcein) to mass-mark juvenile and adult delta smelt. Two independent evaluations of SE-Mark calcein marking grade showed 100% mark retention and higher mark intensity with increasing exposure time (1 to 7 minutes immersion in a SE-Mark calcein solution: 2.5 g/L for juveniles and 5.0 g/L for adults). No evidence of SE-Mark calcein toxicity or abnormal behavior was observed during or after these tests and survival of marked fish was similar to unmarked control fish. Protocols to minimize potential stress-induced handling mortality of juvenile and adult fish resulted in at least 90% average survival 1 week after marking. These results suggest that SE-Mark calcein can be effective to mass-mark delta smelt. We anticipate releasing a total of 3,700 juvenile delta smelt during June 2008 at the Skinner Fish Facility and at two sites in CCF. Control fish will be used to estimate marking induced mortality over time. These results will provide guidance for larger mark-recapture tests for juvenile and adult delta smelt to be conducted in winter-spring 2009. This work is being coordinated with a collaborative IEP hydrodynamic study in CCF.

CALFED Statement of Relevance
Quantifying entrainment losses not accounted for in salvage statistics for juvenile and adult delta smelt should contribute to formulate more effective recovery actions. This study addresses CALFED goals on Water Supply (Environmental Water Account) and Ecosystem Restoration (restore and protect habitats and ecosystem functions and native species).

SESSION: Delta Fish Protection, 10/23/2008, 2:15 PM, Room 306

Brown, R.T., A. Huber
ICF Jones & Stokes, 630 K Street Suite 400, Sacramento, CA 95814
rbrown@jsanet.com

Evaluation of Daily Delta Flows and Delta Smelt Salvage Density Patterns

The daily CVP and SWP delta smelt salvage density and daily Delta flow conditions for the period of 1995-2007 were graphically compared and evaluated. The possibility of reducing the adult and juvenile delta smelt salvage density by imposing reverse flow objectives was considered. Delta smelt adults appear to migrate into the south Delta channels in response to environmental conditions associated with the first major Delta outflow event after mid-December. The density of delta smelt at Chipps Island shows a coincident decrease, suggesting that this is likely a general migration pattern. Regulation of reverse QWEST or reverse Old and Middle River (OMR) flows is unlikely to exert much control on this upstream spawning migration. Reducing the CVP and SWP pumping during this period of peak adult delta smelt density will reduce the take of adult delta smelt, but will leave more of the adults to spawn in the south Delta. The historical daily delta smelt salvage data suggests that the peak juvenile density is also not controlled by reverse QWEST or reverse OMR flows. These juveniles were likely spawned in the south Delta channels from the adults that migrated into the south Delta. A substantial shutdown of the CVP and SWP pumps would be required to allow most of the juveniles that were spawned in the south Delta channels to migrate downstream towards the confluence.

CALFED Statement of Relevance
The evaluation of daily historical flow and delta smelt salvage events does not support the current delta smelt protection strategy to reduce the reverse OMR flows. An alternative strategy for reducing the ESA take from CVP and SWP pumping on the delta smelt population would be to actually pump more during the periods of increased adult salvage density, in order to maximize the number of delta smelt adults that are safely removed from the south Delta by the CVP and SWP salvage facilities.

SESSION: Delta Fish Protection, 10/23/2008, 2:35 PM, Room 306

Foin[1], T.C., R.L. Sitts[2]
[1]University of California, Department of Plant Sciences, Davis, CA 95616
[2]Metropolitan Water District of Southern California, Sacramento, CA
tcfoin@ucdavis.edu

Splittail Population Dynamics and Water Export from the Delta

Sacramento Splittail is one of a number of fish species of special concern in the ecology and management of Sacramento-San Joaquin Delta water resources. While the life history and biology of the species is relatively well known, important questions remain concerning its population dynamics and how they are affected by a number of simultaneous events in the Delta. The biggest issue has long been how water export from the Delta affects the dynamics of the species, but there are other co-occurring factors such as the impact of invasive species, toxic substances and climate change, which greatly complicate the analysis and which are often intractable in the field. We constructed models of the effect of varying inflow and outflow through the Delta on splittail population ecology. Analysis of these models showed that splittail reproduction is robust over water year variation and water export, and that while both may contribute to yearly fluctuation, neither is likely to contribute to endangerment of the splittail population. This analysis is fully consistent with empirical research on the species and adds the ability to examine the population dynamics of the species that is possible no other way.

CALFED Statement of Relevance
The population dynamics of fishes of special concern in the Delta is central to the evaluation of water management in the Sacramento-San Joaquin Delta. This research shows that water export does not significantly affect splittail population growth and survival.

SESSION: Delta Fish Protection, 10/23/2008, 2:55 PM, Room 306

Earley, J.T., M.R. Brown
U.S. Fish and Wildlife Service, 10950 Tyler Road, Red Bluff, CA 96080
james_earley@fws.gov

Evaluating Spring Chinook Re-establishment in Clear Creek

In 2000, the McCormick-Saeltzer Dam was removed, allowing the re-establishment of spring Chinook (SCS) in Clear Creek. Built in 1903 at river mile (rm) 6.5 for agricultural diversions, the dam blocked passage for anadromous fish. Dam removal allowed access to 11.6 miles of useable spawning habitat, colder water temperatures and deep pools for over-summering adult SCS. Reservoir releases to Clear Creek have been increased since 1999 for SCS. Since 1999, the annual adult SCS index has increased over those three years earlier. The U.S. Fish and Wildlife Service have been measuring juvenile SCS passage in Clear Creek since 1998 at rm 1.7 with a rotary screw trap (RST). Initially, (1998-2002) SCS passage indices were inaccurate when generated by the RST due to overlap in spawn timing with fall Chinook salmon (FCS). Spatial separation of FCS and SCS was also incomplete. Since August 2003, a weir at rm 8.1 is seasonally installed to separate FCS and SCS spawning, and reduce the potential for hybridization, redd superimposition, and competition. In October 2003, a second RST was placed at rm 8.3 to sample upstream production and all Chinook captured are assumed to be SCS. Passage indices from the upper RST are more accurate than those generated by the lower RST. From 2003 to 2006, juvenile passage indices measured by the upper RST have not increased. Redd counts from 2003 to 2007 snorkel surveys have not increased. The average number of juveniles produced per redd from 2003-2006 was 2,118. The combination of rotary screw trapping, use of a separation weir, and annual adult and redd counts has greatly improved our ability to manage and monitor the status of SCS in Clear Creek.

CALFED Statement of Relevance
Clear Creek is high priority CALFED watershed. The Clear Creek Anadromous Fish Monitoring Project is funded by CALFED. One of the goals of the project is to monitor spring Chinook salmon populations. The Central Valley spring Chinook salmon is listed as threatened by the State and Federal Endangered Species Acts.

SESSION: Salmon Ecology, 10/23/2008, 3:35 PM, Room 306

Weber[1], P.K., R. Barnett-Johnson[2], B. MacFarlane[3], J.D. Wikert[4], M. Workman[5], C. Phillis[6]
[1]Lawrence Livermore National Laboratory & Institute of Marine Science, UC Santa Cruz, 7000 East Ave, L-231, Livermore, CA 94550
[2]Institute of Marine Science, UC Santa Cruz, 100 Schaffer Road, Santa Cruz, CA 95060
[3]National Marine Fisheries Service, 110 Shaffer Road, Santa Cruz, CA 95060
[4]Anadromous Fish Restoration Program, USFWS, 4001 N. Wilson Way, Stockton, CA
[5]East Bay Municipal Utility District, 1 Winemasters Way, Ste K, Lodi, CA. 95240
[6]UC Berkeley
weber21@llnl.gov

Hatchery or Wild: Does Adult Chinook Salmon Relative Abundance Reflect Juvenile Production?

Impacts of hatchery-produced salmon on the long-term sustainability and persistence of naturally spawned salmon have been difficult to assess. In California's Central Valley (CCV), population estimates of wild salmon are inferred from survivorship estimates of coded wire tag (CWT) marked hatchery fish recovered in commercial and recreational fisheries, spawning ground surveys, or when adults return to hatcheries to spawn. Due to the small proportion of CWT marked fish (historically <10% of hatchery releases), population estimates rely on large expansions from few returned tags introducing substantial error with an underlying assumption of equal survival rates for wild and hatchery fish. This study seeks to increase the accuracy and precision of current estimates. We previously developed otolith-based microchemistry (sulfur isotopes) and microstructure (growth patterns) methods to identify hatchery and naturally produced salmon in the CCV. These methods rely on signatures that result from the feeding and rearing differences between the fish in a hatchery and the wild. For this study, we have applied both methods to determine the relative abundance of hatchery and naturally reared adult spawners in the Mokelumne River watershed in the CCV. Otoliths were collected from adult Chinook salmon in the Mokelumne River and at the Mokelumne River Hatchery and subsampled proportionate to relative escapement to the collection location (13% and 87%, respectively). Preliminary results for 90 samples suggest that 1 to 7% (95% CI) of adults returning to spawn are naturally reared, which is within error of the estimated contribution of in-river juvenile production in the Mokelumne River (~5%). This estimate will be refined and the relative abundances between spawners collected in the river will be compared to spawners collected at the hatchery.

CALFED Statement of Relevance
This work provides fundamental data on Chinook salmon and is relevant to the long-term sustainability and persistence of naturally spawned salmon stocks in the California Central Valley.

SESSION: Salmon Ecology, 10/23/2008, 3:55 PM, Room 306

Zeug, S.C., L. Albertson, B. Cardinale, H. Lenihan
University of California-Santa Barbara, Department of Ecology, Evolution and Marine Biology, Santa Barbara, CA 91306
sczeug@gmail.com

Predictors of Chinook Population Extirpation in California's Central Valley

Chinook salmon are an important economic, recreational and cultural resource in California as evidenced by the millions of dollars spent to rehabilitate their populations. Despite the considerable application of time and money, populations continue to decline at regional scales, leading to increasing concern about the potential for future extinctions. The historical causes of extirpations of Chinook populations in the Central Valley have been associated with a variety of factors related to habitat loss, alteration of stream hydrology and barriers to migration; however, few formal analyses have rigorously compared the relative influence of these factors. Here we examine the weight of evidence for multiple hypotheses to explain patterns of fall-run and spring-run population extirpations in the Central Valley. We compiled data on current hydrologic dynamics, post-regulation changes in hydrology, habitat loss and migration barriers for 38 streams that historically supported fall-run, and 32 streams that supported spring-run populations. Logistic regression revealed that the probability of extirpation of fall-run populations was solely predicted by migration barriers (no populations below high dams had been extirpated), with all other explanatory factors being more >400 times less likely to explain regional loss of Chinook. Causes of spring-run extirpations were less clear with both migration barriers and habitat loss proving to be equally viable models. A subset of models for spring-run populations located below migration barriers suggested that both habitat loss and altered hydrological dynamics are determinants of extirpation probabilities. Taken collectively, our results suggest that regional declines in Chinook salmon have likely been driven by multiple forms of environmental change that differentially impact different the various life-history types. Thus, rehabilitation of salmon populations will need to simultaneously address large-scale issues of dispersal as well as altered physical properties of individual stream channels.

CALFED Statement of Relevance
Salmon populations in the Central Valley continue to decline despite numerous restoration projects designed to stabilize or increase population size. Understanding the causes of previous salmon extirpations will help guide future restoration activities and provide realistic expectations of the effectiveness of current salmon conservation strategies.

SESSION: Salmon Ecology, 10/23/2008, 4:15 PM, Room 306

Barnett-Johnson[1], R.C., J.C. Garza[2], C.B. Grimes[2], R.B. MacFarlane[2]
[1]University of California Santa Cruz, Institute of Marine Sciences, Santa Cruz, CA 95060
[2]National Marine Fisheries Service, Santa Cruz, CA
Barnett-Johnson@biology.ucsc.edu

Linking Freshwater Sources of Chinook Salmon to their Ocean Distributions using Genes and Otolith Signatures of Origin

The extent to which natal populations of salmon mix in the ocean can influence their demography- information critical to sustainable management of the fishery. Despite its ecological and evolutionary importance, our understanding of whether aggregations of salmon consist of separate or mixed populations remains limited. To understand the composition of adult Chinook salmon aggregations along the coast of central California, we combined molecular, otolith microstructure and 87Sr/86Sr analyses on the same individuals to identify their origin. Individuals from seven Evolutionarily Significant Units (ESUs) were found in the ocean samples. The majority of fish from the Central Valley Fall ESU were from the Coleman National Fish Hatchery. Ninety percent (±6%) originated from a hatchery source in the Central Valley indicating that hatchery supplementation may be playing a larger role than previously thought. Adults from different ESUs and natal populations were found to mix among regions off the central California coast. However, at the smaller spatial scale of aggregations within a region, fish from the same ESU and some natal sources associated with individuals from the same populations three years after entering the ocean. These results indicate that there is a degree of permanence in the composition of aggregations perhaps established during their early freshwater phase.

CALFED Statement of Relevance
Understanding the spatial distributions of Central Valley Chinook salmon populations in the ocean provides the necessary information to link important oceanographic factors to realized population sizes in freshwater habitats. A main objective outlined in CVPIA is to double the population size of naturally produced salmonids. There are currently limited tools to evaluate this primary goal due to the inability to identify whether adults were produced in hatcheries or rivers. This study provides a population estimate of naturally produced fish and a novel tool to monitor the status of natural production over time to meet CVPIA goals.

SESSION: Salmon Ecology, 10/23/2008, 4:35 PM, Room 306

Phillis[1], C.C., L. Ingram[1], P.K. Weber[2]
[1]University of California, Berkeley, Department of Earth and Planetary Science, Berkeley, CA 94720
[2]Lawrence Livermore National Laboratory, Chemical Sciences, Livermore, CA
corey@berkeley.edu

River and Estuary Rearing of Successfully Spawned Adult Chinook Salmon, Determined by Otolith Sr Isotopes

The importance of the San Francisco Bay (SFB) Delta to native juvenile salmonid rearing is poorly understood. Fish surveys provide snap shots of the population as it travels down the rivers and enter and exit the SFB-Delta complex. But existing techniques are unable to address the critical question, How do the freshwater rearing strategies of juvenile salmon relate to their success in later life stages and specifically, to becoming a successful spawner? Here we address this question using otolith microanalysis for strontium isotopes. Preliminary results demonstrated the ability to identify strays and yearlings. As the main part of our study, we analyzed over 100 otoliths from 2007 spring-run adult spawner carcass surveys on Mill Creek, Deer Creek, Butte Creek, and winter-run adults collected from Livingston Stone National Fish Hatchery. Preliminary results from the spring-run populations suggest residence time in the natal streams after emerging from the gravel ranged from <2 weeks to 4 months, with most leaving either before 40 days or after 80. After leaving their natal streams, some reared in the mainstem of the Sacramento River, while others continued downstream. The rate of passage from Elkhorn Boat Launch to Chipps Island varied from <2 weeks to 45 days, while unexpectedly many individuals spent at least 45 days in the region between Chipps Island and Golden Gate Bridge. Similar downstream migration patterns were seen with the winter-run otoliths analyzed, with the exception of one individual that clearly reared in the Delta for approximately one month. Overall, Delta rearing was a small portion of juvenile rearing. Total freshwater residence time for all populations ranged from 2½ to 5 months, demonstrating that the “yearling” juvenile life history was not significant among spawners in this year class.

CALFED Statement of Relevance
Techniques and results presented will assist in directing efforts under the CALFED objective of Ecosystem Restoration by identifying important habitats to restore and protect for the benefit of Central Valley salmonid populations.

SESSION: Salmon Ecology, 10/23/2008, 4:55 PM, Room 306

Pasternack, G.B.
University of California at Davis, 211 Veihmeyer Hall, LAWR, Davis, CA 95616
gpast@ucdavis.edu

What Does it Take for a Regulated Central Valley River to Have Ecological Functionality?

Efforts to rehabilitate regulated rivers in the Central Valley of California have generally focused on empirical channel design, ad hoc gravel augmentation, or re-regulated flow releases. Though mindful of some scientific concepts, each of these paradigms has failed to include process based predictive tools to guide design and insure that conceived of ecological benefits will actually come to pass. Instead of pre-supposing which of these approaches should be used or in what combination, it is possible to identify the key environmental processes required for a regulated Central Valley river to be ecologically functional. Based on a decade of research on several streams, it is now evident that many of those are related to persistent channel non-uniformity at multiple spatial scales. Most Central Valley streams now lack such channel non-uniformity, and empirical channel design, gravel augmentation, or flow re-regulation as previously envisioned will not solve the problem. Recent studies of common 1D, 2D, and 3D numerical hydrodynamic models have revealed the capabilities and limitations of each type of model in representing key hydrogeomorphic processes linked to ecological functions and channel non-uniformity. Full-scale manipulative river-rehabilitation experiments on the Mokelumne and Trinity Rivers as well as natural floods on the highly dynamic Yuba River have confirmed the findings of modeling studies and the importance of channel non-uniformity. As a result, it is now possible to use models to predict the hydrogeomorphic and ecological outcomes of design alternatives for proposed projects. The most recent advances now enable such prediction over tens of kilometers of channel simultaneously and at the fish-relevant sub-meter resolution. Consequently, the technical barriers to instream river rehabilitation for the Central Valley are down. Those interested in implementing this peer-reviewed, process-based, comprehensive framework for river rehabilitation in the Central Valley are encouraged to contact the presenter.

CALFED Statement of Relevance
The author presents a summary of a decade of peer-reviewed research that demonstrates how Central Valley rivers can and should be restored. Does CALFED and the audience have the audacity to consider this?

SESSION: River Restoration, 10/23/2008, 8:20 AM, Room 307

Fulton[1], A.A.*, G.B. Pasternack[1], H.J. Moir[2]
[1]Department of Land, Air and Water Resources, UC Davis, One Shields Avenue, Davis, CA 95616-8627
[2]Macaulay Institute, Craigiebuckler, Aberdeen, AB15 8QH, UK
aafulton@gmail.com

Gravel Augmentation in Bedrock Channels: Can it Work?

Dams throughout California and the Pacific Northwest suppress anadromous salmonid populations by blocking access to historic spawning areas and severing the hydrologic, ecologic, and geomorphic continuity that river ecosystems require. To mitigate for these effects, gravel augmentation has been invoked on highly regulated, low gradient, gravel-bed rivers to provide substrate and increase spawning habitat quality and quantity. However this rehabilitation tool has yet to be evaluated in bedrock channels like the Yuba River below Englebright Dam. This study set out to determine the efficacy of gravel augmentation as a habitat rehabilitation tool in this novel environment by comparing historical imagery, 2-D depth and velocity approximations, sediment transport predictions, and habitat quantifications of a bedrock and alluvial site. While flow convergence routing maintained riffle-pool morphology at the alluvial reference reach it was not observed as a dominant mechanism for alluvial deposition at the bedrock controlled Englebright Dam Reach (EDR). The absence of flow convergence routing and overall channel constrictions at the EDR will promote entrainment and transport of augmented gravels. Shields' stress predictions suggest that gravel retention will be maximized along channel margins and near depositional features that reduce local bed shear stress. Overall, gravel augmentation at the bedrock dominated EDR will not create large scale habitat features susceptible to scour but will instead provide highly localized zones of habitat in concert with depositional features.

CALFED Statement of Relevance
CALFED has stated that gravel augmentation will be used on numerous California rivers to increase the quantity and quality of anadromous spawning habitat. Although it's an established mitigation method in gravel-bed streams, it has not been investigated in bedrock channels where the underlying geomorphic processes are quite different. This research provides insights to the overall efficacy of gravel augmentation along the Yuba River below Englebright dam and a methodology for examining its applicability in other bedrock rivers. The results of the study suggest a limitation on the amount of habitat that can be created in bedrock channels and that they cannot provide the same large-scale spawning habitat features that have been created on gravel-bed channels.

SESSION: River Restoration, 10/23/2008, 8:40 AM, Room 307

Matthews, G.W., S.A. Pittman
Graham Matthews and Associates, PO Box 1516, Weaverville, CA 96093
graham@gmahydrology.com

Stream Restoration Tools to Address Stream Channel Degradation: The Lower Clear Creek Floodplain Restoration Project

Historic land use and flow regulation resulted in highly degraded conditions in lower Clear Creek. Many stream segments were scoured to claypan, reducing the structural complexity required for numerous aquatic organisms. Abandoned mining pits favored exotic species and trapped juvenile salmonids. Riffles matrices, winnowed but not replenished by post-dam floods, became fossilized. Reduced sediment supply prevented formation of new alluvial features and simplified the channel pattern. Floodplains were abandoned and riparian regenerative processes were reduced as groundwater retreated following channel incision. The strategy adopted on three miles of lower Clear Creek was to restore the physical processes that would create and maintain key physical attributes of a functional alluvial ecosystem: a frequently mobilized streambed, floodplains accessed by annual floodflows, and a dynamic channel. Tools employed to achieve these conditions included: stream channel and floodplain engineering to accommodate the post-dam flow regime; supplying the new channel with ample spawning-quality gravel; filling off-channel mining pits; floodplain planting to provide hydraulic roughness to enhance fine sediment deposition; reclamation of mining spoils for gravel augmentation; channel alignment determined by depth of alluvium; and bio-engineered structures strategically placed to prevent channel re-capture. The effectiveness of these tools toward achieving management objectives has been continuously monitored since 2002 using a variety of experiments designed to quantitatively evaluate project success. Results of monitoring indicate that designed streambeds mobilize near the design bankfull discharge (3,000 cfs), that floodplains are inundated by the average annual flood, the channel is seeking longer, more sinuous paths through its floodplains and that spawning riffles do not typically scour to a lethal depth for incubating salmon. The successes and lessons learned from the Lower Clear Creek Floodway Restoration Project facilitated a basin-wide vision, in which key reaches are targeted with restoration proposals intended to enhance habitat conditions and facilitate dam-to-mouth sediment transport continuity.

CALFED Statement of Relevance
The restoration of degraded upstream ecosystems is integral to the recovery/integrity of the Bay-Delta system. Restoration tools employed on Clear Creek have a unique history of evaluation and may prove applicable to other central valley systems.

SESSION: River Restoration, 10/23/2008, 9:00 AM, Room 307

Stafford, L.A., M.R. Brown
U.S. Fish and Wildlife Service, 10950 Tyler Road, Red Bluff, CA 96080
Laurie_Stafford@fws.gov

Are Juvenile Chinook Salmon using the Restored Habitat in Clear Creek?

The Lower Clear Creek Floodway Rehabilitation Project is a multi-phase project, designed to restore 2.5 miles of stream channel and floodplain habitat. One of the primary goals of the Project was to maintain or increase the quantity and quality of juvenile salmonid rearing habitat. Our study focuses on Phase 3 of the Project, which constructed new channels and functioning floodplains. Phase 3A, completed in 2002, moved 1,400 feet of creek from a bedrock streambed to a gravel-filled channel, and Phase 3B, completed in 2007 realigned 3,600 feet of the channel. Both Phases incorporated juvenile salmonid rearing habitat features including; revetment and habitat rootwads, boulder clusters, alcoves, retention of old creek channel as backwaters, and preservation of some existing riparian vegetation. We conducted habitat use surveys in the spring of 2003, 2005, and 2008 to evaluate the affect of the Project on juvenile Chinook densities. We estimated both Chinook and Steelhead numbers from underwater snorkel observations. The survey area consists of two control reaches, which are above and below the restoration, and the two restoration phases. We originally predicted that restoration would result in lower juvenile densities due to reductions in channel complexity and cover. The Project exceeded this prediction by incorporating rearing habitat features. In both phases, Chinook densities were high in the revetment rootwads and saved vegetation. Fish density was also high in the old creek channel retained as a backwater in Phase 3A. In Phase 3B, boulders and habitat rootwads had lower densities than expected. Higher densities in Phase 3A during 2005 suggested that the restoration improved the quality of habitat used by juvenile Chinook. We will compare Chinook densities during 2008 between reaches, years, and meso-habitat types. We recommend inclusion of the highly effective juvenile habitat features when designing large-scale geomorpologically-based channel restoration projects.

CALFED Statement of Relevance
Clear Creek is a high priority watershed for CALFED, which funded construction of the Floodway Rehabilitation Project. Our monitoring evaluated one of the goals of the restoration project. CALFED also funds similar projects and this monitoring will be useful in improving future projects.

SESSION: River Restoration, 10/23/2008, 9:20 AM, Room 307

Senter, A.E.*, G.B. Pasternack
University of California, Davis, 219 Veihmeyer Hall, Davis, CA 95616
aesenter@ucdavis.edu

Large Wood Aids Chinook Salmon (Oncorhynchus tshawytscha) Spawning in Marginal Habitat on a Regulated River in Central California

To determine whether large wood (≥1-m length, ≥10-cm diameter) plays a role in chinook salmon redd placements in a regulated, medium-sized (average width 30-m), Mediterranean-climate river, characteristics of 542 large wood pieces, locations of 650 redds, and habitat unit delineations (riffle, run, glide, pool) were collected during a spawning season along a 7.7 km reach directly below Camanche Dam on the Mokelumne River. The amount of large wood in the reach was similar to other highly managed rivers, at 9 tonnes/hectare. Large wood was regularly distributed across the reach an average 70 pieces km-1, whereas at the geomorphic scale of ~100 channel widths, large wood clustered at islands. Chinook salmon built 75% of observed redds where spawning habitat rehabilitation projects—which have occurred predominately in the upper 3 km of the reach—have improved spawning conditions. At a hydraulic scale of ~10-1 channel widths, redds were within a 10-m radius of large wood 36% of the time, suggesting that spawners may have utilized large wood as cover and refugia, thus playing an important secondary role in redd placements. Large wood pieces also appeared to play a more direct hydraulic role, with redds within a 5-m radius of large wood 17% of the time. In the lower 4.7 km where marginal habitat was prevalent, redds were within a 5-m radius of large wood 21% of the time and within a 2.5 m radius 10% of the time. Results from random samplings and t-tests indicate that large wood-redd interactions systematically occurred at a greater rate than by random chance alone in the lower 4.7 km but not in the upper 3 km, which implies that large wood aids spawning in marginal habitats.

CALFED Statement of Relevance
Large wood triggers physical and ecological processes that are important to spawning salmon within regulated rivers. This study validates the importance of large wood to spawning conditions, and encourages large wood additions during habitat rehabilitation projects.

SESSION: River Restoration, 10/23/2008, 9:40 AM, Room 307

Wood, D.M., C.D. McClain, C.A. Little, A.E. Holt
Department of Biological Sciences, California State University, Chico, CA 95929
dmwood@csuchico.edu

Long Term Vegetation Monitoring in Restoration Sites

Riparian forest habitat restoration along the Sacramento River has been occurring for nearly twenty years. The main goal of this effort is to create habitat for animals of high conservation importance. Metrics of success for restoration can therefore be developed for both the target animal species and for the habitat (vegetation) itself. This study measures vegetation development and habitat complexity in 20 x 30m plots (n=106) at four restoration sites originally planted by The Nature Conservancy in 1993 and 1994 and sampled in 2003 and 2008. Plots in remnant forest were used for reference. At the time of planting a soil auger was used to document soil texture and type of refusal (sand, gravel, groundwater, or none at 20 ft). Within a plot, field measurements at the species level include the diameter at breast height (dbh) of woody stems, canopy height, and shrub and herb cover. Derived values include total basal area and species importance value. Results showed that restoration plots varied widely in structure, from zero woody stems to total basal areas > 1000 cm2 and stem densities > 100 in plots with a well-developed tree canopy. Both total basal area and stem density are strongly related to refusal type. Forest growth is promoted by groundwater refusal and inhibited by sand, gravel, or no refusal (indicating no groundwater at 20 ft). Sites with no or limited forest development in 2003 remained that way in 2008. Valley oak had the highest importance value across the sites, followed by arroyo willow, elderberry, boxelder and sycamore. The herb layer remains predominantly nonnative (no native herbaceous species were planted). Where soil conditions permit, forest growth continues to be good and appears to achieve the desired habitat complexity for wildlife.

CALFED Statement of Relevance
A substantial amount of money and effort has gone into habitat restoration along the Sacramento River. The study helps document the success of this effort.

SESSION: Riparian Habitat, 10/23/2008, 10:20 AM, Room 307

Hayden[1], M.K.*, J.C. Stella[2], J.J. Battles[1], S. Dufour[3], H. Piégay[4]
[1]University of California, Berkeley, Dept. of Environmental Science, Policy, and Management, Berkeley, CA 94720-3114
[2]SUNY College of Environmental Science and Forestry, One Forestry Drive, Syracuse, NY 13210
[3]CEREGE CNRS - Universite de Provence, 13545 Aix En Provence, cedex 04, France
[4]CNRS (Centre National de la Recherche Scientifique), 15 Parvis Rene Descartes, 69342 Lyon, cedex 07, France
mhayden@nature.berkeley.edu

Riparian Forest Patterns in Abandoned Channels on the Middle Sacramento River: An Alternative Recruitment Pathway for Pioneer Riparian Vegetation in Gravel-bed Meandering Rivers

Pioneer riparian forests dominated by cottonwood (*Populus*) and willow (*Salix*) are typical of alluvial gravel-bed rivers in semi-arid and temperate climates, and provide a host of ecosystem functions that sustain natural resources and benefit human societies. From our preliminary work along the middle reach of the Sacramento River, California, we have developed a conceptual model that incorporates linkages between vegetation dynamics and the geomorphic evolution of abandoned channels that formed as a result of episodic, punctuated channel cutoff or avulsion events. To date, the contribution of this alternative recruitment pathway to overall riparian vegetation dynamics has received little study, despite the prominence of abandoned channels on the landscape and their potential importance in maintaining functioning riparian forests over the long-term, particularly under regulated river conditions. Based on 1999 vegetation mapping for the entire 100-mile reach, cottonwood-dominated forest associated with abandoned channels comprised 54% of the total mapped cottonwood forest area. In addition, we propose that the rate at which sediment fills the abandoned channel may allow for repeated recruitment events. As the abandoned channel fills, sedimentation rate decreases over time while total sediment accumulation approaches an equilibrium depth. Texture of deposited sediment also becomes finer, and is linked to improved water availability for plants. We propose that a sediment texture threshold occurs where pioneer woody species are excluded by competition with herbaceous vegetation that quickly colonizes finer substrates. Our hypothesis is that abandoned channels experiencing faster initial sedimentation reach this threshold sooner, so there are fewer recruitment opportunities for woody pioneers. We examined the age structure of existing forest stands via dendrochronological techniques on cottonwood, and cored sediments to gauge accumulation on the floodplain. Preliminary results correlate well with estimates of time-since-cutoff based on time-series historical aerial photography, and successive recruitment events were documented at some sites.

CALFED Statement of Relevance
This work seeks to directly inform CALFED's Ecosystem Restoration Program goals by understanding the patterns and drivers of cottonwood establishment and dynamics within abandoned channels. Improving our knowledge of the ecology and population dynamics of Fremont cottonwood is a necessary foundation for conserving, managing, and restoring Central Valley floodplain habitats.

SESSION: Riparian Habitat, 10/23/2008, 10:40 AM, Room 307

Stella[1], J.C., J.J. Battles[2], J.R. McBride[2], B.K. Orr[3]
[1]SUNY College of Environmental Science and Forestry, One Forestry Drive, Syracuse, NY 13210
[2]Department of Environmental Science, Policy, and Management, University of California at Berkeley, 137 Mulford Hall, Berkeley, CA 94720-3114
[3]Stillwater Sciences, 2855 Telegraph Ave., Suite 400, Berkeley, CA 94705
stella@esf.edu

Riparian Seedling Mortality in Semi-arid Ecosystems and Applications to River Restoration

Seasonal water limitation exerts a strong ecological filter on stream communities in semi-arid regions. A major population limitation for riparian willow and poplar trees is desiccation in the first year from declining river flows following germination. We investigated survivorship of first-year riparian seedlings to simulated river stage declines, focusing on the three dominant species in California's San Joaquin Basin: Fremont cottonwood, Goodding's black willow, and narrow-leaved willow. Seedlings grown in mesocosms were subjected to water table decline rates typical in spring on unregulated and regulated rivers. We compared the species differences in survival time and fit the empirical data to accelerated failure time (AFT) models that predicted time until death as a function of drawdown rate, initial seedling size and maternal line. We used AIC to select the most parsimonious model for each species. Water table decline rates 6 cm/day were fully lethal to all species, whereas 1 cm/day had no effect compared to a stable water table (>63% survival). At an intermediate rate (3 cm/day) survival varied most among species (12-38%) and was lowest for cottonwood. For all species the time to peak mortality was negatively correlated with drawdown rate, indicating a cumulative effect of water stress on survival. The best failure time models included drawdown rate as the single parameter for willows, and rate and initial size for cottonwood. Across the range of survivable drawdown rates (¡Ü4 cm/day), Goodding's black willow sustain >20% higher survivorship over the other species after 30-40 days of stage decline. Current river management practices in the San Joaquin Basin have a disproportionately-large impact on spring runoff, and stage declines in most years are greater than can be sustained by seedlings. Using AFT model results we simulated non-lethal flow scenarios for the Tuolumne River in wet years that did not increase the overall discharge volume.

CALFED Statement of Relevance
The technical approach developed herein can guide flow releases along regulated rivers to promote large-scale habitat restoration, influence plant community dynamics, and balance ecosystem needs with growing human demand. This is crucial both in the California Bay-Delta ecosystem and other water-limited regions worldwide.

SESSION: Riparian Habitat, 10/23/2008, 11:00 AM, Room 307

Johnston[1], P.L.*, K.D. Holl[2], D.M. Wood[1]
[1]California State University Chico, Dept. of Biological Sciences, Chico, CA 95929
[2]UC Santa Cruz, Department of Environmental Studies, Santa Cruz, CA 95064
prairiej6@hotmail.com

Factors Affecting and Strategies for Facilitating the Recruitment of Native Understory Plant Species in Restored Riparian Forest on the Upper Sacramento River

Most riparian forest restoration projects have focused on restoring overstory species, whereas few studies have experimentally assessed factors limiting recruitment of understory species. The goal of this research is to determine whether canopy cover or exotic grass competition more strongly affect seedling recruitment, survival, and growth of native understory plants in order to inform restoration efforts. In fall 2005, we broadcast seeded and planted seven species (*Aristolochia californiCA Artemisia douglasiana, Carex barbarae, Clematis ligusticifolia, Euthamia occidentalis, Rubus ursinus*, and *Vitis californica*) at three old restoration sites (restored 1998-99) and three new restoration sites (restored 2004-06) along the Sacramento River. Understory species were introduced to plots with and without grass-specific herbicide and with and without overstory cover (old sites only). As of September 2007, seedlings showed relatively high overall survival given that they were not irrigated (range: *Rubus* - 55% to *Aristolochia* - 14%). Survival of five species was higher in old restoration sites, whereas *Artemisia* and *Euthamia* had higher survival in the new sites. At the old sites *Carex, Clematis, Aristolochia*, and *Vitis*, all had significantly higher survival in plots with overstory cover. The other species showed no difference in survival between the open and overstory plots. Treatments to reduce grass competition had minimal effect on survival and growth, which is likely due to extensive growth of broadleaved weeds in the exotic grass control plots. Establishment from seeds in spring 2006 was low (<5 seedlings/m2) for all species, so plots were reseeded in fall 2006. In spring 2007 seed germination was significantly higher in the canopy treatments for all species except Artemisia and *Euthamia*. Results thus far show some understory species require a closed canopy for germination. Therefore, we recommend introducing these species to restoration sites where the overstory canopy has matured.

CALFED Statement of Relevance
The goal of this research is to determine whether canopy cover or exotic grass competition more strongly affect seedling recruitment, survival, and growth of native riparian understory plants. This information can be used to increase the survival of understory plants in forest restoration projects taking place along the Sacramento River.

SESSION: Riparian Habitat, 10/23/2008, 11:20 AM, Room 307

Souza, E.J., G. Treber
Tehama Environmental Solutions, Inc., 910 Main St., Ste D, Red Bluff, CA 96080
jeff@tehamaenvironmental.com

Monitoring of Active and Passive Riparian Restoration on Constructed Floodplains, Lower Clear Creek, Shasta County, California

The Lower Clear Creek Floodway Rehabilitation Project, located near Redding, in Shasta County, California, was designed to restore the stream channel and floodplains that were severely altered by aggregate and dredger gold mining and an altered flow regime resulting from the construction of Whiskeytown Dam. During the initial phases of the project, forty-six acres of floodplain were constructed using dredge tailings and floodplain deposits and planted primarily using hardwood cuttings of Fremont cottonwood (*Populus fremontii*), willow (*Salix* spp.) and mulefat (*Baccharis salicifolia*), as well as valley oak (*Quercus lobata*) container stock and acorns. Scour channels were constructed to intercept spring groundwater and encourage natural regeneration of riparian vegetation. A monitoring program was designed to measure the success of the project relative to two broad project objectives along with a number of more specific quantitative objectives. Permanent belt transects were established on the constructed floodplains to measure planting survival, height, and canopy diameter, along with natural recruitment. Line-intercept transects were established within constructed scour channels to measure natural recruitment. Measures of rooted frequency and aerial cover of herbaceous species were added to the monitoring program in 2007. A site assessment was conducted to collect soil and groundwater information in areas with significant differences in survival and productivity. After eight years of monitoring the initial plantings, results indicate that hardwood cuttings are successfully establishing in a patchy distribution, where site conditions are favorable. Structural diversity is somewhat lacking due to the low soil productivity and lack of shallow soil moisture. Woody riparian vegetation is naturally recruiting in reaches of the scour channels where hydrologic conditions are favorable, and is creating high-quality songbird nesting habitat. Valley oak survival and productivity is very low. Recruitment of non-native woody plant species was initially minimal, but is increasing as site conditions become more favorable.

CALFED Statement of Relevance
The use of highly-permeable tailings and floodplain materials to reconstruct floodplains, coupled with an undulating, water-perching claypan layer presents a unique challenge for riparian restoration. Monitoring results are providing adaptive management feedback information for future phase designs of this project and other riparian restoration projects in mined watersheds.

SESSION: Riparian Habitat, 10/23/2008, 11:40 AM, Room 307

McClain[1], C.D.*, K.D. Holl[2], D.M. Wood[1]
[1]California State University, Chico, Department of Biological Sciences, 400 West First St, Chico, CA 95929
[2]UC Santa Cruz, Department of Environmental Studies, Santa Cruz, CA 95064
cdmcclain@gmail.com

Assessing Long-Term Recovery of Native Understory Plants at Riparian Forest Restoration Sites Along the Sacramento River

Over the past 150 years, the extent of riparian forests along the Sacramento River has been reduced by 98%. Initial restoration efforts in 1989-1997 were directed towards planting trees and shrubs with the assumption that native understory vegetation would colonize the sites naturally. Holl and Crone (2004 – J. Applied Ecology 41:922-933) found native understory plants made up 21% of the relative cover compared to 70% in remnant forests. In addition, six fewer native species were found in restored sites compared to remnant forests. Recent restoration efforts (1998-present) incorporate native understory species at the onset of restoration to increase native cover and richness. We conducted a study to determine how initial planting approach and time since restoration affect the recovery of native understory plants. In 2007, we resurveyed the 15 sites Holl and Crone surveyed in 2001. Relative native cover increased by only 6% and species richness did not increase significantly with high variability among sites. We also surveyed 20 sites restored 1997-2003, 14 of which were planted with understory species. Sites planted with understory species showed 1.5 times greater relative native cover than sites of the same age that were not planted with understory species; however, there was high variability among sites and both groups had five native species. California Blackberry (Rubus ursinus) made up 3% of the relative native cover in sites where it was planted versus <1% in sites where it was not planted. The cover of other planted species was not significantly higher in planted and unplanted sites. Our results suggest the following restoration recommendations: closer monitoring of plant survival after three years of management have ended, removal of shade-tolerant non-native competitors (e.g. Himalayan Blackberry) in older sites, and waiting to plant native understory species until after the overstory has developed.

CALFED Statement of Relevance
Our research will contribute to effective restoration and management of riparian forests along river floodplains.

SESSION: Riparian and Wetland Systems, 10/23/2008, 1:35 PM, Room 307

Fremier[1], A.K., J.H. Viers[2], J.C. Stella[1]
[1]SUNY-ESF, One Forestry Drive, Syracuse, NY 13210
[2]University of California, Davis, Department of Environmental Science & Policy
fremier@gmail.com

Floodplain Heterogeneity as a Driver of Riparian Vegetation Composition and Structure through Channel Abandonment

Riparian vegetation composition and structure reflect the legacy of small- and large-scale patterns of hydrology, geomorphology and ecology. Understanding the dynamics of complex systems requires scaling-up mechanistic processes. Coupling hydro-geomorphic processes with vegetation development is an integral step in understanding habitat evolution in riparian corridors. We modeled floodplain deposition and topographic complexity to better understand how riparian forest structure and composition changed through time and over the floodplain. We used LiDAR and a temporally-rich dataset of aerial photography coupled with field data to correlate landscape-scale processes with species composition and dynamics at the site scale. Floodplain heterogeneity and forest structure was quantified using LiDAR imagery. In particular, we examined the significance of two definable large-scale floodplain processes that drive riparian forest dynamics, meander migration and channel abandonment. Channel abandonment accounted for approximately 10-30% of the surfaces created over the last 100 years compared to progressive meander migration. Abandoned channel surfaces were less likely to be converted to agriculture and therefore are overrepresented in current remnant stands. Similar vegetation dynamics and proportion of cottonwood occur on both surface types. Canopy structure and floodplain complexity (coefficient of variation) generally showed a log-linear relationship over time and correlated well with species composition.

CALFED Statement of Relevance
Understanding the complex interchange of biological and physical processes is an urgent need as we consider managing ecosystems. The success of these measures, both in the long and short term, depends on an integrating life history knowledge with a quantitative understanding of physical process.

SESSION: Riparian and Wetland Systems, 10/23/2008, 1:55 PM, Room 307

Collins[1], J.N., M. Sutula[2], E. Stein[2], R. Clark[3], R. Chad[4], A. Wiskind[5], L. Grenier[1]
[1]San Francisco Estuary Institute, 7770 Pardee Lane, Oakland, CA 94621
[2]Southern California Coastal Water Research Project, 3535 Harbor Blvd, Costa Mesa, CA 92626
[3]California Coastal Commission, 725 Front St, Santa Cruz, CA 95060
[4]Humboldt Bay Harbor Recreation and Conservation District, 601 Startare Drive, Eureka, CA 95502
[5]Moss Landing Marine Laboratory, 8272 Moss Landing Rd, Moss Landing, CA 95039
josh@sfei.org

Progress toward Comprehensive Wetland Monitoring in California

Large amounts of public and private funds are invested in the protection, restoration, and management of wetlands in California. These investments cannot be evaluated because the ambient conditions of wetlands are not being monitored or the methods are inconsistent over time and from place to place. Furthermore, the results of monitoring are not readily available to analysts and decision makers. A solution is being demonstrated in California coastal watersheds, based on a 3-level assessment framework plus information management that employs new IT tools. Level 1 consists of wetland inventories and landscape profiles that meet local agency needs while updating the National Wetland Inventory and the National Hydrographic Dataset. New methods for mapping wetlands and riparian areas have been developed. Maps of project wetlands are updated as conditions of the State's 401 Certifications and WDR's. Level 2 features cost-effective probabilistic surveys of overall functional capacity of wetland projects and populations of wetlands relative to their best achievable conditions using the California Rapid Assessment Method. Level 3 consists of standardized intensive assessment of specific wetland functions or stressors. Correlations between Level 3 results and CRAM scores are used to validate CRAM for all types of California wetlands. Level 1 and 2 assessments of ambient condition have been completed for riverine wetlands in three demonstration watersheds and for estuarine wetlands statewide. Current Level 3 efforts specifically designed as part of the 3-level monitoring framework focus on stream eutrophication, hydromodification, mercury bio-accumulation, and avian community support. The Wetland Tracker (www.wetlandtracker.org) is a web-based information system for tracking Level 1-3 results and for enabling planners to see every wetland and related project in the context of all others at regional and watershed scales. These pilot efforts are expected to lead to a statewide program of regional wetland monitoring that improves wetland policies, programs, and projects.

CALFED Statement of Relevance
This presentation reports progress on comprehensive wetland monitoring that is programmatically linked to federal and California state wetland and water quality policies and can therefore help CalFed reach its goals to restore the ecological health and improve water management for the Bay-Delta system in the long-term.

SESSION: Riparian and Wetland Systems, 10/23/2008, 2:15 PM, Room 307

Schile[1], L.M.*, T.R. Carson[2], J.C. Callaway[3], V. Parker[4], M.C. Vasey[4], S. Siegel[2]
[1]University of California, Berkeley, Department of Environmental Science, Policy and Management, Berkeley, CA 94720
[2]Wetlands and Water Resources, 818 Fifth Ave Suite 208, San Rafael, CA 94901
[3]University of San Francisco, 2130 Fulton St, San Francisco, CA 94117
[4]San Francisco State University, 1600 Holloway Ave, San Francisco, CA 94132
lschile@nature.berkeley.edu

Elevation, Inundation, and Vegetation Patterns in Natural and Restored Tidal Wetlands

Tidal wetland restoration efforts have focused on establishing appropriate elevations for plant colonization, with the assumption that elevation determines inundation rates and other critical factors for plant establishment and growth. While elevation is the key factor driving inundation rates, within-site variation due to impoundments, pannes and other features also affect local flooding and draining. Substantial research has evaluated elevational distributions of tidal wetland plants in San Francisco Bay wetlands; however, little work has directly linked elevation to patterns of inundation across a tidal wetland. We evaluated plant distributions across five tidal wetlands in the northern San Francisco Bay Estuary. Plant and elevation surveys were conducted at 200-500 points around three to four water level stations per site. Inundation data were collected for approximately one year. Data were combined in 5-cm intervals according to tidal elevations, and mean and maximum depth and duration of inundation were calculated for each interval. Patterns of vegetation zonation were apparent from our data, with species showing peaks in distributions across the tidal wetlands. There was substantial overlap and spatial variability in distributions relative to both elevation and inundation patterns for some dominant species. We found little evidence for critical thresholds for plant distributions across all wetlands, although, there is evidence that plants respond to minor changes in elevation and inundation.

CALFED Statement of Relevance
Plant distributions in tidal wetlands are directly linked to patterns of inundation and salinity. Understanding the influence of these factors on vegetation is crucial to understanding how distributions might change under predicted climate change scenarios and in restoration sites.

SESSION: Riparian and Wetland Systems, 10/23/2008, 2:35 PM, Room 307

Ryan, A.B.*, K.E. Boyer
San Francisco State University, Romberg Tiburon Center for Environmental Studies, Tiburon, CA 94920
abryan@sfsu.edu

Interactive Effects of Nitrogen and Salinity on Structure and Composition of Pickleweed (Sarcocornia pacifica) Dominated Salt Marshes

Both nitrogen (N) and salinity levels have been increasing in the San Francisco Bay Estuary over the last hundred years, and predicted climate change and future population growth indicate these trends will likely continue. In tidal marshes, nitrogen is a key limiting nutrient for plant growth and a component of the response to salinity stress for many plants. Community dominance patterns can shift when N is in excess. How increases in N and salinity will interact to influence biomass production, canopy architecture, and community dynamics is not clear. Through a series of experiments we examined how increases in nitrogen and salinity, alone and together, affect the structure and composition of plant communities in the mid/high marsh. We repeated experiments in both the pickleweed (*Sarcocornia pacifica*) dominated plain and adjacent to channels where pickleweed is mixed with other species. We examined the response of three species -*S. pacifiCA Distichlis spicata*, and *Jaumea carnosa* – to our treatments. These species' responses were gauged through changes in biomass, percent cover, plant height, canopy layering, and changes in soil and plant tissue nutrients. Pickleweed showed a dramatic positive response to increased nitrogen and no negative response to increased salt. In mixed species habitats, all species responded positively to N addition; however, pickleweed increased in cover whether or not salt was also added, at the expense of the other species. Increases in these two human-caused factors may not be harmful to pickleweed, but may have negative implications for overall salt marsh diversity.

CALFED Statement of Relevance
Human caused changes to the watershed are increasing the Bay nitrogen and salinity levels. These changes may confer pickleweed with increased competitive ability at the expense of other species.

SESSION: Riparian and Wetland Systems, 10/23/2008, 2:55 PM, Room 307

Chen[1], Z.R., N. Ohara[2], M.L. Kavvas[2], J. Albietz[3], J. Wilcox[3]
[1]Department of Water Resources/UC Davis J. Amorocho Hydraulics Lab, 1416 Ninth Street, Room 252-5, Sacramento, CA 95814
[2]UC Davis J. Amorocho Hydraulics Lab, One Shields Ave, Davis, CA 95616
[3]Feather River Resource Management (CRM), Quincy, CA 95971
zchen@water.ca.gov

Hydrologic Impacts of River Restorations in the Headwater Watersheds of Feather River

Most of the meadows and streams in the headwater watersheds of the Feather River basin are degraded with accelerated erosion, gully formation, habitat loss, and flashy runoff patterns due to historical misuse of land. In order to reverse the degrading trends, watershed restoration actions have been carried out in the headwater watersheds of the Feather River basin, California. A new approach has been developed to assess the long-term cumulative hydrologic impacts of the localized restoration actions in the Indian Creek watershed in the Upper Feather River Basin. This new approach involves coupling a regional hydroclimate model, a snow model, a physically-based watershed model and a local groundwater model at various spatial scales, together with a GIS database and local field monitoring over the watershed. All physical parameters for the physically-based watershed model are derived from the local GIS and satellite driven data sets, such as DEM data, soil map, local vegetation map, and MODIS data. Spatially distributed precipitation, temperature, evapotranspiration, and snowcover/snowmelt are estimated over the Indian Creek watershed at hourly intervals using the hydroclimate model and the snow model. This is necessary since headwater watersheds are usually gauged sparsely or have no gauges. The presentation will focus on the issues of coupling hydrologic processes at various scales. Assessment of meadow restoration actions in one of subwatersheds in the Indian Creek watershed, indicates that spring flow decreases and fall flow increases after the restoration. It was shown that meadow restoration in the subwatershed may increase the its long-term averaged summer flow by 2-3 % over dry years. California's water supply is dependent upon the condition of its source headwater watersheds. The new assessment approach can help us to manage the future restoration activities more efficiently in watersheds from headwaters to the San Francisco Bay/Delta.

CALFED Statement of Relevance
The new assessment approach can help us to manage the future restoration activities more efficiently in watersheds from headwaters to the San Francisco Bay/Delta.

SESSION: Watersheds, 10/23/2008, 3:35 PM, Room 307

Pittman, S.A., G. Matthews
Graham Matthews & Associates, 4902 Cedar Ravine, Placerville, CA 95667
smokey@gmahydrology.com

Geomorphic Monitoring of Lower Clear Creek: Ten Years of Observations

Impacts to Clear Creek below Whiskeytown Dam vary by reach, with distance downstream from the dam and with proximity to tributaries. Since dam closure in 1965, riparian encroachment, sediment starvation, riffle coarsening and channel incision have combined to reduce the instream and floodplain habitat quality in Clear Creek. Numerous projects oriented toward restoration design, gravel augmentation and flow and sediment transport modeling have incorporated a geomorphic monitoring component. Types of monitoring studies included: repeat channel geometry surveys (cross section, thalweg profile, topography, bathymetry); particle size analyses; thresholds of bed mobility; repeat ground-level photography; and aerial photo analyses. Riparian confinement continues to promote undesirable channel form and high sediment transport capacities in upstream reaches. Available spawning area has increased in these upper reaches (within the influence of the Whiskeytown Dam gravel injections) by several hundred percent. Headcuts and channel incision persist in downstream alluvial reaches despite restoration efforts. Thresholds of bed mobility appear to be reduced on riffles influenced by injections. However, within floodway restoration areas, vegetation colonization is reducing the threshold of bed mobility on bar surfaces. Saeltzer Dam-liberated sediments overwhelmed some sub-reaches while moving through others. Much of the deposit passed as suspended sediment in the first hydrologically significant water year (2003) following removal. In tributary-influenced reaches, the leading edge of gravel injections was difficult to discern. In sediment-starved reaches, surveys of channel segments below gravel injections reveal leading edges translating as lobes, partially filling lateral voids, and to a lesser degree pools, as the threshold of alluviation is met. Translation rates (length of channel “re-charged”) of 250 to 450 feet/year were measured, corresponding to injection rates of 750 to 1,800 tons/year. At these rates, it will take over 60 years to achieve complete sediment routing in Clear Creek.

CALFED Statement of Relevance
Millions of dollars have been allocated toward the restoration of Clear Creek below Whiskeytown Dam. Geomorphic monitoring provides direct, quantitative feedback on project performance and guides subsequent actions.

SESSION: Watersheds, 10/23/2008, 3:55 PM, Room 307

Orr[1], K.E., J.T. King[2], B.K. Orr[1], M.S. Singer[1]
[1]Stillwater Sciences, 279 Cousteau Place, Davis, CA 95616
[2]Bioassessment Services, 24988 Blue Ravine Rd., Fulsom, CA 95630
krista@stillwatersci.com

Aquatic Bioassessment as Part of the Merced Alliance Project

The Merced Alliance Project biological monitoring component was designed to address a lack of contemporary watershed-scale data for fish, benthic macroinvertebrates (BMI), and birds along the Merced River, a major tributary to the San Joaquin River. The data deficiency was problematic because, although a number of Merced River restoration projects have been undertaken during the past two decades, baseline information has not been available for evaluating the effects of reach scale restoration efforts. The BMI study component was conducted during fall 2006 , spring 2007, and fall 2007, with study plan development paralleling that of SWAMP protocols for sampling BMI in California's rivers and streams. Thus, this project was one of the first extensive applications of SWAMP BMI sampling methods. Following the SWAMP protocols, both targeted riffle composite (TRC) and multihabitat composite (MHC) samples were collected from 40 sites located along the mainstem Merced River, from the confluence with the San Joaquin River to upstream of Yosemite Valley. The project approach also involved systematic adaptation of SWAMP wadeable protocols to effectively sample the prevailing nonwadable conditions in lower river reaches, as well as in several locations in the upper river. Results indicated that despite slight differences, biological metrics associated with the two sample types were highly correlated, suggesting that it may not be necessary to collect both sample types. An additional major finding was the clear partitioning of taxonomic composition and biological metrics between the upper and lower river, regardless of sample season, year, and type. While partially due to elevation-related physical habitat changes, this finding is also likely attributable to effects of foothill reservoirs on temperature, flow, and geomorphic conditions in the lower river.

CALFED Statement of Relevance
Study findings are relevant to the CALFED Program objectives of water quality and ecosystem restoration, because they support a better understanding of the applicability of SWAMP methods for watershed-scale assessments of water and habitat quality on major rivers, and provide information for prioritizing ecosystem restoration within the San Joaquin Basin.

SESSION: Watersheds, 10/23/2008, 4:15 PM, Room 307

Bartholomaus[1], T.C., J.F. Stamm[1,2], B. Hecht[1], G. Syphers[3]
[1]Balance Hydrologics, Inc., 800 Bancroft Way, Suite 101, Berkeley, CA 94710
[2]U.S. Geological Survey, South Dakota Water Science Center, 1608 Mountain View Road, Rapid City, SD 55702
[3]Sonoma Mountain Village/Codding Enterprises, 1400 Valley House Drive; PO Box 3550; Rohnert Park, CA 94928
tbartholomaus@balancehydro.com

Monitoring-based Annual Water Balances as Targets for Low Impact Development

As the Bay-Delta environment comes under increasing stress from population growth and development, traditional stormwater management practices are often not sufficient in mitigating hydrologic impacts on downstream channels and habitat. More appropriate, aggressive, stormwater management extends traditional goals by mimicking natural processes such that post-construction water balances and annual hydrographs closely approximate their pre-construction states. Sonoma Mountain Village, a 200-acre planned residential and commercial community 18 miles northwest of the San Francisco Bay, seeks to minimize the impact it will have on the hydrologic cycle through its adherence to a thorough site baseline monitoring program which informs innovative engineering design. At Sonoma Mountain Village, a comprehensive water budget has been established on two sub-watersheds with markedly different characters. In a substantially urbanized watershed, at least 80% of incident precipitation runs off the site, regardless of the season. However, in the adjacent undeveloped watershed, the site water balance and hydrograph are more interesting and complex. Only about 32% of precipitation ran off the watershed during water year 2007, while 57% ran off during water year 2008. During both years, runoff was concentrated during the mid-winter and in response to the most intense storm events. For example, during the late January/early February storms of 2008, 7.6 inches ran off the undeveloped watershed out of 7.7 inches of precipitation. This particular pattern of natural runoff is common to many sites throughout the Bay-Delta located on lowlands with clay-rich native soils. These baseline water balance data present targets for (a) post-construction preservation of the hydrologic balance on the undeveloped watershed and (b) restoration of a natural water balance on the urbanized watershed. Advanced engineering techniques such as rainwater harvesting can be implemented to meet these goals while augmenting the community water supply.

CALFED Statement of Relevance
At a planned North Bay community with physical similarities to other sites within the Bay-Delta region, ongoing baseline water balance work presents targets for engineering design that will maintain and improve downstream ecosystem function while revealing new opportunities for augmenting local water supply.

SESSION: Watersheds, 10/23/2008, 4:35 PM, Room 307

Lee, L.C., L. Xu, E.A. Zedler
Santa Clara Valley Water District, 5750 Almaden Exwy., San Jose, CA 95118
llee@valleywater.org

Engineering Basis of Bankfull and Related Geomorphic Features

Engineers and geomorphologists have long recognized the presence of bankfull channel and floodplains in a river. Significant efforts have also been spent to collect watershed data to develop regression relationships for bankfull channel dimensions of stable streams. However, little engineering data have been published to show how bankfull-floodplain geometry affects the long-term stability of a river. Restoration projects that incorporate a bankfull channel without considering relevant requirements for stability are likely to suffer structural failure. Urbanized watersheds, such as the Santa Clara Valley, often find top of banks hydraulically detached from the river channel. Channel design in these incised channels requires consideration of a wider range of flow conditions. This paper will use simple engineering analyses to show how floodplains affect the boundary shear stress in a river, and how it may play a role in achieving stability. Surface armor is another geomorphic feature that has attracted extensive discussions in the literature. Some reported that it persisted through floods, and others indicated that it was demolished during high flows and re-established after flood receded. This difference in observations may also be explained when floodplain geometry and shear stress distribution are considered. The paper will also provide procedures for engineering design of an urban channel under restoration. Field data collected from urbanized watersheds of the Santa Clara County will be presented to illustrate this procedure. The paper will show that, when there is a choice between setting back levees and raising levee heights, the consideration should go beyond flood protection to encompass ecosystem restoration and long-term stability.

CALFED Statement of Relevance
This paper describes the application of engineering analysis on geomorphic parameters to determine their validity in river restoration designs. The focus on long-term stability fulfills the objectives of the ecosystem restoration and watershed management programs.

SESSION: Watersheds, 10/23/2008, 4:55 PM, Room 307

Sommer, T.R.
Department of Water Resources, 901 P Street, Sacramento, CA 95814
tsommer@water.ca.gov

An Introduction to the Pelagic Organism Decline

This presentation will provide an introduction to the pelagic organism decline (POD) for the upper San Francisco estuary. We will briefly discuss abundance indices calculated by the Interagency Ecological Program (IEP) through 2008, which suggest recent marked declines in the four major pelagic fishes of the upper San Francisco Estuary. Most of the talk will be dedicated to describing the ongoing POD investigation to evaluate the potential causes. The presentation will explain how talks in the special session address different aspects of the POD "story". The oral session and its companion poster cluster are organized around a several relatively simple conceptual model components: 1) previous abundance levels, which describes how continued low abundance of adults leads to juvenile production; 2) habitat, which describes how water quality variables (including contaminants and toxic algal blooms) affect estuarine species; 3) top-down effects, which posits that predation and water project entrainment affect mortality rates; and 4) bottom-up effects, which focuses on food web interactions in Suisun Bay and the west Delta. The oral session will conclude with a series of talks that consider how stressors may interact in their effects on POD species.

CALFED Statement of Relevance
The pelagic organism decline is one of the major issues facing resource managers in the region. This presentation will introduce the POD session, where the latest results to evaluate the decline will be presented.

SESSION: Pelagic Organism Decline (I), 10/23/2008, 8:20 AM, Rooms 308-310

Newman, K.B.
US Fish and Wildlife Service, 4001 N. Wilson Way, Stockton, CA 95205
ken_newman@fws.gov

Population Estimates for Smelt

For over 40 years, annual fish abundance indices in the California Delta have been calculated from catches by midwater trawl sampling during the months of September through December. The indices are weighted combinations of fish and water volume, ignore the effects of fish size on the probability of capture, and lack measures of uncertainty. Using a combination of classical probability sampling and model-based procedures, estimates of absolute abundance for the years 1990 to the present were calculated along with standard errors. The model-based framework is flexible enough that alternative life history theories can be incorporated and compared.

CALFED Statement of Relevance
Ecosystem restoration: Mathematical models formulated on biological principles and fit using the available data and statistically valid methodology can serve as tools to attempt to understand the possible effects of environmental factors on population abundance. In this particular case, such models may be one piece of an approach to understanding the reasons for the Pelagic Organism Decline (POD).

SESSION: Pelagic Organism Decline (I), 10/23/2008, 8:40 AM, Rooms 308-310

Baxter, R.D.
California Dept. of Fish and Game, 4001 North Wilson Way, Stockton, CA 95205
rbaxter@dfg.ca.gov

Longfin Smelt (the other white-bait), Investigating Possible Causes for the Decline

Longfin smelt has undergone a long-term decline in the San Francisco Estuary and a more recent deviation from its strong outflow-abundance relationship. In 2001, abundance dropped in conjunction with low outflow and subsequently failed to improve with increasingly favorable outflow conditions in 2003, 2004 and 2005. Concurrent low abundance indices for longfin smelt as well as delta smelt, striped bass and threadfin shad instigated the Pelagic Organism Decline program, a multifaceted effort investigating whether declines could be explained by one or a combination of parental effects, mortality effects, food web effects, and habitat changes. Answers to the decline remain elusive. Increased adult salvage in winter occurred coincidental with the decline, as did some high juvenile salvage. Impacts of piscine predation remain unknown. Though major food web changes did not coincide with the most recent decline, longfin smelt feeding remains focused on *Eurytemora affinis* in winter and spring and several scarce mysids in summer and fall; during recent fall mysid declines, benthic Gammarid and Corophium amphipods were eaten to fill the void. This benthic oriented feeding might explain some changes in species distribution within the estuary. Increased use of pyrethroid pesticides and urbanization within the watershed may have enhanced toxicity for adhesive eggs or buoyant pelagic larvae, and systematic water sampling has detected toxicity and contaminants at locations overlapping longfin smelt distribution, but health investigations did not detect signs of contaminant effects to organs or increased disease or parasite problems. However, sub-lethal effects may still be present and affecting longfin smelt survival. Recent petitions for state and federal listing as an Endangered Species underline the urgency of uncovering causes of the decline.

CALFED Statement of Relevance
Longfin smelt is one of several pelagic fishes in decline. Understanding the causes for the decline is necessary to effectively manage the health of these populations and the estuary as a whole.

SESSION: Pelagic Organism Decline (I), 10/23/2008, 9:00 AM, Rooms 308-310

Grimaldo[1], L.F., T. Sommer[1], N. Van Ark[1], E. Holland[1], C. Ruhl[2]
[1]California Dept. of Water Resources, 901 P Street, Sacramento, CA 95816
[2]United States Geological Survey, 6000 J Street Placer Hall Sacramento, California 95819
lgrimald@water.ca.gov

How Does the Behavior of Ichthyoplankton in a Highly Modified Tidal Freshwater Estuary Influence their Entrainment Risk?

Although ichthyoplankton possess limited ability to swim against strong currents, research shows they can minimize or maximize advection by vertical or lateral migration in the water column. In estuarine ecosystems, such behavior is critical for fish larvae to retain themselves in favorable nursery areas. However, little is known about larval fish behavior in heavily-altered estuaries with manipulated flow regimes, particularly when large water diversions are present. In this paper, we present results from a three-year field study aimed at understanding the factors that influence larval fish behavior and their potential entrainment vulnerability in the Sacramento-San Joaquin Delta, a heavily urbanized estuary. We sampled fishes and zooplankton at discrete-depths during continuous hourly sampling in the southern and northern regions of the Delta between 2005 and 2007. Overall, fish abundances were higher in edge habitats but some species were strictly found in channels. Delta smelt were highly abundant in surface areas during the day but it is unclear whether they exhibited any vertical migration behavior. Other species such as striped bass and prickly sculpin exhibited more dramatic vertical and horizontal behavioral patterns. In general, we found good agreement between fish and zooplankton abundances and, in some surveys, the diets of larval fish reflected the zooplankton species of highest overlapping distribution. Our results suggest that fish behavioral patterns play a role in water diversion entrainment, especially for the channel-orientated species. Hence, insights into larval fish behavior may provide an important tool to reduce fish losses at estuarine water divisions.

CALFED Statement of Relevance
Our study addresses two key areas of interest in the estuary 1) entrainment and 2) pelagic species biology. We wish to present our study in the POD session.

SESSION: Pelagic Organism Decline (I), 10/23/2008, 9:20 AM, Rooms 308-310

Gross, E.S., M.L. MacWilliams
Environmental Consultant, 6452 Regent Street, Oakland, CA 94618
ed.gross@baymodeling.com

Three-Dimensional Bay-Delta Hydrodynamic and Particle Tracking Simulations

The population of delta smelt and other pelagic organisms of the upper San Francisco Estuary has declined dramatically in recent years. One possible factor contributing to this decline is entrainment of delta smelt into export pumps. Changes to water operations in the Delta and associated tributaries may reduce losses by entrainment. One region of great interest is the South Delta and, in particular, Clifton Court Forebay. Better understanding of flow patterns and residence time of particles in this region is required to interpret fish salvage data and evaluate the influence of intake gate operations on entrainment. A three-dimensional unstructured grid model (UnTRIM) of San Francisco Bay and the Sacramento-San Joaquin Delta was developed and calibrated to resolve water levels, flow patterns and salinity throughout the estuary. A 3-D particle tracking model was implemented that closely follows the salt transport method of UnTRIM and tracks particles with specified vertical migration behaviors. These models are now applied to improve understanding of possible reasons/mechanisms for the pelagic organism decline (POD) and the efficacy of any actions taken to sustain pelagic fish populations. The particle tracking results indicate predicted pathways of particle movement through the Delta and the likelihood of entrainment in the pumps for different release locations and Delta conditions. Flow patterns and residence times of particles are calculated in Clifton Court Forebay for different wind and operating conditions. The model calibration indicates that the model is sufficiently accurate for transport simulations in the Delta. The particle tracking model results are shown to be consistent with the salt transport results of UnTRIM. Complex wind-driven flow patterns are predicted in Clifton Court Forebay during some periods. Due to vertical variability in the wind-driven velocities, movement of fish could be substantially influenced by vertical migration behavior. In Clifton Court Forebay and many other regions, three-dimensional processes substantially influence particle movement in the estuary.

CALFED Statement of Relevance
The Pelagic Organism Decline program (POD) is part of the Interagency Ecological Program (IEP) which is part of the CALFED Science program. The hydrodynamic and particle tracking models will allow refinement of hypothesis to explain the observed decline of pelagic organism populations. Furthermore, the model can estimate of the efficacy of hypothetical actions to reduce entrainment of pelagic organisms.

SESSION: Pelagic Organism Decline (I), 10/23/2008, 9:40 AM, Rooms 308-310

Sullivan[1], L.J., W.J. Kimmerer[1], B. Baskerville-Bridges[2], D.J. Ostrach[3], T.R. Ignoffo[1]
[1]Romberg Tiburon Center, SFSU, 3152 Paradise Dr., Tiburon, CA 94920
[2]Dept. of Biology & Agr. Eng., UC Davis, One Shields Ave., Davis, CA 95616
[3]Dept. of Civil and Env. Eng., UC Davis, One Shields Ave., Davis, CA 95616
ljswr@sfsu.edu

Prey Selection of Larval Delta Smelt and Striped Bass: Impacts of an Introduced Species

Populations of pelagic fish in the San Francisco Estuary are in a state of dramatic decline. Declines of several planktivorous species have been correlated to changes in both the abundance and distribution of their zooplankton prey. These correlations provide indirect evidence that changes in food supply are contributing to the decrease in fish abundance. Over the past two decades, there has been a shift in the species composition of zooplankton from a community dominated by calanoid copepods to one dominated by cyclopoid copepods, particularly the small, introduced *Limnoithona tetraspina*. In recent years, *L. tetraspina* has become the most abundant copepod in the brackish reach of the estuary, at times outnumbering all other copepods by a factor of ten. Because this introduced copepod is smaller than the historically dominant calanoid species, *Eurytemora affinis* and *Pseudodiaptomus forbesi*, the relative contribution of these groups to the total zooplankton biomass differs greatly. This difference in biomass may however be offset by the high numerical abundance of *L. tetraspina*. We quantified the relative consumption of the different copepod groups by larval delta smelt (*Hypomesus transpacificus*) and striped bass (*Morone saxatilis*) using laboratory feeding experiments. Prey selection was correlated to prey size and life history stage. Although both species consume *L. tetraspina*, the peak abundance of this copepod does not overlap spatially or temporally with the larval period of either species. Information on the differential consumption of prey and the mechanisms that control it will help determine how changes in the prey assemblage translate into population success of planktivorous fish. In addition, information on diet and prey selection will lead to a better understanding of how these species will respond to new predators, competitors, or prey.

CALFED Statement of Relevance
Information on the differential consumption of prey and the mechanisms that control it has direct implications for the CALFED Science program's effort to restore populations of pelagic fish, particularly delta smelt, in the San Francisco Estuary. This information will help managers determine how changes in the prey field translate into population success of planktivorous fish allowing them to more accurately interpret temporal changes in fish abundance.

SESSION: Pelagic Organism Decline (II), 10/23/2008, 10:20 AM, Rooms 308-310

Dugdale, R.C.
Romberg Tiburon Center, San Francisco State University, Tiburon, CA 94920
rdugdale@sfsu.edu

Effects of Ammonium on Phytoplankton Growth and Consequences for the POD

Decreased phytoplankton abundance (food limitation) has been suggested as a potential contributor to the Pelagic Organism Decline (POD) observed in the low salinity zone (LSZ) of the San Francisco Estuary. Recent studies in the northern estuary suggest that increasing levels of ammonium may impair the development of phytoplankton blooms. These studies show that phytoplankton supplied with nitrate as their primary nitrogen source exhibit rapid growth whereas, phytoplankton growing on ammonium or a combination of ammonium and nitrate grow more slowly as long as ammonium is present. Since the implementation of the Clean Water Act and the mandated conversion of waste water treatment plants to secondary treatment, sewage effluent contains high concentrations of ammonium and in many situations has resulted in increased ammonium concentrations in receiving waters, e.g. Sacramento River. Since the ammonium concentrations increase in the freshwater direction, the consequences on primary productivity tend to be more severe upstream from the Golden Gate. Recent changes have been made to wastewater treatment practices in the San Joaquin River, which results in the discharge of nitrate rather than ammonium. The contrasting ammonium conditions of the Sacramento and San Joaquin rivers offer an ecosystem scale experiment to study the mechanisms that may have changed the LSZ food web and influence the POD.

CALFED Statement of Relevance
Our results showing low primary production as a result of high ammonium concentrations are relevant to the problem of food limitation for pelagic organisms of the Bay-Delta ecosystem.

SESSION: Pelagic Organism Decline (II), 10/23/2008, 10:40 AM, Rooms 308-310

Parker, A.E., U. Lidstrom, F. Wilkerson, R. Dugdale, E. Carpenter
Romberg Tiburon Center, SFSU, 3152 Paradise Drive, Tiburon, CA 94920
aeparker@sfsu.edu

CALFED Foodweb Project: Quantifying Organic Matter Supply to the Foodweb of the Low Salinity Zone the San Francisco Estuary

Food limitation has been suggested as a potential contributor to the Pelagic Organism Decline (POD) observed in the low salinity zone (LSZ) of the San Francisco Estuary. One hypothesis is that declining rates of primary production and shifts in phytoplankton community structure in the LSZ may have led to a reorganization of the pelagic foodweb from a system based on organic matter supply by local primary production to a system dependent on exogenous organic matter and captured by heterotrophic bacteria and supplied through microbial loop. To better constrain foodweb structure and organic matter (OM) flow in the LSZ, heterotrophic bacteria and phytoplankton parameters were measured during the spring and summer of 2006 and 2007. Results suggest that bacterial OM demand is several-fold higher than OM supply via local primary production, implying a significant subsidy from exogenous OM. Bacterial growth efficiency appears to be low in the LSZ, and as a consequence, after bacterial metabolism, bacteria may at times supply equivalent amounts of OM (that originated from an exogenous source) to the LSZ food web. Future models of OM flow in the LSZ should include bacteria and microbial loop processes to better evaluate the food limitation hypothesis.

CALFED Statement of Relevance
This project addresses the food limitation hypothesis for the Pelagic Organism Decline.

SESSION: Pelagic Organism Decline (II), 10/23/2008, 11:00 AM, Rooms 308-310

Lehman[1], P.W., S. Teh[2], G. Boyer[3], M. Nobriga[4], F. Feyrer[1], E. Bass[1], C. Hogle[1], M. Bettencourt[1]
[1]CA Department of Water Resources, Division of Environmental Services, 901, P Street, Sacramento, CA 95814
[2]University of California at Davis, One Shields Ave, Davis CA 95616
[3]State University of New York, Syracuse, New York
[4]CA Bay-Delta Authority, 650 Capitol Mall, Sacramento CA 95814
plehman@water.ca.gov

The Impact of Microcystis on Food Web Organisms in San Francisco Estuary

The impact of the recently developed cyanobacteria harmful algal bloom, *Microcystis*, on the San Francisco estuarine food web is unknown. It is hypothesized that *Microcystis* contributed to the recent decline in pelagic organisms (POD) directly through its toxicity or indirectly through its impact on the food web. To evaluate these hypotheses, phytoplankton, zooplankton and fish were collected biweekly at stations throughout the estuary between 2005 and 2007. Concentrations of the cancer causing *Microcystis* toxin, microcystin, were measured in algal and animal tissue by protein phosphatase inhibition assay. The percent of individual microcystins was determined by HPLC and the relative toxicity of these microcystins DNA was quantified by quantitative polymerase chain reaction (qPCR). Fish health was assessed by histopathology of liver tissue. Toxic microcystins were present at low concentrations throughout the food web, but the relative toxicity varied among regions of the estuary. Total microcystins concentration was greater in striped bass than their prey and suggested toxins accumulated between trophic levels. Histopathology of liver tissue suggested fish were stressed and impacted by cancer causing toxins at stations where total microcystins had elevated toxicity based on percent composition and toxic gene expression. There was no evidence that *Microcystis* significantly affected total zooplankton or phytoplankton biomass but it may have influenced species composition. Data suggest that even at current low densities, *Microcystis* may influence fishery production.

CALFED Statement of Relevance
This work is important because it examines the potential impact of the newly established blooms of toxic *Microcystis* on the recent decline in pelagic organisms (POD). Critical in this abstract is the information on fish health and its relation to toxic *Microcystis* populations.

SESSION: Pelagic Organism Decline (II), 10/23/2008, 11:20 AM, Rooms 308-310

Ger[1], K.A.*, S.J. Teh[2]
[1]UC Davis, Environmental Science and Policy, Davis, CA 95616
[2]UC Davis, Aquatic Toxicology, Davis, CA
kager@ucdavis.edu

Extent of Acute, Chronic, and Nutritional Impacts of Microcystis Blooms on the Delta's Calanoid Copepods

Microcystis aeruginosa is a colony forming cyanobacteria (bluegreen algae) common in most nutrient enriched estuarine and freshwaters globally, with strains of varying toxicity due to powerful hepatotoxic microcystins and other metabolites. Its toxicity comes from microcystins, a class of hepatotoxins produced by *Microcystis* cells that cause severe liver damage and tumor formation, along with other metabolites. In recent years there has been an increase in the abundance and distribution of the toxic cyanobacteria Microcystis blooms in the upstream portion of the Delta. Though *Microcystis*–zooplankton interactions have been extensively studied, little information exists regarding effects on copepods, which are often the primary food sources to organisms of higher trophic levels in the Delta. Relatively scarce good-quality algal food resources may limit zooplankton growth in this system, and the increased abundance of *Microcystis* can further restrict optimal feeding conditions for copepods that are key prey species for pelagic fish. Here we present the preliminary results of acute and chronic toxicity testing using dissolved microcystin, and results from feeding trials with a mixed diet including *Microcystis*. Both the routes of exposure to microcystins, and the nutritional impacts of ingesting *Microcystis* are considered in the study. The dominant calanoid copepods of the Delta (*Pseudodiaptomus forbesi* and *Eurytemora affinis*) are used as test organisms to identify mechanisms by which *Microcystis* can impact copepods, with implications for the Delta's pelagic ecosystem.

CALFED Statement of Relevance
Implications to zooplankton survival and food quality from recently expanding toxic blooms of *Microcystis*.

SESSION: Pelagic Organism Decline (II), 10/23/2008, 11:40 AM, Rooms 308-310

Feyrer, F.
CA Dept Water Resources, Office of Water Quality, Sacramento, CA
ffeyrer@water.ca.gov

Modeling the Effects of Water Management Actions on Suitable Habitat and Abundance of Delta Smelt

The opportunity to manage estuarine inflow to benefit critically imperiled fish was tested by modeling the likely effects for delta smelt. Endemic solely to the euryhaline portion of the San Francisco Estuary, delta smelt is a small annual species that is on the verge of extinction. During autumn when delta smelt are pre-adults, the amount of suitable abiotic habitat is positively associated with estuarine inflow and has a measurable effect on recruitment of juveniles the following summer. Long-term declines in delta smelt abundance have coincided with a decline in the area of suitable abiotic habitat. Simulations based on a set of linked models for the abundance of pre-adult and juvenile delta smelt showed that management strategies allowing either (1) randomly occurring or (2) variable but persistently high estuarine inflow produced higher abundance than scenarios of (3) variable but persistently low or (4) non-variable median inflow. Our results suggest managing estuarine inflow offers one possible tool to help assist in the recovery of imperiled fish species by enhancing habitat space and other beneficial ecological processes.

CALFED Statement of Relevance
Invited presentation for the POD session

SESSION: Pelagic Organism Decline (III), 10/23/2008, 1:35 PM, Rooms 308-310

Hestir[1], E.L., D. Schoellhamer[2], T. Morgan[2], S.L. Ustin[1]
[1]University of California Davis, The Barn, Davis, CA 95616
[2]United States Geological Survey, Sacramento, CA 95819
elhestir@ucdavis.edu

Trends in Submerged Aquatic Vegetation and Turbidity in the Sacramento-San Joaquin Delta

Invasive submerged aquatic vegetation (SAV), such as Brazilian waterweed (*Egeria densa*) reduces the ecological health of estuaries. SAV can decrease water turbidity which is cited as one of the factors contributing to the decline of the Delta smelt. However, the association between the spread of SAV and turbidity trends in the Delta is not well understood. Although turbidity in the Delta has been decreasing since 1975, it is not clear whether this is attributable to decreased sediment supply or the invasion of SAV during this period. In order to assess trends in SAV coverage, and characterize the relationship between SAV and turbidity, we used airborne hyperspectral remote sensing image data and GIS technology. We mapped annual SAV distributions in June 2004-2007, and examined trends in areal infestation. The extent of SAV in the Delta covered 7% of waterways (1,578 ha) in 2004, 12 % of waterways (2,762 ha) in 2005, 10% of waterways (2,266 ha) in 2006, and 8% of waterways (1,748 hectares) in 2007. We determined the fraction of 2006 SAV coverage within a 1 km buffer of sites with water speed or turbidity data. Our results show that SAV coverage is greatest in sites with mean water speed less than about 1 ft/sec. We applied a Seasonal Kendall trend test to turbidity adjusted for sediment supply from the Sacramento River. Sites with the greatest fraction of open water occupied by SAV in 2006 had the strongest negative trends. Sites with little SAV had no significant trend in sediment supply-adjusted turbidity. Thus, SAV and decreased turbidity co-vary, implying that SAV has significantly reduced Delta turbidity.

CALFED Statement of Relevance
Studies conducted by research teams for the Interagency Ecological Program investigating pelagic organism decline have concluded that turbidity is a key habitat variable for several fish species in the Delta. Understanding the impact of submerged aquatic vegetation on the aquatic habitat quality is critical in understanding current projected Delta ecosystem function and health.

SESSION: Pelagic Organism Decline (III), 10/23/2008, 1:55 PM, Rooms 308-310

Fullerton, D.K.
Metropolitan Water District of Southern California, 1121 L Street, Suite 900, Sacramento, CA 95814
dfullerton@mwdh2o.com

Effects of Temperature on Delta Smelt

Delta smelt juvenile growth rates appear sensitive to water temperature based upon work by Lindberg and Baskerville-Bridges. Spring growth rates peak at around 20 degrees Centigrade and fall rapidly as temperatures diverge from that point. One hypothesis based upon this observation is that higher water temperatures in Suisun Bay and the Delta will lead to reduced FMWT fork length. Another hypothesis is that higher temperatures will lead to lower Summer Tow Net and Fall Midwater Trawl Indices if smaller smelt suffer higher mortality. Continuous water temperature data is limited in Suisun Bay and the Delta. However, air temperatures are abundant. Fortunately, air temperatures and water temperatures are closely related to each other. Therefore, air temperature can be used as a proxy for water temperature. Regression of STN and FMWT Delta smelt indices against July air temperatures in current and previous years for the period 1962 – 2007 gives statistically significant results with R2 values of .5 or greater. The upward spikes in Delta smelt abundance during the mid 1970s and late 1990s are both associated with low July temperatures. The smelt declines during the late 1980s and the POD years are associated with the highest July temperatures recorded since at least 1918. Similarly average FMWT fork length appears closely related to temperatures in August, September, and perhaps July. The apparent step decline in smelt fork length observed around 1990 can thus be explained as a response to a sharp increase in August air temperature that began in 1990. The increases in summer temperature observed over past several decades may be associated with a weakening of the Delta breeze.

CALFED Statement of Relevance
Better understanding of physical factors that may limit Delta smelt abundance and size will help to put the various proposed Delta smelt stressors into their proper context. Recovery of smelt population may not occur until summer temperatures abate for a period of years, no matter what else is done.

SESSION: Pelagic Organism Decline (III), 10/23/2008, 2:15 PM, Rooms 308-310

Werner, I.
UC Davis, Aquatic Toxicology Laboratory, Davis, CA 95616
iwerner@ucdavis.edu

Results of Water Toxicity Monitoring in the Sacramento-San Joaquin Delta, California: 2006-2008

In the last several years, abundance indices of numerous pelagic fish species residing in the Sacramento-San Joaquin Delta of California, USA, have shown marked declines and record lows for several pelagic fish species including the endemic delta smelt (*Hypomesus transpacificus*).While several of these species have shown evidence of long-term declines, there appears to have been a precipitous “step-change” to very low abundance during the period 2002-2004. It is presently unclear what might have caused this critical population decline, but toxic contaminants may be one of several factors acting individually or in concert to lower pelagic productivity. A toxicity monitoring program was initiated in 2005. Seventeen sites were selected among the California Department of Fish and Game survey stations and in accordance with the prevalent distribution patterns of fish species of concern. Biweekly 10-d toxicity tests were performed using the resident amphipod *Hyalella azteca* with and without the addition of PBO. In addition, testing protocols were developed for larval and juvenile delta smelt, and water samples from 6-7 sites tested during late spring/early summer of each year. Toxicity data obtained to date suggest that water quality is at times compromised in the lower Sacramento River/Deep Water Shipping Channel and Carquinez Strait near Benicia. Insecticides and ammonia were likely contributing to the observed toxicity to *H. azteca*.

CALFED Statement of Relevance
The results of this project will be used to geographically focus management actions in the Delta and assist in identifying the sources and quantifying the effects of contaminants on aquatic species of concern.

SESSION: Pelagic Organism Decline (III), 10/23/2008, 2:35 PM, Rooms 308-310

Teh, S.J.
UC Davis, Aquatic Toxicology Program, 1231 Haring Hall, Davis, CA 95616
sjteh@ucdavis.edu

Assessing Health Status of Delta Smelt in the Upper San Francisco Estuary

The health of wild populations of fish is a result of a series of complex interactions with numerous variables in the aquatic environment. The presence of toxic- and infectious- diseases is viewed as the ultimate health indicator because it represents the cumulative effects of multiple stressors, many of which may be unknown or poorly defined. In 2005, histopathological analysis revealed that adult smelt (*Hypomesus transpacificus*) populations in the Central Delta had better health than smelt in Suisun Bay, Suisun March, East Delta, and Sacramento Deep Water Ship Channel of the upper San Francisco estuary. In this POD session, the health status of larval, juvenile, and adult smelts sampled from the similar regions in years 2006 to 2008 will be presented. In addition, the beneficial of being larvae of larger females will be discussed.

CALFED Statement of Relevance
Understanding the health status of larval, juvenile, and adult delta smelts of different regions in the SFE will provide critical information to IEP POD management work team whose efforts are to protect and restore the smelt populations and habitats in the SFE

SESSION: Pelagic Organism Decline (III), 10/23/2008, 2:55 PM, Rooms 308-310

Riordan[1], D.D., B.D. Adam[2]
[1]California Department of Water Resources, 901 P St, Sacramento, CA 95814
[2]USEPA, 26 W. MLK Cincinnati, OH 45236
driordan@water.ca.gov

In-Situ Exposure of Fish for Biomarker Experimentation at DWR Real-Time Monitoring Sites

For decades, the field of aquatic toxicology has assessed the health of water bodies using, primarily, laboratory based static-renewal toxicity tests. In recent years, there has been a push to supplement traditional toxicity tests with experiments using molecular biomarkers to determine the physiological and biochemical responses of an organism to specific stressors. Molecular changes often result from the direct binding of a toxicant to its cognate receptor and thus are toxicant specific. Because they occur proximal to exposure, these changes are often tied directly to the toxicity and can potentially inform the mechanism of action. One of the most well characterized molecular biomarkers is vitellogenin (Vtg) gene expression. Vtg is usually quiescent in males. but can be induced upon exposure to estrogenic compounds, which have been shown to negatively affect the reproductive capacity of aquatic vertebrates. We have designed a system that screens for estrogen mimicking compounds while exposing male fish in-situ. During two successive years, adult male fathead minnows (*Pimephales promelas*) were exposed to ambient water in flow through systems at two DWR field sites, the Sacramento river at Hood and the San Joaquin River at Vernalis, for seven days for four successive weeks in both low and high flow periods. The second year had an additional 28-day exposure concurrent with the four single week exposures. Upon test termination, the brain, liver and gonads of each individual were removed and flash-frozen. Liver samples were analyzed for Vtg expression using Real-Time quantitative Polymerase Chain Reaction analysis and all samples were analyzed for histological anomalies. For year one, Vtg gene expression was elevated for several weeks at the Hood field station. Year two QPCR and histological results are pending. These data indicate the presence of estrogenically active substances in the Sacramento River, which coincides with periods of high flow.

CALFED Statement of Relevance
This work describes the assessment of estrogenic exposure of deployed fish in two California rivers, the Sacramento and the San Joaquin. This was accomplished using a novel in situ deployment method coupled with QPCR analysis of vitellogenin gene expression.

SESSION: Pelagic Organism Decline (IV), 10/23/2008, 3:35 PM, Rooms 308-310

Bennett[1], W.A., S.J. Teh[2], J.A. Hobbs[3]
[1]Center for Watershed Science, UC Davis, Bodega Marine Laboratory, Bodega Bay, CA 94923
[2]UC Davis
[3]UC Berkeley
wabennett@ucdavis.edu

Artificial and Natural Selection in a Changing Climate: the "Big Momma Hypothesis", and Understanding the POD.

The oft'-cited hypothesis for the Pelagic Organism Decline (POD) is that multiple factors are responsible. These are loosely categorized as (1) changes in the extent of estuarine habitat and food web due to invasive species, (2) chemical pollutants, and (3) water export operations. However, the POD problem is not new; decades of work shows that "finding the cause(s)" of fish declines is extremely difficult. We provide a logical and logistical framework for approaching such questions. First, we categorize multiple factors by effect on individuals, and populations, with regard to life history strategy in space and time. We then evaluate the role of multiple factors, or potential "causes", in the recent decline of delta smelt. Evidence is compared from the period “before” the population collapsed (1999-2001) with recent years (2005-2006) “after” the decline. Patterns in selective mortality in the “before” period indicate that fish larger-at-age or with higher growth rates generally also had higher survival to the adult stage (in December): a pattern consistent with life history and recruitment theory. In contrast, however, patterns of survival in the “after” period were generally opposite, with survivors initially smaller-at-age and growing slower than average. Data on exposure to pesticides, poor feeding success, and habitat quality, as well as prevailing climatic conditions, are then used to assess the likely influences of these patterns. Overall, the results suggest “artificial” size-selection, i.e. entrainment of larvae from larger females in water export operations, systematically interfered with natural selection and played a significant role in the decline: the so-called "Big Momma" hypothesis. However, current climate trends appear to be further warping the naturally adaptive landscape for delta smelt. Finally, the implications are outlined for approaching problems with other POD species and in other systems.

CALFED Statement of Relevance
Our study has important implications for the primary CALFED objectives. We provide a logical and logistical framework for evaluating the relative importance of multiple factors involved in the Pelagic Organism Decline, and in particular, the decline of delta smelt.

SESSION: Pelagic Organism Decline (IV), 10/23/2008, 3:55 PM, Rooms 308-310

Kimmerer[1], W.J., G. McManus[2], Y. Joanna[2], A. Gould[3], T. Ignoffo[3], A. Parker[3], A. Slaughter[3]
[1]San Francisco State University, Romberg Tiburon Center, Tiburon, CA 94920
[2]University of Connecticut, Avery Point Marine Lab, Groton, CT
[3]Romberg Tiburon Center, 3152 Paradise Drive, Tiburon CA 94920
kimmerer@sfsu.edu

CALFED Foodweb Project: Structure and Function of the Foodweb of the Low-Salinity Zone in the San Francisco Estuary

One of the contributing factors to the Pelagic Organism Decline may be the low abundance of copepods in the low-salinity zone (LSZ), which may limit production of delta smelt and other pelagic fish. This low level is believed due to low primary productivity coupled with the small size of the primary producers. A CALFED-funded project examined this foodweb in spring-summer of 2006-2007; details appear in several other presentations. Box modeling showed a modest subsidy of chlorophyll from the Delta to the LSZ, small compared to in situ primary productivity. However, the subsidy of phytoplankton-derived organic matter from the Delta may be larger, and has been invoked to explain high bacterial carbon demand in the LSZ. The foodweb is longer and more reticulate than originally believed. Incubation experiments showed that the base of the foodweb up to copepods was weakly coupled, indicating extensive omnivory and multiple trophic pathways. Copepods occupied a higher trophic level than in most systems, with two species probably at the sixth trophic level, resulting in a very low foodweb efficiency. Productivity of the copepod species examined was modest, with specific growth rates around 10-15% d-1 in summer. Abundance of calanoid copepods, more common food of small fish than the smaller cyclopoids, occurs across two gradients: a temporal gradient increasing from spring to the summer maximum, and a decrease from freshwater into the LSZ, probably due to grazing by clams. These gradients increase variability in the LSZ compared to the freshwater Delta, especially in spring when several fish species are likely sensitive to food concentration. The transport of copepods from freshwater to the LSZ therefore provides an essential subsidy to that region. The importance of transport between sub-regions of the estuary means that large changes in flow patterns may have unpredictable consequences for the aquatic ecosystem.

CALFED Statement of Relevance
The Pelagic Organism Decline is a huge impediment to restoration of the Delta and resolution of the major issues surrounding water project operations, not least because of the lack of understanding of its causes. This project is helping to understand this decline and contributing processes.

SESSION: Pelagic Organism Decline (IV), 10/23/2008, 4:15 PM, Rooms 308-310

Loboschefsky[1], E.J.*, A. Massoudieh[1], T.R. Ginn[1], K.A. Rose[2], F.J. Loge[1]
[1]University of California, Davis, Department of Civil & Environmental Engineering, One Shields Ave., Davis, CA 95616
[2]Louisiana State University, Department of Oceanography & Coastal Sciences, Coastal Fisheries Institute, 218 Wetland Resources, Baton Rouge, LA 70803
elobo@ucdavis.edu

Comparative Analyses of Factors Influencing the Decline of the Striped Bass (Morone saxatilis) Population in the San Francisco Bay Delta

Recent declines in the abundance of striped bass (*Morone saxatilis*) in the Sacramento Delta and San Francisco Bay (Bay-Delta) have increased the need for casual identification. Evidence suggests that health effects associated with multiple stressors in the Bay-Delta have substantially contributed to the decline of the striped bass population. Stressors can affect fish health through changes in growth, movement, reproduction, and survival, which in turn, can lead to decline in population numbers. The challenge of understanding this decline calls for data-supported quantification of relationships between the dynamics of striped bass population numbers and ecosystem components that affect survival. To address this challenge, a population life-cycle model that integrates field and laboratory data into a quantitative measure of the impact of multiple stressors on striped bass population dynamics has been developed. The model addresses important constitutive relationships at each life-stage that govern striped bass movement, growth, contaminant uptake, mortality and fecundity in the Bay-Delta. This overall model is subdivided into an egg/larvae component, represented by a distributed model, and a juvenile/adult component, represented by an individual based model. The use of two different model types reflects largely on the differences governing constitutive relationships at each respective life stage. This modeling approach allows for the evaluation of population level effects under multiple different simulations by varying flows, contaminant concentrations, prey availabilities and habitat suitability.

CALFED Statement of Relevance
The development of a striped bass life cycle model aims to assess the significance of contaminants relative to other factors (e.g., food web modifications and water exports, to mention a few) in the Pelagic Organism Decline (POD) conceptual model on the observed decline in population numbers.

SESSION: Pelagic Organism Decline (IV), 10/23/2008, 4:35 PM, Rooms 308-310

Thomson[1], J.R., K. Newman[2], R. Mac Nally [1], W. Bennett[3], W. Kimmerer[4], F. Feyrer[5]
[1]Monash University, School of Biological Sciences, Clayton, Victoria, 3079
[2]US Fish and Wildlife Service
[3]University of California, Davis
[4]San Francisco State University
[5]California Department of Water Resources
jim.thomson@sci.monash.edu.au

A Bayesian Change-point Approach to Characterizing Temporal Patterns in Fish Abundances in the Upper San Francisco Estuary

We examined temporal trends in abundance indices and catch per unit effort data for nine fish species in the upper San Francisco Estuary. Our goal was to characterize temporal trends and to identify any abrupt "change-points" in abundance–time relationships that may indicate altered environmental conditions or population dynamics. We used Bayesian change-point models to simultaneously estimate the number and timing of any changes in the slope (i.e. rate change) or intercept (i.e. step change) in abundance – time relationships for each species. This approach provides an objective test for the presence of abrupt changes without the need to specify a priori when such changes may have occurred. We then refitted models allowing for the inclusion of covariates to determine whether temporal patterns (trends or change-points) could be predicted by key environmental variables. Six species (delta smelt, longfin smelt, striped bass, yellowfin goby, northern anchovy, and splittail) showed evidence of long-term declines in abundance since monitoring began (1967 or 1980). Abrupt declines in abundance were detected for four species (delta smelt, longfin smelt, striped bass, northern anchovy) in the early 1980s and for three species (Delta smelt, striped bass, threadfin shad) in 2002. For delta smelt and striped bass, the magnitude of 2002 declines was small relative to earlier declines and only evident on the log-scale. While variation in mean abundances of several species can be partially predicted by variables such as freshwater flow, Pacific Decadal Oscillation, and species-specific habitat indices, these variables alone cannot explain the long-term declines or step changes for any species.

CALFED Statement of Relevance
This paper will present preliminary results from the Pelagic System Dynamics Working Group, convened by the National Center for Ecological Analysis and Synthesis (NCEAS) and the Interagency Ecological Program (IEP) to investigate fish declines in the upper San Francisco Estuary.

SESSION: Pelagic Organism Decline (IV), 10/23/2008, 4:55 PM, Rooms 308-310

Fujii, R., B.A. Bergamaschi, T. Kraus, J.A. Fleck, B.A. Pellerin, M. Fram
U.S. Geological Survey, 6000 J St., CSUS Campus, Placer Hall, Sacramento, CA 95819
rfujii@usgs.gov

Land Use Influence on Dissolved Organic Carbon in the Sacramento-San Joaquin River Delta and Its Tributaries

Over the past couple of decades we have learned much about the contribution of different sources of dissolved organic carbon (DOC) to water diverted for municipal, domestic, and agricultural uses from the Delta. We also have gained considerable knowledge into the biogeochemical and hydrological processes that control the release and transport of DOC from different land uses and open-water habitat. This talk focuses on what we have learned about the relative contributions of DOC sources to the Delta. In the past, the general conceptual model for DOC in the Delta was that relatively "clean" water from the Sacramento River, the major source of water exported from the Delta, traversed the Delta to diversion points in the south Delta. It was previously thought that peat island drainage pumped over levees into channel waters contributed, much of the time, the largest loads of DOC to the Delta overall. Today, research has shown that this conceptual model was inaccurate and much too simple. A revised conceptual model includes a considerable amount of variability in DOC contributions both seasonally and as a function of water year type – wet or dry. We also have been able to quantify the variable inputs from numerous sources of DOC to the Delta. The Sacramento River watershed generally contributes the largest load of DOC, 50 – 90%, and in-Delta sources contribute variable amounts: wetlands, 5 – 30%; algae, about 5%; and peat island drainage, 5 – 40%. Recent and current research is focusing on DOC contribution from out-of-Delta sources – watershed, urban, and floodplain. For example, a recent study of Sacramento urban drainage found that urban sources, on a short term basis, can add as much as 3-93% of the total organic carbon load to the Sacramento River. Implications of these findings relative to potential formation of disinfection byproducts also will be discussed.

CALFED Statement of Relevance
Discusses what we have learned about sources of DOC in the Delta and its tributaries over the past couple of decades. These results demonstrate that what was thought in the past is not correct and the situation is much more complicated.

SESSION: Land Use and Drinking Water Quality (I), 10/23/2008, 8:20 AM, Rooms 311-313

DiGiorgio[1], C.L., E. Archibald[2], J. Sickman[3], R. Pisor[1], M. Zanoli[4]
[1]Department of Water Resources, MWQI Program, PO Box 942836, Sacramento, CA 94236
[2]Archibald Consulting, 1604 Potrero Way
[3]University of California, Riverside
[4]California Department of Public Health
caroldi@water.ca.gov

Organic Carbon Dynamics Associated with a Rapidly Urbanizing Watershed to the Sacramento River

Steelhead Creek drains approximately 181 square miles in one of the fastest growing urban areas in the Sacramento metropolitan area and the State. Steelhead Creek flows into the Sacramento River immediately upstream of the confluence of the American and Sacramento River. The Sacramento River provides drinking water to the Sacramento area, and to millions of Californians. Beginning in 1997, the Department of Water Resources began studying this urban drainage as it transitioned from agricultural to urban land uses to obtain information on the loads of drinking water constituents entering the Sacramento River and the Delta. In 2004, a CALFED grant provided support for DWR and the Dry Creek Conservancy to conduct in-depth monitoring of the area. This talk focuses on organic carbon contributions from the drainage. During the dry season, total organic carbon (TOC) and dissolved organic carbon (DOC) concentrations generally ranged between 4 and 6 mg/L. During the wet season, concentrations generally increased and ranged between 6 and 10 mg/L. During first flush events, TOC concentrations ranged between 9 and 36 mg/L. Average monthly TOC loads ranged from 10,000 kg/month, in the dry season to approximately 500,000 kg/month during the wet season. Load contributions from Steelhead Creek were compared to loads in the Sacramento River at Hood, and urban loads contributed by the Sacramento Regional Wastewater Treatment Plant (SRWTP). The SRWTP contributed the greatest urban loads during the dry months, while Steelhead Creek contributed the greatest loads during storm events. As a percent of the TOC load in the Sacramento River at Hood, the daily load from Steelhead Creek ranged from 3 to 93 percent. On, a monthly basis, Steelhead Creek contributed between 0.1 to 8.2 percent of the load to the Sacramento River at Hood.

CALFED Statement of Relevance
This study quantifies the TOC load to the Sacramento River from a rapidly urbanizing area in the Sacramento area and the State. Understanding the effects of urbanization to Sacramento River water quality is necessary for informed policy decisions regarding a resource with multiple, competing, needs.

SESSION: Land Use and Drinking Water Quality (I), 10/23/2008, 8:40 AM, Rooms 311-313

Engelage[1], S.K., W.T. Stringfellow[2], T. Letain[2]
[1]Lawrence Berkeley National Laboratory, 1 Cyclotron Road, Berkeley, CA 94720
[2]Ecological Engineering Research Program, University of the Pacific, Sears Hall, 3601 Pacific Ave., Stockton, CA 95211
skengelage@lbl.gov

Disinfection Byproduct Formation Potential of Wetlands, Rivers, and Agricultural Drains in the San Joaquin River Watershed

Concern has developed over the presence of trihalomethane (THM) precursors detected in the San Joaquin River (SJR) Watershed, an important source of drinking water for over 20 million people. THM precursors diminish drinking water quality and are formed during natural decomposition of reactive organic matter in aquatic systems. This study sought to identify sources of reactive dissolved organic carbon (DOC) in the SJR watershed and to determine if wetlands were more important sources of THM precursors than nearby rivers and agricultural drains. Samples from wetlands, rivers, and agricultural drainages were analyzed for DOC, biochemical oxygen demand, suspended solids, UV absorbance, specific UV absorbance (SUVA254), trihalomethane formation potential (THMFP), specific THMFP, bromide, and chlorophyll concentrations. Results show wetland drainage contained comparable bromide concentrations and organic carbon aromaticity, but contained more than two times the average DOC concentrations found in regional agricultural drains and rivers. DOC concentration was found to be a good surrogate for the total reactivity of heterogeneous water samples (THMFP = 86.65DOC – 49.62, r2 = 0.9272). Aromatic content, as measured by SUVA254, was found to be a poor surrogate for reactivity across sites. Results from this study indicate that regional wetlands have not measurably increased the specific reactivity of DOC in the SJR watershed; however, the continued restoration of wetlands may increase concentrations of THM precursors in the SJR due to higher organic carbon concentrations in wetland drainage.

CALFED Statement of Relevance
This study compared wetland trihalomethane formation potential with that of nearby rivers and agricultural drains in the San Joaquin River Watershed. Results have implications for wetland restoration and drinking water treatment.

SESSION: Land Use and Drinking Water Quality (I), 10/23/2008, 9:00 AM, Rooms 311-313

Ruark, M.D., B.A. Linquist, C.A. van Kessel, S.W. Johan, R.G. Mutters, C.A. Greer, J.E. Hill
University of California-Davis, 1 Shields Ave. S., Davis, CA 95616
mdruark@ucdavis.edu

Dissolved Organic Carbon Losses from Rice Production Systems in Northern California

Rice production systems dominate the landscape of California's Sacramento Valley. Historically, rice straw was burned after harvest, but since the mid-1990s, most rice straw is incorporated and the fields are flooded during winter months to promote decomposition. While this practice has improved air quality, some water quality concerns have arisen related to the potential increase in dissolved organic carbon (DOC). Greater quantities of DOC exported into surface waters can affect in-stream biogeochemical processes, and in turn, the quality of drinking water. The objectives of this study were to (1) measure seasonal concentrations and fluxes of DOC from rice fields and (2) assess how varying straw and water management practices affect DOC losses. At four locations, straw-burned and straw-incorporated fields were monitored between 20065 and 2008. Water samples were collected from field inlets and outlets during winter flooding and growing season flooding. Weirs and pressure sensors were used to estimate drain flow. During the first month of winter flooding, DOC concentrations among all straw-incorporated fields ranged between 35 and 77 mg L-1. Burned fields were not typically flooded over winter, but DOC concentrations in runoff ranged between 6 and 14 mg L-1. At the onset of drainage during the growing season, DOC concentrations from straw-incorporated fields were larger (2 sites) or similar (2 sites) compared to straw-burned fields. No practical differences in DOC concentration were observed later in the growing season. Results indicate that changes in rice straw management have increased annual DOC fluxes from these agricultural systems. However, additional research needs to be conducted to evaluate the chemical nature of rice field DOC in order to assess how much Sacramento River DOC originates from rice production systems.

CALFED Statement of Relevance
Little information is available regarding losses of dissolved organic carbon (DOC) from agricultural systems in northern California. These results are the first to quantify seasonal losses and concentrations of DOC from rice production systems.

SESSION: Land Use and Drinking Water Quality (I), 10/23/2008, 9:20 AM, Rooms 311-313

Pellerin[1], B.A., P.A. Bachand[2], P.J. Hernes[3], W.R. Horwath[3], S.J. Deverel[4], R.G. Spencer[3], N. Oh[3], B.A. Bergamaschi[1]
[1]US Geological Survey, CA Water Science Center, 6000 J Street, Placer Hall, Sacramento, CA 95831
[2]Bachand and Associates, Davis, CA 95618
[3]UC-Davis, LAWR, One Shields Ave, Davis, CA 95616
[4]Hydrofocus, Inc., Davis, CA 95618
bpeller@usgs.gov

Organic Matter Dynamics in an Agricultural Watershed: Sources, Significance, and Strategies to Reduce Drinking Water Concerns

Organic matter from the breakdown of plant and animal material is a significant concern for drinking water quality in California owing to the potential formation of carcinogenic disinfection byproducts (DBPs) during treatment. Several studies have shown that the majority of dissolved organic carbon (DOC) at Delta drinking water intakes is from upstream rivers, where land use and land-cover change is evident. The Willow Slough Watershed Study was funded by CALFED to investigate the sources and significance of organic matter in a model Central Valley agricultural watershed. In addition, the study is evaluating the potential for developing and implementing practical management strategies that reduce organic matter and DBP concerns in upstream source waters. Here we present data from the 415 km2 Willow Slough watershed over 3 years and across a range of hydrologic conditions to evaluate the trends, sources and reactivity of organic matter in an agricultural landscape. Using a watershed approach and a suite of qualitative analyses that include specific DBP formation potential, optical measurements, isotopes and biomarkers, we have revealed seasonal and event-based organic matter dynamics in surface waters indicative of both anthropogenic and natural watershed processes. Our results indicate low winter baseflow DOC concentrations (2-4 mg/L) related to in situ algal production and ground water discharge, and elevated summer DOC concentrations (6-8 mg/L) due presumably to field runoff and sediment carbon transport. In contrast, high DOC concentrations during winter storms (7-10 mg/L) reflects terrestrial runoff from headwaters and fields with a relatively high propensity to form DBPs. The management of DOC and DBP precursors at the farm to watershed scale may include further improvements in irrigation efficiencies and practices that promote the transport of runoff along subsurface flowpaths with a high abiotic and biotic capacity to retain organic matter.

CALFED Statement of Relevance
This research enhances our understanding of a fundamental process affecting dissolved organic matter (DOM) cycling in agricultural watersheds, which is essential for managing drinking water quality and maintaining ecosystem health in the Bay-Delta, two of the CALFED Program goals.

SESSION: Land Use and Drinking Water Quality (I), 10/23/2008, 9:40 AM, Rooms 311-313

Bachand[1], P.A., B. Pellerin[2], S. Prentice[1], S.M. Bachand[1], T. Pritchard[1], B. Bergamaschi[2]
[1]Bachand & Associates, 2023 Regis Drive, Davis, CA 95618
[2]USGS, Sacramento, CA
phil@bachandassociates.com

Differences in DOC, Nutrients and Particulate Export Concentrations and Loads between Agricultural Land Uses and the Implications on Cultural Practices

An agricultural watershed is composed of a mosaic of land uses and crop types. Within the 415 km2 Willow Slough watershed, agriculture crops (rice, alfalfa, walnuts, grapes, tomatoes, peppers, sunflowers, pasture and orchard grass), irrigation techniques (e.g. drip, flood, sprinklers) and other cultural practices vary widely. The complexity of these agricultural systems and their associated management practices complicate general statements regarding agriculture's contribution of dissolved organic carbon (DOC), nutrients and other particulate and dissolved constituents from fields to sloughs. Associated with these different crop types is a complex and extensive water delivery system that begins with small-scale and temporary farmer maintained ditches through sloughs and rivers that ultimately transport surface waters through and from the watershed. These networks also contribute to the export of DOC and other constituents of concern. For the Willow Slough Watershed Study, we initiated a number of intensive winter and summer field-scale studies focusing on several crop types (e.g. orchard grass, alfalfa, walnuts, rice, corn and sunflowers) to differentiate changes in and transport of dissolved and particulate constituents. We sampled for DOC, nitrogen, phosphorus and TSS in a series of intense, event-based studies (e.g. rain events, irrigation events). Additionally, we measured surface water flows in order to develop hydrologic and load budgets. Concurrently, we conducted studies on associated drainage ditches to characterize their contributions to constituent transport. Our 2007 summer data show only slight changes in dissolved constituent concentrations across furrowed fields but large changes across fields receiving short-term flood irrigation. In contrast, particulate concentrations increase across furrowed fields and in drainage ditches, but do not in flood irrigated fields. Understanding the mechanisms controlling transport facilitates the development of cultural practices to manage exported DOC and particulate loads and concentrations from the different crop types.

CALFED Statement of Relevance
This research investigates field level management implications for an agricultural watershed and differentiates water quality and load exports based upon the different crop types and associated cultural practices. This study differentiates between likely mechanisms controlling transport of dissolved and particulate contaminants and discusses implications on hydrology and BMPs.

SESSION: Land Use and Drinking Water Quality (II), 10/23/2008, 10:20 AM, Rooms 311-313

Mailapalli, D.R., W.W. Wallender, W.R. Horwath
University of California, Davis, Department of Land, Air and Water Resources, 224, Viehmeyer Hall, One Shields Ave., Davis, CA 95616
dmailapalli@ucdavis.edu

Spatial and Temporal Variations of Dissolved Organic Carbon in Furrow Irrigation Systems

The runoff from furrow-irrigated fields enters surface waters and potentially causes downstream water quality impairment. Since surface water is the major source of drinking water for over two-thirds of Californians, measures need to be taken to reduce the impact of irrigation runoff. Organic materials, which produce dissolved organic carbon (DOC) in runoff, are responsible for degraded taste, odor and color of water and the formation of carcinogenic disinfection byproducts during water treatment. One of the important methods of controlling surface water pollution is to use best management practices (BMPs) such as conservation tillage (CT) and use of cover crops (CC) in furrow irrigated fields, which reduce the transport of organic materials by promoting water infiltration into soil. Landscape characteristics such as slope and field length may impact the efficacy of BMPs. The objective of our research is to investigate BMPs, which can mitigate the runoff and therefore the DOC from furrow fields by studying spatial and temporal variations. A furrow irrigated field of 1200 feet in length with three treatments, cover crop (CC), no-till (NT) and standard tillage (ST) with three replications (at Russell Ranch facility, UC Davis) was used in our study. During two days of irrigation, water samples were collected at regular time intervals from 400 and 800 feet distances along the length of all treatments and the tail end water samples were collected using ISCO auto-samplers. The water samples were used to determine DOC concentrations and analyzed for spatial and temporal variations with respective to the cultivation practices. At each location, initially, the DOC concentration was highest and then decreased gradually interspersed with a series of peaks for all treatments. The high initial DOC concentration is likely due to the initial flush of water through soil and crop residue. This is followed by gradual decrease to background levels (i.e. 4 to 3 mg/L). The increase in field length increased the volume averaged DOC concentration for a given treatment. For a given field length, the volume averaged DOC concentration was more in NT (15 to 3 mg/L) than CC (8 to 3 mg/L) and ST (12 to 3 mg/L). The regression analysis between DOC concentrations and runoff rates shows very poor correlation. This study suggested that longer furrow fields with winter cover cropping could mitigate DOC concentration in irrigation runoff.

CALFED Statement of Relevance
The results of the irrigation experiments show that conservation tillage and cover cropping have varying effects on DOC export on/from agriculture fields. This information is important in devising strategies to reduce DOC export and to maintain irrigation efficiency in Bay-Delta Systems.

SESSION: Land Use and Drinking Water Quality (II), 10/23/2008, 10:40 AM, Rooms 311-313

Burger, M., W.R. Horwath, I. Park, K.M. Scow, B. Smith, W.W. Wallender
University of California Davis, Dept. of Land, Air and Water Resources, Davis, CA 95616
mburger@ucdavis.edu

Cover Crop and Field Configuration Effects on Sediment, Nutrient and Pesticide Load in Agricultural Runoff

Agriculture is the biggest consumer of water and contributes to pollution in the form of sediment, nutrients, and pesticides in runoff water that feeds back into streams and rivers. In furrow-irrigated systems, the practice of winter cover cropping has the potential to slow down storm runoff by increasing infiltration. Furthermore, furrow length and slope can be expected to affect runoff. To quantify concentrations and seasonal load of water quality constituents, discharge from seven grower fields in Yolo county was monitored by automated water samplers, and concentrations of nitrogen and phosphorus in organic and mineral form, sediment, and 8 common pesticides in the runoff water were measured during four winter storm seasons. Concentrations of nutrients were within drinking water standards at all times, and seasonal load was less than 1 percent of the applied fertilizer. Total seasonal sediment load was between 0 and 16 kg per ha from cover-cropped fields and between 4 and 617 kg per ha from fallow fields. Metolachlor was the pesticide most consistently detected in runoff. Concentrations of metolachlor were inversely related to discharge volume and were not correlated with sediment concentrations. The results indicate that non-point source pollution from agricultural runoff is low regardless of field configuration except for sediment loss. Total load of constituents affecting water quality depends on discharge rather than concentration. Therefore, the practice of cover cropping can improve water quality by reducing runoff.

CALFED Statement of Relevance
Improvement of surface water quality as a result of a reduction in contaminated runoff is a CALFED priority.

SESSION: Land Use and Drinking Water Quality (II), 10/23/2008, 11:00 AM, Rooms 311-313

Saraceno[1], J.*, B.D. Downing[1], B.A. Pellerin[1], P.A. Bachand[2], B.A. Bergamaschi[1]
[1]USGS, 6000 J St Placer Hall, Sacramento, CA 95819
[2]Bachand and Associates, Davis, CA
saraceno@usgs.gov

DOM Dynamics during a Storm Event in an Agricultural Watershed: Insights on Changes in DOM Composition from Optical Measurements

Dissolved organic matter (DOM) receives considerable attention in California due to its impact on drinking water quality. Storms are important forcing events on the landscape. However, the extent to which they impart rapid changes in biogeochemical variables is poorly understood. In situ measurements are useful as they can be made autonomously at high temporal resolution, aiding in the quantification of rapid changes in the DOM pool. We collected in situ and discrete samples during a storm event (Feb 22nd - March 3rd) at the mouth of the 415 km2 agricultural Willow Slough watershed. The watershed is characterized by steep grasslands in the headwaters and agriculture (largely in alfalfa, rice, tomato, grasses and orchard) in the valley. The in situ measurements included turbidity and DOM absorbance and fluorescence which were critical in capturing high frequency changes in water quality. Discharge and turbidity were strongly correlated during a period of rapid increase (two orders of magnitude). In situ DOM absorbance and fluorescence correlated well with laboratory dissolved organic carbon (DOC) concentrations providing a highly resolved proxy for DOC throughout the flow event. Baseflow DOC concentrations (2.6 mg/L) increased to 9.8 mg/L during peak flow (38 cubic meters per second), while specific UV absorbance, an indicator of DOC aromaticity, doubled at the peak in DOC concentration. Spectral slope, a proxy for DOM molecular weight, decreased from 0.018 to 0.013 in less than twenty four hours. Peak DOC followed the peak in turbidity by ten hours and recessed to 3.1 mg/L over the study period. These results suggest rapid movement of allochthonous DOM through the watershed during storm events, with post-peak DOC presumably from the draining of soils and surface runoff of natural and agricultural landscapes. Together, laboratory and in situ data provide insights into the range and magnitude of changes in DOM quantity and quality during a storm event.

CALFED Statement of Relevance
Dissolved organic matter (DOM) receives considerable attention in California due to its impact on drinking water quality. Storms are important forcing events on the landscape. However, the extent to which they impart rapid changes in biogeochemical variables is poorly understood.

SESSION: Land Use and Drinking Water Quality (II), 10/23/2008, 11:20 AM, Rooms 311-313

Chow, A.T., A.T. O'Geen, R.A. Dahlgren
Dept. of Land, Air, and Water Resources, UC Davis, Davis, CA 95616
atchow@ucdavis.edu

Disinfection Byproduct Formation Potentials of Dissolved Organic Matter from Foliar Litter in Oak Woodland Watersheds

Oak woodlands are a significant physiographic component in California representing an estimated 3 million hectares in the interior valleys and foothills of Central California. Water from these landscapes ultimately flow to the Sacramento-San Joaquin Delta, which is a source of drinking water for 23 million people. Of particular concern is the export of dissolved organic matter (DOM) from oak woodland watersheds into the surface water system because DOM has been identified as a precursor of disinfection byproducts (DBPs) formed during drinking water chlorination. To better understand dissolved organic matter leaching dynamics in California oak woodlands, leachates of fresh and decomposed litter (defined as duffs) from four dominant plants in oak woodlands, including blue oak (*Quercus douglassii* H. & A.), live oak (*Quercus wislizenii* A. DC.), foothill pine (*Pinus sabiniana*), and annual grass were collected for an entire rainy season to evaluate the formation potentials of two chlorinated DBPs: trihalmethanes (THMs) and haloacetonitriles (HANs). Results showed that a majority of DBP precursors was leached in the earlier portion of the rainy season. DBP precursors from duffs with dissolved organic carbon (DOC) to dissolved organic nitrogen (DON) ratio less than 40 had lower THMs but higher HANs formation as compared to DOM from fresh litters with DOC/DON greater than 40. Blue oak litter had the highest yield of DOC and DBP precursors whereas annual grass duff contributed the most DON and inorganic N per mass of C in starting materials. Due to larger biomass and area coverage at the watershed scale, blue oak duff was the major source of DBP precursors. Results demonstrated that foliar litter in oak woodlands watershed could be a source of DBP precursors in the Sacramento-San Joaquin Delta

CALFED Statement of Relevance
Export of DOM from foliar litter in oak woodland watersheds into the Sacramento-San Joaquin Delta is uncertain. This study evaluated the temporal changes in the quantity of DOC, DON, and DBP formation potential in leachates from foliar litter.

SESSION: Land Use and Drinking Water Quality (II), 10/23/2008, 11:40 AM, Rooms 311-313

Sobota[1], D.J., J.A. Harrison[1], R.A. Dahlgren[2]
[1]Washington State University-Vancouver, Science Programs, Vancouver, WA, 98686
[2]University of California-Davis, Department of Land, Air and Water Resources, Davis, CA 95616
sobota@vancouver.wsu.edu

Input and Export of Nitrogen in Watersheds in the Central Valley, California: Annual and Seasonal Patterns

We present an original data set of N input and export for 25 watersheds in the Central Valley (CV) of California and use it to provide insights on annual and seasonal effects of climate, catchment geomorphology, and land use on watershed N dynamics in this diverse and rapidly changing region. Annual input of total N to CV watersheds was estimated for the late 1990s through early 2000s and ranged from 717 to 12,085 kg N per square km, similar to other agricultural regions in North America. Three key results emerged from this spatially-explicit analysis. First, agricultural N sources dominate N input to the CV as a whole (accounting for 60 and 81% of total N inputs to the Sacramento and San Joaquin River Basins, respectively). Second, the fractional export of N inputs for 21 of 25 watersheds was < 10% and appeared to respond to variation in temperature and stream flow, showing a similar pattern to eastern North American streams. Third, watersheds in the CV exhibited three general seasonal patterns of N export: dilution of N concentrations by releases from reservoir systems (8 watersheds), a peak in N concentrations coinciding with the onset of spring/summer fertilizer application (six watersheds), and a peak in N concentrations in the fall/early winter with the onset of the wet season (10 watersheds) (one watershed had no discernable seasonal pattern). These results suggest that improving N management within a relatively small area could disproportionately decrease the N load in CV rivers. For example, we estimated that agricultural lands in three major tributaries of the San Joaquin River, which made up only 10% of land area in the basin, contributed 34% of N exported from the entire San Joaquin watershed.

CALFED Statement of Relevance
This research addressed two of CALFED's main objectives: 1) improving ecosystem quality and 2) improving water quality. The budgets and models that we have developed specifically provide managers with insight into what land-based sources of N in individual watersheds are most important in contributing to water quality degradation.

SESSION: Land Use and Drinking Water Quality (III), 10/23/2008, 1:35 PM, Rooms 311-313

Horwath[1], W.R., D. Geisseler[1], S. Bachand[2], P.A. Bachand[2], S. Pettygrove[1], T. Pritchard[2]
[1]UC Davis, Dept. of Land, Air and Water Resources, Davis, CA 95616
[2]Bachand & Associates, 2023 Regis Drive, Davis, CA
wrhorwath@ucdavis.edu

Nitrogen Dynamics and Hydrology of Dairy Silage Crops

Dairy farms are under greater pressure to manage their lagoon water and other manure-containing wastes. High nitrate and salt levels in groundwater resulting from these systems are health and environmental concerns. In response, the SWQCB has begun more stringently regulating the industry. In 2005, the Central Valley RWQCB required all dairies to submit a Report of Waste Discharge. In May 2007, regulations were adopted requiring dairies to develop nutrient and manure management plans, establishing numeric limits on the manure nitrogen amount applied to cropland. The regulations will also require groundwater monitoring by dairies. This project addresses two critical areas related to dairy nitrogen dynamics and lagoon water application. First, though guidelines and strategies for managing inorganic N have been developed, organic N management is more difficult because mineralization rates are not well understood. Second, these systems are flood irrigated. The spatial and temporal heterogeneity associated with regard to infiltration into the vadose zone is not well defined. This project addresses both these areas. For this project, soil and surface water monitoring equipment and methods were implemented on a number of dairy farms with different cultural practices and underlying soil conditions. The collected hydrologic data are being used to develop hydrologic budgets and to quantify soil moisture changes in response to irrigation events. Soil and plant N levels are also being monitored during both summer and winter cropping seasons. These data are being used to develop an understanding of unsaturated zone soil nitrogen changes in response to fertigation events and to develop total system nitrogen budgets. For instance, dairy producers space out nutrient applications to correspond with crop uptake requirements. This method reduces nitrogen losses past the root zone. The USDA RZWQM model is being used with these data to better understand and to develop cultural practices for these cropping systems.

CALFED Statement of Relevance
The dairy industry is under increased scrutiny and regulation. Critical to understanding the lagoon water application effects is better quantification of 1) manure organic N fraction mineralization rates and of 2) surface and unsaturated zone hydrology. These findings will help in developing effective BMPs and a reasonable regulatory strategy.

SESSION: Land Use and Drinking Water Quality (III), 10/23/2008, 1:55 PM, Rooms 311-313

O'Geen[1], A.T., R. Dahlgren[1], J. Gan[2], N. Brauer[1], R. Budd[2], P. Diaz[1], A. Chow[1]
[1]UC Davis, Dept. of Land Air and Water Resources, Davis, CA 95616
[2]UC Riverside, Dept. of Environmental Sciences, Riverside, CA
atogeen@ucdavis.edu

Reducing Non-point Source Pollution with Constructed Wetlands

The conversion of marginal farmland to constructed wetlands is a common practice along the San Joaquin River. Many constructed wetlands were built to restore wildlife habitat and are maintained by tailwaters from surrounding farmland. Constructed wetlands have great potential to mitigate non-point source pollution from irrigated agriculture. We studied the efficacy of using constructed wetlands to remove water quality contaminants from tailwater. Four wetlands were monitored during the 2007 irrigation season, representing differences in size, design, and contributing area. Constructed wetlands ranged in size from 2 to 150 hectares and contributing areas varied from 300 to over 1,600 hectares. Input and output waters from constructed wetlands were collected on a weekly basis and analyzed for an extensive list of water quality contaminants. Nutrient, sediment, pathogen, and pesticide retention efficiencies were evaluated from input and output concentration data. Results show that certain wetlands were more efficient contaminant removal systems compared to others. All wetlands were highly effective at removing sediment (TSS). Average TSS removal efficiency was over 90%. Average P removal efficiency was low and only statistically significant at one site 20%. Average nitrate-N removal efficiency was high ranging from 40 to 90%. Removal of Pyrethroid pesticides was also high ranging from 62 to 95 % depending on the compound. The concentration of E. coli in the wetland input water changed widely over the season with 58% of the samples exceeding the maximum concentration for water quality regulations in California (126 ufc/100ml). Approximately 69.0 to 93.9% of total E. coli concentration was retained by the wetlands. Results demonstrate that constructed wetlands are effective filters for some contaminants. Wetland size and water residence time appear to the main factors that affect contaminant removal, however, exceedingly long residence times resulted in negative feedback mechanisms such as increased EC, dissolved organic carbon, and BOD.

CALFED Statement of Relevance
Best management practices that reduce non-point source pollution are needed for irrigated agriculture in the Central Valley. Constructed wetlands can improve water quality by filtering irrigation return flows ultimately destined for the San Joaquin River.

SESSION: Land Use and Drinking Water Quality (III), 10/23/2008, 2:15 PM, Rooms 311-313

Maynard, J.J.*, A.T. O'Geen, R.A. Dahlgren
University of California, Davis, One Shields Ave., Davis, CA 95616
jjmaynard@ucdavis.edu

Carbon Dynamics in a Constructed Flow-through Wetland in the San Joaquin Valley, California

In the U.S., an estimated one third of all eroded material is deposited in small sediment sinks such as wetlands. Constructed and restored wetlands are being used in California to treat agricultural runoff, and may serve as important carbon sinks. This study examines the spatial and temporal dynamics of carbon and sediment accumulation to evaluate the potential for carbon sequestration in an eight-year-old seasonally saturated constructed wetland. Net sedimentation and net above-ground biomass were measured in 2004 and 2005. Sediment cores were collected to the antecedent (time zero) soil layer, which ranged between 2 and 50 cm below the surface. All samples were analyzed for total carbon. The spatial variability of carbon and sediment accumulation was modeled with geostatistics. Average sediment accumulation rate, nearly doubled from 2004 to 2005, with rates of 5.8 kg m-2 y-1 (range: 0-80 kg m-2 y-1) in 2004 and 11.9 kg m-2 y-1 (range: 0-93 kg m-2 y-1) in 2005. Average carbon accumulation rate did not change between years, with rates of 0.290 kg m-2 y-1 in 2004 and 0.294 kg m-2 y-1 in 2005, indicating a change in carbon source between years. Average carbon content in the top 2.5 cm of the wetland surface was 24 g kg-1 and decreased to 10 g kg-1 in sediment directly overlaying the antecedent layer. Average total carbon content of soils in the contributing watershed is 8 g kg-1. This indicates an enrichment of carbon in the surface layer due to the addition of endogenous carbon sources. Average carbon content in sediment directly above the antecedent layer was similar to topsoil in surrounding agricultural land, indicating no net loss of carbon from transported sediment. Wetlands can play a significant role in carbon storage through processes such as in-situ enrichment and protection of carbon deposited by erosion.

CALFED Statement of Relevance
Constructed and restored wetlands are being used in California to treat agricultural runoff, and may serve as important carbon sinks. This study shows that wetlands can play a significant role in carbon storage through processes such as in-situ enrichment and protection of carbon deposited by erosion.

SESSION: Land Use and Drinking Water Quality (III), 10/23/2008, 2:35 PM, Rooms 311-313

Brauer, N.E.*, S. Lee, A.T. O'Geen, R.A. Dahlgren
University of California Davis, 1 Shields Avenue, PES Building, Davis, CA 95616
nebrauer@ucdavis.edu

Denitrification in Constructed Wetlands: Protecting Groundwater from Nitrate Contamination

It has been well documented that constructed wetlands effectively remove nitrate from agricultural runoff. However, the fate of nitrate in water lost as downward seepage is not known, and could be a potential source of groundwater contamination. The site for this study is a constructed flow-through wetland adjacent to the San Joaquin River, receiving irrigation return flows from 420 ha of farmland. Approximately 80% of the water received was lost to deep seepage. We monitored denitrification potential (DNP), redox potential, and pore water nitrate concentration at 12 locations at depths of 10, 50, and 100cm below the sediment surface. Nitrate concentration in pore water was compared to that in the wetland water column at each location. There was an average 85% reduction of nitrate from 13.9 mg L-1 in the surface water to 2.0 mg L-1 at the 100 cm depth. Redox potentials varied with depth and location, but were consistently below nitrate reduction levels throughout the season. Average, denitrification potential under ambient conditions in the upper 10 cm was 168g NO3- m-2 day-1. DNP was non detectable at most locations at the 50 and 100 cm depths. DNP significantly increased in the incubation study with the addition of nitrate, indicating nitrate limitation. Results indicate that allowing seepage from constructed wetlands facilitates nitrate removal and is not a source of groundwater pollution.

CALFED Statement of Relevance
Nitrate contamination of ground and surface water resources due to agricultural non-point source pollution is of great concern in the San Joaquin valley. High denitrification rates in constructed wetlands allowing seepage facilitate the removal of nearly all nitrate, protecting groundwater from contamination.

SESSION: Land Use and Drinking Water Quality (III), 10/23/2008, 2:55 PM, Rooms 311-313

Sickman[1], J.O., C. DiGiorgio[2], E. Archibald[3], M. Zanoli[4]
[1]University of California, Riverside, Department of Environmental Sciences, Riverside, CA 92521
[2]Department of Water Resources, Sacramento, CA 94236-0001
[3]Archibald and Wallberg Consulting, Sacramento, CA 95822
[4]California Department of Public Health, Sacramento, CA 95899-7377
jsickman@ucr.edu

Effects of Urbanization on Nitrogen and Phosphorus Loads in the Sacramento River

To gain better understanding of the effects of urbanization on nutrient transport in the Sacramento River, we quantified total and inorganic N and P loading from point and non-point urban sources within the metropolitan area of Sacramento and compared these inputs to nutrient loads carried in the downstream Sacramento River. Data used in the study come from a multi-year study of Steelhead Creek in Sacramento, discharges from the Sacramento Regional Wastewater Treatment Plant and water quality monitoring in the Sacramento River at Hood. In Steelhead Creek total N ranged from < 0.1 to 6.6 mg/L, nitrate plus nitrite ranged from < 0.01 to 5.7 mg/L, and ammonium ranged from < 0.01 to 0.32 mg/L. Total P concentrations ranged from < 0.01 to 1.33 mg/L and soluble reactive phosphorus concentrations ranged from < 0.01 to 1.2 mg/L. The median total N concentration in Steelhead Creek, 2.2 mg/L, was more than 10x the median concentration in the Sacramento River, 0.20 mg/L. Median total P median concentrations were 0.06 mg/L in the Sacramento River and 0.39 mg/L in Steelhead Creek. Steelhead Creek alone contributes between 0.6 and 19.2 percent of the nitrate plus nitrite load to the Sacramento River, with an average contribution of 7.5 percent. Steelhead Creek contributes 0.6 to 14 percent of the load in the Sacramento River at Hood, with an average contribution of 5 percent. The highest nutrient contributions from Steelhead Creek occurs in the wet season.

CALFED Statement of Relevance
Understanding of linkages between land use and nutrient inputs is critically needed to inform restoration efforts in the Sacramento-San Joaquin Delta.

SESSION: Land Use and Drinking Water Quality (IV), 10/23/2008, 3:35 PM, Rooms 311-313

Oki[1], L.R., D. Haver[2], S. Bondarenko[3], R. Mazalewski[1], T. Majcherek[2], S. Greco[1], J. Kabashima[2], M. Yates[3], J. Gan[3]
[1]University of California, Dept of Plant Sciences, MS6, Davis, CA 95616
[2]UC Cooperative Extension, 1045 Arlington Dr., Gate 4, Costa Mesa, CA
[3]University of California, Dept of Environmental Sciences, Riverside, CA 92521
lroki@ucdavis.edu

Characterizing Runoff from Residential Sources

In a statewide collaborative project characterizing the runoff from single family residences, 4 neighborhoods in Sacramento County and Orange County were selected for monitoring based on size, type and age of homes, drainage conditions, and lack of other land-use types. Equipment installed at each site monitors and records flow velocity, depth, pH, conductivity, temperature, and rainfall. Runoff samples are collected every 1-2 weeks at drainage outfall sites in those neighborhoods that contain between 152 to 460 homes each. Runoff samples from the first few storms of the season are also collected. Sample collection began in Sacramento County in July 2006, in October 2006 in Orange County, and will continue through 2008. All samples are analyzed to determine levels of: a) pathogens including total coliforms, *E. coli*, *enterococci, Clostridium perfringens*, somatic coliphage, male-specific coliphage, *Cryptosporidium, Giardia*; b) nutrients (nitrate, TKN, phosphate, total P); c) drinking water quality standards including: organic carbon (TOC & DOC), bromide, chloride, total dissolved solids, total suspended solids, turbidity; and d) pesticides, specifically: diazinon, chlorpyrifos, pyrethroids (esfenvalerate, bifenthrin, permethrin, cyfluthrin, cypermethrin, deltamethrin, fenpropathrin, L-cyhalothrin), and fipronil. Pollutant loading models of dry season runoff will be developed utilizing the flow data. Model parameters include landscape features and temporal (hourly) flow variability. Loading from residential areas within larger watersheds will be estimated using these “neighborhood” models. Outreach focusing on methods to reduce irrigation water use and runoff and proper pesticide use is delivered to the homeowners in 2 of the neighborhoods in each county. Printed materials, demonstrations, and workshops are provided to these residents utilizing University of California Master Gardeners trained specifically for these outreach activities. Topics include ant control, the safe pesticide use, and lawn and landscape management. The effect of the outreach will be assessed through pre- and post survey results and continued runoff monitoring and analyses.

CALFED Statement of Relevance
This information will determine the quantities of water used to irrigate residential landscapes that may be conserved and the pollutants contained in runoff. This study will evaluate outreach methods that may reduce the runoff volumes and the pollutants therein.

SESSION: Land Use and Drinking Water Quality (IV), 10/23/2008, 3:55 PM, Rooms 311-313

Kraus[1], T.E., B.A. Bergamaschi[1], P.J. Hernes[2], R.G. Spencer[2], R. Stepanauskas[3], C. Kendall[4], R.F. Losee[5], R. Fujii[1]
[1]US Geological Survey, California Water Science Center, Sacramento, CA 95819
[2]UC Davis, Davis, CA
[3]Bigelow Laboratory for Ocean Sciences, West Boothbay Harbor, Maine
[4]US Geological Survey, Menlo Park, CA
[5]Metropolitan Water District of Southern California , La Verne, CA
tkraus@usgs.gov

Assessing the Contribution of Wetlands and Subsided Islands to Dissolved Organic Matter and Disinfection Byproduct Precursors in the Sacramento-San Joaquin River Delta: A Geochemical Approach

This study assessed how rivers, wetlands, island drains and open water habitats within the Sacramento-San Joaquin River Delta affect dissolved organic carbon (DOC) content and composition, and disinfection byproduct (DBP) formation. Eleven sites representative of these habitats were sampled on six dates to encompass seasonal variability. Using a suite of qualitative analyses we applied a geochemical fingerprinting approach to characterize the DOC originating from different Delta habitats, infer DOC and DBP precursor sources, and estimate the relative DOC contribution from different sources. Although river input was the predominant source of DOC to the Delta, we observed that 13-49% of the DOC arriving at the Clifton Court export pumps originated from sources within the Delta, depending on season. Interaction with shallow wetlands and subsided islands significantly increased DOC and DBP precursor concentrations, and affected DOM composition, while deep open water habitats had little discernable effect. Shallow wetlands contributed the greatest amounts of DOC and DBP precursors in the spring and summer, in contrast to island drains which appeared to be an important source during winter months. The DOC derived from wetlands and island drains had greater haloacetic acid precursor content relative to incoming river water, while two wetlands contributed DOC with greater propensity to form trihalomethanes. These results suggest that large scale introduction of shallow wetlands in the Delta could alter existing DOC and DBP precursor concentrations, depending on their hydrologic connection to Delta channels.

CALFED Statement of Relevance
Understanding how existing Delta habitats affect channel water organic carbon concentration and composition will help us predict how future changes in land use might impact water quality in the Delta. This is particularly relevant in light of proposed large scale wetland restoration projects.

SESSION: Land Use and Drinking Water Quality (IV), 10/23/2008, 4:15 PM, Rooms 311-313

Ohara[1], N.N., M. Kavvas[1], Z.R. Chen[1], S. Bachand[2], P. Bachand[2], B. Bergamaschi[3], B. Pellerin[3], F.E. Anderson[3]
[1]University of California, Davis, Department of Civil and Environmental Engineering, Davis, CA 95616
[2]Bachand and Associates
[3]U.S. Geological Survey, 6000 J Street, Placer Hall, Sacramento, CA 95819
nohara@ucdavis.edu

Reconstruction of Hydrologic Regime toward Water Quality Modeling at Willow Slough Watershed

As most drinking water is taken from surface water, management of the drinking water constituents of concern (DWCC) release from source watersheds may be a cost effective way for drinking water quality improvement. In order to quantify the concentration and load of DWCC such as dissolved organic carbon (DOC) under various land management conditions from the watersheds, understanding of the hydrologic process is critical. The attempts toward modeling of the hydrologic/biogeochemical processes in a typical agricultural watershed in Central Valley, the Willow Slough watershed, are presented. The natural hydrologic condition in the watershed has been effectively modeled by the Watershed Environmental Hydrology (WEHY) model. However, it is found that, since the agricultural irrigation dominates the flow regime during early summer through late fall, the modeling of agricultural practices is needed for this study. As reliable data collection is a key to successful modeling for such a man-controlled watershed, the actual crop type, manmade irrigation and drainage channel network, and diverting and pumping locations in addition to the existing database have been surveyed. However, since some of the information on the important flow paths, such as the pumping rate from ground water and conveyance loss, are not accessible, a practical algorithm has been developed in order to estimate these missing variables. The computational results for discharge are validated at several locations within the watershed. It is noted that this methodology quantifies several flow paths: direct runoff, return flow from surface and ground water irrigation, consumptive use by crops, and seepage to the aquifer over the agricultural fields.

CALFED Statement of Relevance
The reconstructed hydrologic conditions at Willow Slough watershed will be used for the water quality modeling together with findings from the field studies of the DWCC.

SESSION: Land Use and Drinking Water Quality (IV), 10/23/2008, 4:35 PM, Rooms 311-313

Harter[1], T., C. Lawrence[1], E.R. Atwill[2], C. Kendall[3]
[1]University of California, 125 Veihmeyer Hall, Davis, CA 95616
[2]University of California, School of Veterinary Medicine, Davis, CA 95616
[3]U.S. Geological Survey, 345 Middlefield Rd., Menlo Park, CA 94025
ThHarter@ucdavis.edu

Groundwater Monitoring of Agricultural Discharges for Regulatory Compliance

Regulatory programs frequently require monitoring of first encountered (shallow-most) groundwater for purposes of determining whether an actual or potential, permitted or incidental waste discharge has had or will have a degrading effect on groundwater quality. Traditionally, these programs have focused on monitoring of incidental discharges from industrial sites. Increasingly, sources with an implied groundwater recharge are subject to monitoring requirements. These recharging sources include, for example, land application of municipal, food processing, or animal waste to irrigated cropland. Some programs use existing production wells for ambient monitoring of agricultural contaminants. Time of travel and significant vertical mixing in the well limit the usefulness of these for source monitoring. Other programs rely on monitoring well networks similar to those on industrial sites. Groundwater monitoring of a recharging source, however, requires a different approach to groundwater monitoring than traditional (incidental source) monitoring programs. Besides being an intentional source of groundwater recharge, the scale of these applications is orders of magnitude larger than typical point sources. Furthermore, the shallow groundwater aquifer targeted for compliance monitoring commonly consists of highly heterogeneous unconsolidated alluvial, fluvial, lacustrine, glacial, or subaeolian sediments of late tertiary or quaternary age. Particularly in arid and semi-arid climates, groundwater is also frequently subject to significant seasonal and interannual groundwater level fluctuations that may exceed ten feet seasonally and several tens of feet within a three- to five-year period. We developed a hydrodynamically rigorous approach to designing groundwater monitoring wells for recharging sources under conditions of aquifer heterogeneity and water level fluctuations. The approach was applied to the design of a monitoring well network for monitoring confined animal farming operations (CAFOs) with irrigated crops located on alluvial fans with highly fluctuating, deep groundwater table.

CALFED Statement of Relevance
With the new dairy WDR and the irrigated agriculture waiver, the state, for the first time, is moving to regulate and monitor nonpoint sources of potential groundwater contamination. Currently, monitoring well networks are the regulatory tool of choice to monitor compliance. Our work proposed, implements, and evaluates an alternative approach to constructing monitoring wells and their networks on agricultural systems.

SESSION: Land Use and Drinking Water Quality (IV), 10/23/2008, 4:55 PM, Rooms 311-313

Kirlin, J.
Delta Vision Blue Ribbon Task Force, 650 Capitol Mall, Sacramento, CA 95814
John.Kirlin@resources.ca.gov

Delta Vision Strategic Plan

Established by Governor Schwarzenegger's Executive Order S-17-06, the Delta Vision Blue Ribbon Task Force was to "develop a durable vision for sustainable management of the Delta" with the goal of "...managing the Delta over the long term to restore and maintain identified functions and values that are determined to be important to the environmental quality of the Delta and the economic and social wellbeing of the people of the state." It also directed the Task Force to develop a Strategic Implementation Plan by October 2008. The Task Force completed the "Delta Vision" in December 2007. This Vision contains 12 integrated and linked recommendations that set Delta ecosystem and a reliable water supply as the primary, co-equal goals for sustainable management of the Delta. As part of the on-going development of the Delta Vision Strategic Plan, the Task Force established four working groups - ecosystem, water supply and reliability, Delta as place, and governance and finance – to provide strategic recommendations to the Task Force across its four topic areas. These working groups, combined with continued input from the Stakeholder Coordination Group that was first established to provide input into the "Delta Vision" are integral components of the setting for the Delta Vision Strategic Plan.

CALFED Statement of Relevance
The Governor's Delta Vision Blue Ribbon Task Force established four working groups - ecosystem, water supply and reliability, Delta as place, and governance and finance – to provide strategic recommendations to the Task Force across its four topic areas. This effort is part of the Strategic Plan process that uses the Task Force's "Delta Vision", completed in December 2007, which contains 12 integrated and linked recommendations that set Delta ecosystem and a reliable water supply as the primary, co-equal goals for sustainable management of the Delta. This presentation will include the general background of the Delta Vision and the Draft Strategic Plan and discuss how the recommendations of the work groups are integrated into the final plan.

SESSION: Delta Vision: A Durable Vision and Strategy for a Sustainable Delta, 10/23/2008, 8:20 AM, Room 314

Siegel, S.
Wetland and Water Resources, Inc., 818 5th Ave, Suite 208, San Rafael, CA 94901
stuart@swampthing.org

Ecosystem Workgroup Recommendations

The Ecosystem Workgroup was charged by the Delta Vision Blue Ribbon Task Force to recommend strategies that would ensure that the Delta ecosystem functions as an integral part a healthy ecosystem and that the ecosystem and water supply reliability will be co-equal goals. The workgroup recommended that by achieving a set of desired ecosystem characteristics, this vision could be achieved. The five characteristic are: 1) Viable populations of native resident and migratory species; 2) Functional corridors for migratory species; 3) Diverse mosaics of habitats and ecosystem processes; 4) Stressors below adverse effects levels; and 5) Provide important human services. From these, the work group developed key strategic principles and then set indicators for the characteristics with associated performance goals.

CALFED Statement of Relevance
The Governor's Delta Vision Blue Ribbon Task Force established four working groups - ecosystem, water supply and reliability, Delta as place, and governance and finance – to provide strategic recommendations to the Task Force across its four topic areas. This effort is part of the Strategic Plan process that uses the Task Force's "Delta Vision", completed in December 2007, which contains 12 integrated and linked recommendations that set Delta ecosystem and a reliable water supply as the primary, co-equal goals for sustainable management of the Delta. This presentation will cover the relationship of the Ecosystem Workgroup to the Task Force's effort and the specific recommendations of this work group.

SESSION: Delta Vision: A Durable Vision and Strategy for a Sustainable Delta, 10/23/2008, 8:40 AM, Room 314

Young, G.
Tully & Young, 3600 American River Drive, Suite 260, Sacramento, CA 95864

Water Supply and Reliability Workgroup Recommendations

This talk will address strategies proposed to resolve water supply and reliability issues and conflicts under the Delta Vision paradigm. Specific strategies will focus on improving regional self-sufficiency, managing diversions from the Delta watershed, shifting timing and patterns of water diversions, improving water quality for anthropogenic contaminants and managing naturally occurring contaminants, new and modified storage and conveyance facilities, institutionalizing the Reasonable Use and Public Trust Doctrine, and several cross cutting issues. Embedded within these overarching strategies are many additional approaches, such as water conservation, improved regional water planning, water transfers, surface and groundwater storage, and facilities operations.

CALFED Statement of Relevance
The Governor's Delta Vision Blue Ribbon Task Force established four working groups - ecosystem, water supply and reliability, Delta as place, and governance and finance – to provide strategic recommendations to the Task Force across its four topic areas. This effort is part of the Strategic Plan process that uses the Task Force's "Delta Vision", completed in December 2007, which contains 12 integrated and linked recommendations that set Delta ecosystem and a reliable water supply as the primary, co-equal goals for sustainable management of the Delta. This presentation will cover the relationship of the Water Supply and Reliability Workgroup to the Task Force's effort and the specific recommendations of this work group.

SESSION: Delta Vision: A Durable Vision and Strategy for a Sustainable Delta, 10/23/2008, 9:00 AM, Room 314

Tully, G.
Tully & Young, 3600 American River Drive, Suite 260, Sacramento, CA 95864

Governance and Finance Workgroup Recommendations

The Governance and Finance Workgroup was charged by the Delta Vision Blue Ribbon Task Force to recommend strategies to resolve governance and finance issues and conflicts as the Delta Vision Strategic Plan is implemented. The workgroup set up three overarching themes: responsibility, clarity, and adaptability. From this, they devised strategies including recommendations for a governing entity, a science and engineering advisory entity, an entity with land use authority, and a conservation management entity. These entities would, in coordination, follow a "Plan" that will be developed to provide details on how to manage towards attainment of the co-equal goals of ecosystem health and water reliability as well as identified land use issues in the Delta region. The Plan will ensure coordination, cooperation, consistency and transparency in decision making in regards to the Delta and will require specific types of funding. Categories of funding include: acquiring ownership interests in lands; levee improvements and maintenance; floodplain improvements; emergency management actions; studies and reports for understanding climate change; high priority ecosystem revitalization projects; and water supply reliability including improvements in water conveyance, groundwater storage, surface water storage, conservation programs, and water recycling and reuse.

CALFED Statement of Relevance
The Governor's Delta Vision Blue Ribbon Task Force established four working groups - ecosystem, water supply and reliability, Delta as place, and governance and finance – to provide strategic recommendations to the Task Force across its four topic areas. This effort is part of the Strategic Plan process that uses the Task Force's "Delta Vision", completed in December 2007, which contains 12 integrated and linked recommendations that set Delta ecosystem and a reliable water supply as the primary, co-equal goals for sustainable management of the Delta. This presentation will cover the relationship of the Governance and Finance Workgroup to the Task Force's effort and the specific recommendations of this work group.

SESSION: Delta Vision: A Durable Vision and Strategy for a Sustainable Delta, 10/23/2008, 9:20 AM, Room 314

Mraz, D.
California Dept. of Water Resources, PO BOX 942836, Sacramento, CA 94236
dmraz@water.ca.gov

Delta as Place Workgroup Recommendations

This portion of the Delta Vision Strategic Plan will identify specific actions that will achieve the key goals of the Vision for the Delta as a place, and preserve it as a unique and valued area. Specific goals of this section are, 1) to increase recognition and protection of the Delta, enhance agriculture, and expand tourism and recreation; 2) to discourage inappropriate urbanization and to foster a land use pattern that enhances the region; 3) to reduce flooding risks and to strengthen selected portions of the levee system; and 4) to reduce risks to the critical infrastructure crossing the region.

CALFED Statement of Relevance
The Governor's Delta Vision Blue Ribbon Task Force established four working groups - ecosystem, water supply and reliability, Delta as place, and governance and finance – to provide strategic recommendations to the Task Force across its four topic areas. This effort is part of the Strategic Plan process that uses the Task Force's "Delta Vision", completed in December 2007, which contains 12 integrated and linked recommendations that set Delta ecosystem and a reliable water supply as the primary, co-equal goals for sustainable management of the Delta. This presentation will cover the relationship of the Delta as Place Workgroup to the Task Force's effort and the specific recommendations of this work group.

SESSION: Delta Vision: A Durable Vision and Strategy for a Sustainable Delta, 10/23/2008, 9:40 AM, Room 314

Suddeth, R.J.*, J. Mount, J. Lund
UC Davis, Center for Watershed Sciences, Davis, CA 95616
rjsuddeth@ucdavis.edu

Sustainability of Delta Levees

The landscape of the Sacramento-San Joaquin Delta is defined by its network of 1100 miles of levees. Poor foundations, design and construction make the levees prone to failure, with consequent flooding of Delta islands. Additionally, on-going sea level rise, subsidence, seismicity and changing inflows will increase the rate of levee failure with time. Management of increased island flooding in the Delta poses a major challenge. A fundamental issue is where to invest in levee upgrades and whether to repair levees once they fail. This study presents an economic-based model for prioritizing island levee upgrades and repairs. We focus here on 34 non-urban subsided islands. Model inputs include property values for each island, the failure probability of each island, levee upgrade costs, and the effectiveness of upgrades at reducing failure probabilities. Our initial analysis indicates that it is economically optimal for the state to not upgrade all 34 Delta islands examined, mostly due to the high cost of levee upgrades that produce little relative improvement in levee reliability. Our analysis also suggests that from an economic perspective, taking into account land and asset values (including infrastructure), it is not cost effective to repair between 10 and 19 of these islands when they fail. This initial analysis has several important limitations. It is based solely on economic valuation and does not incorporate other values. These results also are based on limited economic and geotechnical information from various sources. Regardless of limitations, an important and inescapable conclusion of this analysis is that maintaining the current Delta landscape is unlikely to be economical from a statewide perspective. For this reason, we envision a future Delta with large tracts of open water as levees are not repaired and islands remain flooded.

CALFED Statement of Relevance
This talk focuses on the sustainability of Delta Levees, and evaluates various possible levee policies for the Delta.

SESSION: Future Delta Ecosystem and Water Supply, 10/23/2008, 10:20 AM, Room 314

Fleenor[1], W.E., E. Hanak[2], J. Lund[1], J. Mount[1]
[1]UC Davis, 2634 Regatta Lane, Davis, CA 95618
[2]PPIC
wefleenor@ucdavis.edu

Hydrodynamics and Salinity of the Future Delta

An initial assessment of the salinity implications of four broad strategies for managing Delta water exports is presented. The four strategies include: (1) continued pumping of exports through the Delta (the current policy), (2) diverting water upstream and conveying it around the Delta through a peripheral canal, (3) combining the current through-Delta pumping strategy with a peripheral canal (so-called "dual conveyance" or "dual facility"), and (4) ending exports altogether. Salinity implications of two main aspects of change in the Delta over this century: one to three feet of sea level rise and increased island flooding are considered. The focus is on salinity, the water quality characteristic of primary interest to water users and the one most easily represented in most models. Change will occur in the Delta, with outcomes of export possibilities depending on what conveyance strategy is chosen, how the system is operated, and how sea level and climate conditions evolve. With sea level rise predicted over the next century, initial model simulations suggest significant increases in salinity in the Delta, eventually pushing Delta salinity beyond reasonable levels for drinking water and irrigation unless large (and costly) increases in Delta outflows or reductions in upstream use and exports are made. Similarly, permanently flooded western islands significantly increase salinity intrusion into the Delta. In contrast, some islands elsewhere in the Delta might be pre-flooded without long-term effects on Delta salinities. Modeling concurrent sea level rise and island flooding was not done, but these two effects would be at least additive, making Delta salinity conditions difficult indeed for both urban and agricultural users. The approach represents a first cut at predicting trends and magnitudes of likely changes with different export management strategies and changed natural conditions. The analysis also points to many areas that require more detailed modeling work to more thoroughly evaluate issues related to sea level rise, island flooding, and the effects of operational changes (notably varying the timing of exports and the operation of upstream reservoirs) both now and in the future.

CALFED Statement of Relevance
Considers future changes to the Delta as relevance to water supply and quality.

SESSION: Future Delta Ecosystem and Water Supply, 10/23/2008, 10:40 AM, Room 314

Moyle, P.B., W.A. Bennett
UC Davis, Center for Watershed Sciences, 1 Shields Ave, Davis, CA 95616
pbmoyle@ucdavis.edu

Ecosystem and Fishes of the Future Delta

The future of the Delta ecosystem is best viewed by using fish as indicators because they are major drivers of ecosystem-related policy. We address four basic questions. (1) What species of fish are important (desirable) for making decisions that affect ecosystem function? (2) What are likely to be attributes of the Delta ecosystem in the future? (3) What are the likely effects on fish of the four strategic export intake alternatives; (4) What actions could improve the Delta for desirable fish? An analysis of the characteristics of the most abundant fishes in the Delta indicates that they fall into five distinct groups that respond differently to environmental change. The present Delta has environmental conditions that consistently are unfavorable for desirable species. The condition of the Delta will most likely change to a system with much more open water, with poorly understood effects on fishes (although most likely better than the present system for most desirable fishes). Of four basic water management options, only halting exports completely from the Delta is likely to significantly improve conditions for desirable fishes, although new invasions of harmful species can even reduce the positive effects of this option. Without significant improvements to Delta habitats, continuing to export large amounts of water from the South Delta will most likely continue the decline of many desirable fish species. Numerous actions can be taken to improve conditions in the Delta and Suisun Marsh for desirable fishes, but all require innovative management and some will require major land and channel manipulations.

CALFED Statement of Relevance
The Delta ecosystem is a central concern of CALFED.

SESSION: Future Delta Ecosystem and Water Supply, 10/23/2008, 11:00 AM, Room 314

Lund, J.R.
Center for Watershed Sciences, University of California, Davis, CA 95616
jrlund@ucdavis.edu

Decision Analysis of Strategic Water Export Options

Only four possible strategies exist for taking water from the Delta: a) through the Delta (current policy), b) around the Delta (some sort of peripheral canal), c) both through and around the Delta, and d) not take water from the Delta at all. We compared the statewide economic cost and fish population viability performance of each strategy in a context of uncertainty. The major costs involved were quantified, along with expert assessments of how these choices would affect the likelihood of having viable fish populations for delta smelt and Chinook salmon. Using standard decision analysis, the costs and decisions included the likelihood of failure for each strategy, with a peripheral canal failing to improve fish populations and earthquake or other extensive failure for through Delta operations. The results of the analysis were a range of fish and economic performance for each strategy. For the fish objective alone, ending exports was the most favorable alternative, having the best chances of supporting viable fish populations in 2050. Where both fish and statewide economic objectives are considered to be “co-equal,” a peripheral canal export strategy was found to be superior. The current through-Delta export policy was found to be inferior for both fish and statewide economic objectives. These conclusions were found to be unexpectedly robust to uncertainties in all scientific and technical estimates. However, the implementation details of these strategies are very important for both fish and economic objectives. Much institutional and policy work remains on selecting a better Delta export strategy and a great deal of scientific work remains on how to best implement a preferred strategy.

CALFED Statement of Relevance
Classical decision analysis is applied to a major Delta policy decision

SESSION: Future Delta Ecosystem and Water Supply, 10/23/2008, 11:20 AM, Room 314

Hanak, E.E.
Public Policy Institute of California, 500 Washington St., San Francisco, CA, 94111
hanak@ppic.org

Translating Science into Long-term Delta Policy

Science and engineering analysis of Delta problems is often somewhat detached from decisionmaking. This seems true both in the sense of decisionmaking not being overly concerned with scientific findings, and scientific and engineering studies not being particularly or directly relevant to decisionmaking problems. This presentation discusses some possible approaches to bringing science and engineering analyses into the forefront of policy discussions, drawing on the experiences of the two PPIC-UC Davis studies, Envisioning Futures for the Sacramento-San Joaquin Delta (2007) and Comparing Futures for the Sacramento-San Joaquin Delta (2008). Tools that have been particularly useful in these analyses include syntheses of the existing science, application of available quantitative modeling tools to address key policy questions, solicitation of expert judgment to inform questions for which hard data are unavailable, and use of decision analysis to synthesize large amounts of information and put bounds on ranges of uncertainty in the data. An interdisciplinary approach – involving physical, natural, and social sciences – has been important for shaping the research questions and analyses. Consultation with stakeholders has been a valuable scoping tool. Although this process has helped to bring science into discussions of long-term policy alternatives for the Delta, it also highlights the need for more systematic solution-oriented science and engineering work going forward. Some options for institutionalizing a more solution-oriented approach are explored.

CALFED Statement of Relevance
Part of a session on the report "Comparing Futures for the Sacramento-San Joaquin Delta"

SESSION: Future Delta Ecosystem and Water Supply, 10/23/2008, 11:40 AM, Room 314

Scarborough, K.
Undersecretary for Resources, 1416 Ninth Street #1311, Sacramento, CA 95628
karen.scarborough@resources.ca.gov

The Bay Delta Conservation Plan (BDCP) – A Collaborative Approach to Restore the Delta Ecosystem and Protect Water Supplies

The BDCP is being developed in response to continued ecosystem decline in the Delta and resultant unreliability of water supplies. Its purpose is to help recover endangered and sensitive species and their habitats in the Delta in a way that will provide for sufficient and reliable water supplies. It is being developed under the Federal Endangered Species Act and the California Natural Community Conservation Planning Act and will undergo extensive environmental analysis, both including opportunities for public review and comment. The BDCP is being prepared through a voluntary collaboration of state, federal and local water agencies, state and federal fish agencies, environmental organizations and other interested parties. The BDCP will identify and implement conservation strategies to improve the overall ecological health of the Delta, while providing for environmentally sensitive ways to move fresh water through and/or around the Delta. It will also provide a framework to implement the plan over time. The conservation strategy for the BDCP will be available by the end of 2008 with a draft of the full plan available by the middle of 2009.

SESSION: Integrating Science and Management (I), 10/23/2008, 1:35 PM, Room 314

Wilcox[1], C.G., R.M. Grossinger[2], D.E. Rankin[1], S.M. Summers[1], A.A. Whipple[2], C.L. Sears[1], B.C. Hogan[1], E.E. Beller[2]
[1]California Department of Fish and Game, 830 S Street, Sacramento, CA 95811
[2]San Francisco Estuary Institute, 7770 Pardee Lane, Oakland, CA 94621
CWilcox@dfg.ca.gov

Pre-modification Habitat Mosaics of the Sacramento-San Joaquin Delta: The use of Historical Data to Identify Potential Subregional Ecosystem Targets for the ERP Conservation Strategy

A detailed understanding of pre-modification ecosystem characteristics has been an important tool for large wetland ecosystem restoration efforts in the US (e.g. South Florida, San Francisco Bay, Puget Sound). However, information about the habitat mosaics and subregional variations of the historical Sacramento-San Joaquin Delta does not exist at a spatial scale sufficient to inform regional ecological planning, including the CALFED Ecosystem Restoration Program Conservation Strategy. To address this data gap, we are applying recently developed methodologies for historical landscape reconstruction and analysis to the Delta, focusing on the pre-modification habitat characteristics of the North and South Delta and the linkages to adjacent lowlands and floodplains. A number of previously-unanalyzed data sources (including Mexican land case materials and field notes of the General Land Office) provide detailed technical information that illustrates regional and local variations in the distribution of large lacustrine features, extent of tidal influence, broad versus narrow riparian forest, and the character of the wetland-terrestrial ecotone. The historical reconstruction of Delta habitat patterns will help to better understand regional variations in native species support functions and controlling physical processes within the native landscape. Such information will provide a basis for identifying target locations and physical conditions necessary to restore sustainable habitat mosaics in the projected future Delta landscape.

CALFED Statement of Relevance
The study is designed to help scientists identify what habitats should be restored where as part of the CALFED Ecosystem Restoration Program Conservation Strategy, with particular consideration of less well-documented aspects of the Delta ecosystem such as the fluvial-tidal linkage and the upland ecotone transition zone.

SESSION: Integrating Science and Management (I), 10/23/2008, 1:55 PM, Room 314

Clamurro, L.E.
California Department of Fish and Game, Water Branch, 830 S Street, Sacramento, CA 95811
lclamurro@dfg.ca.gov

The ERP Conservation Strategy for the Delta and Suisun Planning Area: A Common Blueprint to Guide Ecosystem Restoration

State and federal fish and wildlife agencies (CA Department of Fish and Game, National Marine Fisheries Service, and U.S. Fish and Wildlife Service) are the entities responsible for implementation of the CALFED ERP (Ecosystem Restoration Program). Evaluation of ERP implementation during Stage 1 shows that despite significant investment and progress in some areas of the program, the problems plaguing the Sacramento-San Joaquin Delta estuary have worsened, as evidenced by the precipitous decline in abundance of pelagic fish and food web organisms since 2000 (the Pelagic Organism Decline, or POD). While many factors are cited as contributing to the POD, the agencies are approaching these problems from the broad perspective of restoring key ecological processes to influence the quality and extent of functional habitats, while ameliorating stressors, to achieve species recovery targets. The ERP Conservation Strategy for the Delta and Suisun Planning Area is the first of several regional conservation plans that is being prepared to guide implementation of the ERP during Stage 2. It describes ecosystem restoration goals, objectives, and priorities for the Delta and Suisun Planning Area, and is intended to be used as a “blueprint” to facilitate the coordination and integration of restoration actions among all resource planning, conservation, and management decisions affecting the Delta and Suisun Planning Area. Through the use of newly-developed conceptual models which are compilations of best available scientific knowledge for Bay-Delta ecosystem processes, habitats, stressors, and species, agency managers will be better able to determine monitoring needs to measure the outcomes of restoration actions, and to quickly adapt program implementation in light of new information.

CALFED Statement of Relevance
The ERP Conservation Strategy for the Delta and Suisun Planning Area is a reflection of what was learned from ERP implementation during Stage 1, and identifies where investment should be focused in the future. Because ERP is an established, ongoing program, it is intended that those undertaking restoration actions use the Conservation Strategy to help guide their activities and to pursue collaborative partnerships to achieve mutual goals.

SESSION: Integrating Science and Management (I), 10/23/2008, 2:15 PM, Room 314

Golet[1], G.H., T. Gardali[2], C. Howell[2], J. Hunt[3], R. Luster[1], W. Rainey[4], M. Roberts[1], J. Silveira[5], H. Swagerty[6], N. Williams[7]
[1]The Nature Conservancy, 500 Main St, Chico, CA 95928
[2]PRBO Conservation Science
[3]California State University Chico
[4]UC Berkeley
[5]USFWS
[6]River Partners
[7]Bryn Mawr College
ggolet@tnc.orgt

Wildlife Response to Riparian Restoration on the Sacramento River

Studies that assess the success of riparian restoration projects seldom focus on wildlife. More generally vegetation characteristics are studied, with the assumption that animal populations will recover once adequate habitats are established. On the Sacramento River, millions of dollars have been spent on habitat restoration, yet few studies of wildlife response have been published. Here we present the major findings of a suite of studies that assessed responses of four taxonomic groups (insects, birds, bats, and rodents). Study designs fell primarily into two broad categories: comparisons of restoration sites of different ages, and comparisons of restoration sites with agricultural and remnant riparian sites. Older restoration sites showed increased abundances of many species of landbirds and bats relative to younger sites, and the same trend was observed for the Valley elderberry longhorn beetle, a federally threatened species. Species richness of landbirds and ground-dwelling beetles appeared to increase as restoration sites matured. Young restoration sites provided benefits to species that utilize early successional riparian habitats, and after about ten years, the sites appeared to provide many of the complex structural habitat elements that are characteristic of remnant forest patches. Eleven-year old sites were occupied by both cavity nesting birds and special-status crevice roosting bats. Restored sites also supported a wide diversity of bee species, and had similar richness to remnant sites. Remnant sites had species compositions of beetles and rodents more similar to older sites than to younger sites. Because study durations were short for all but landbirds, results should be viewed as preliminary. Nonetheless, in aggregate, they provide convincing evidence that restoration along the Sacramento River has been successful in restoring riparian habitats for a broad suite of faunal species.

CALFED Statement of Relevance
This talk is relevant because it presents data on wildlife species response to horticultural riparian restoration efforts on the Sacramento River. CALFED funded some of these restoration projects and studies.

SESSION: Integrating Science and Management (I), 10/23/2008, 2:35 PM, Room 314

Luster, R.A., M.D. Roberts, G.H. Golet
The Nature Conservancy, 500 Main Street, Chico, CA 95928
rluster@tnc.org

The Nature Conservancy's 20 Years of Sacramento River Riparian Habitat Conservation

In 1989 The Nature Conservancy initiated its Sacramento River Project whose goal is to conserve and restore a 33,000 acre riparian corridor between Red Bluff and Colusa. The Nature Conservancy has developed a three-pronged approach to achieve this goal: 1) acquire flood prone lands from willing sellers, 2) conduct riparian habitat restoration, and 3) facilitate and investigate how to encourage natural river processes. Since 1989, TNC has directly acquired or assisted with the acquisition of over 25,000 acres within the Sacramento River floodplain through fee title or conservation and agricultural easements. The majority of these conservation acres are now in state or federal ownership (U.S. Fish and Wildlife Service, Department of Fish and Game, State Parks) providing recreation access for people, critical habitat for threatened and endangered wildlife, and flood damage reduction. The Nature Conservancy pioneered the science of riparian habitat restoration on the Sacramento River developing the restoration techniques that are now accepted and utilized by other conservation and resource managers. Since 1989, TNC has restored over 4,600 acres and planted over 1.1 million native plants between Red Bluff and Princeton. The riparian restoration techniques TNC developed on the Sacramento River are now employed on rivers throughout California and the world. TNC has recently completed a study investigating the relationship between river flow and the health of certain species dependent on the river through its Sacramento River Ecological Flows Study. The results from this study will allow resource managers to understand the positive and negative impacts water management operations have on Sacramento River dependent species. The Nature Conservancy has been able to carry out a significant proportion of its Sacramento River work thanks to the generosity of the CALFED program. This talk will discuss the evolution of TNC’s Sacramento River conservation activities over the last 20 years.

CALFED Statement of Relevance
The Nature Conservancy has been able to carry out a significant proportion of its Sacramento River work thanks to the generosity of the CALFED program. This talk will discuss the evolution of TNC’s Sacramento River conservation activities over the last 20 years.

SESSION: Integrating Science and Management (I), 10/23/2008, 2:55 PM, Room 314

Gutstein[1], J.J., T.Y. Garcia[2], P.E. Alvarez[3], M.E. Harns[1], O.G. Garzon[4], R. Marovich[5]
[1]John Muir Institute of the Environment, University of California, Davis, Davis, CA 95616
[2]Dept of Chemistry, University of California, Davis
[3]Defenders of Wildlife, Sacramento, CA
[4]Cunningham Engineering Corporation, Davis, CA
[5]Solano County Water Agency, Elmira, CA
jjgutstein@ucdavis.edu

Engaging Local Communities Increases Success of Ecosystem Restoration Projects

Long term protection of restored watersheds is enhanced through the voluntary actions of those who have access to the restored areas. A CALFED-funded riparian restoration project on a stretch of Putah Creek adjacent to an economically disadvantaged community presented an opportunity for fostering environmental stewardship and a sense of place. We developed a community stewardship program to accompany the restoration led by the Lower Putah Creek Coordinating Committee. Graduate students, participating in an innovative UC Davis Environmental Liaison Program, engaged community members in activities directly relevant to restoration goals and in roles consistent with participant availability, age, and interests. Strategies included adult participation in initial riparian restoration design; multi-aged groups in seasonal plantings and cleanups; weekly nature club for youth; occasional teen field trips; multi-aged educational talks, demonstrations, and hands-on activities (water quality monitoring). Activities were conducted in English and Spanish. Findings, gathered from a summative analysis, indicated marked changes in community awareness and attitudes towards the creek, increased interest and participation in restoration activities, and increased knowledge of local plants and animals. Additional liaison-led activities with indirect relevance to riparian restoration (helping design a butterfly garden, planting trees in the playground) contributed to maintaining relationships with community members. Partnerships with local agencies, nonprofits, and university programs also contributed to success with partners applying knowledge gained to nearby community sites. We conclude that ongoing, culturally appropriate, and responsive interaction with local communities adjacent to or with preferential access to targeted environmental resources is critical to the development of stewardship that leads to long term success of ecosystem restoration projects. The university-based liaison program offers a model for effective low cost accompaniment to scientific investigation and ecosystem restoration. Resource managers need take such findings into account in planning for citizen-based resource protection, particularly with populations with historically low participation.

CALFED Statement of Relevance
Directing a small portion of funding for CALFED objectives to tightly linked, culturally appropriate, liaison-led community participation is an effective way to develop enduring citizen-based resource protection, particularly if built into initial project design. The sustained nurturing of youth involvement also provides a foundation for long term environmental stewardship.

SESSION: Integrating Science and Management (II), 10/23/2008, 3:35 PM, Room 314

Langridge, S.M.*
UC Santa Cruz, Environmental Studies, Santa Cruz, CA 95064
sml@ucsc.edu

Using Science in Collaborative Restoration Processes: Transboundary Effects of Riparian Habitat Restoration on Farms

I use the large-scale restoration occurring on the Sacramento River to examine scientific questions associated with transboundary interactions of agricultural pests and pest-predators. In particular, I investigate whether abundances of plant, insect and bird pests on farms on the Sacramento River are affected by proximity to and area of riparian habitat. I also investigate whether bird pest-predator density, species richness, and behavior is affected by proximity to and area of riparian habitat. I conducted bird surveys and behavioral observations on 26 walnut farms and adjacent restored, remnant and agricultural habitats to determine abundance and diversity of weeds, two major insect pests, and insectivorous birds. I also analyzed the foraging behavior of insectivorous birds at the interface between agricultural, remnant riparian, and restored riparian habitat on the Sacramento River. I found that weeds had significantly higher abundance on the edge of restored riparian habitat. I found that insect and bird pest species abundance were not significantly affected by proximity to or area of riparian habitat. However, I found that insectivorous riparian bird densities and species richness increased with greater area of riparian habitat around the farm. I also found that foraging and successful foraging of insectivorous birds increased with increasing riparian habitat around the farm. I describe how this information is used in the collaborative process occurring within the Sacramento River restoration project.

CALFED Statement of Relevance
This work has been incorporated into the locally-based collaborative restoration process happening along the Sacramento River.

SESSION: Integrating Science and Management (II), 10/23/2008, 3:55 PM, Room 314

Hughes, S.M.*
UC Santa Barbara, 4526 Bren Hall, Santa Barbara, CA 93106
shughes@bren.ucsb.edu

Management That Fits: The Implications of Urban Water Management for the Bay-Delta

Water resources in the San Francisco Bay-Delta are a critical resource for California. The institutions designed to govern their distribution and quality play an important role in determining their sustainability and the sustainability of the ecosystems and communities they support. Institutions encompass the rights, rules, and decision making procedures surrounding water management. The way that water management institutions in California are designed will therefore have significant consequences for the water resources and ecosystems of the Bay-Delta. My research proposes that one way of measuring the ability of institutions to deliver sustainable outcomes is by assessing the fit between an institutional arrangement and the socio-ecological system it governs. One area of particular importance for the Bay-Delta is the fit of urban water management institutions. Urban water use has always been a key driver of water policies and decision making in California; large urban centers rely on receiving a clean and reliable water supply from the Bay-Delta. However, the institutions that have arisen to secure and deliver these water supplies may not be a good fit with the socio-ecological systems of the Bay-Delta. Evidence for a lack of fit can be seen in the current battles with fish recovery and contaminants, but there are also examples of efforts to improve fit. Using the framework of institutional fit may allow for a more systematic understanding of the successes and failures that efforts to reform have encountered, and provide evaluative criteria for new proposals. Here I present the research I propose to undertake as part of the CALFED Science Fellows program to answer these questions.

CALFED Statement of Relevance
This research is directly relevant to the CALFED Science Conference agenda because it addresses Bay-Delta water management concerns and their outcomes for ecosystems, and is being undertaken as part of my CALFED Science Fellows pre-doctoral research award.

SESSION: Integrating Science and Management (II), 10/23/2008, 4:15 PM, Room 314

Andrews, E.S., P.B. Williams, A. Collison, E. Ginney, S. Bozkurt
Philip Williams & Associates, Ltd., 550 Kearny St., Suite 900, San Francisco, CA 94108
b.andrews@pwa-ltd.com

Conceptualizing, Designing, and Monitoring Floodplain Projects for Cumulative Benefit

Re-establishing active inundation of at least half of all remaining unurbanized floodplains in the Central Valley is a laudable CALFED goal in support of ecosystem function, but a nebulous one. What is an actively inundated floodplain, and how will we know if we've re-established one? We propose that specific inundation regime criteria be established to identify floodplain lands that qualify as being actively inundated. These criteria will address the relationship between two key components that collectively create inundation: hydrology and land elevation. They must also address the requirements for biotic utility. Tremendous ecosystem benefit can occur, for example, when floodplains are inundated in most years for an extended period in the spring, providing both dramatic support to the food web and ephemeral but highly beneficial habitat for native fish species such as splittail and salmon. Because these inundation flows must occur routinely to benefit species with life cycles spanning only a few years, the flows required are of necessity the smallest flows capable of inundating a floodplain. Yet available information suggests that the area of such floodplains, while historically widespread in the Central Valley, has been dramatically reduced through loss of connectivity, hydrologic alteration, and geomorphic change. These observations point towards a powerful strategy for initiatives to restore floodplain function through active inundation. We can use information about inundation regime to identify the limited number of reasonably feasible locations for creating activated floodplains. We can also apply the information to the design of floodplain restoration projects both at a site and from a system-wide perspective. Lastly, we can use the inundation regime to identify and thereby quantify floodplain lands as "activated," thereby providing a readily understandable, integrative metric of accomplishment, as well as a monitoring tool to support adaptive management.

CALFED Statement of Relevance
This presentation is directly relevant to strategic planning and project implementation to achieve specific CALFED Program habitat and native fish species goals. In addition, it addresses the identified need for performance measures to assess progress toward Program goals and inform adaptive management of the Bay-Delta system.

SESSION: Integrating Science and Management (II), 10/23/2008, 4:35 PM, Room 314

Anderson, L.W.
US Department of Agriculture- Agricultural Research Service, Exotic and Invasive Weed Research, Davis, CA 95616
lwanderson@ucdavis.edu

Multi-species Aquatic Plant Management Essential for Sustainable Habitats

Aquatic plant management actions in the Sacramento- San Joaquin Delta over the past 12 to 25 years have specifically and exclusively targeted egeria (*Egeria densa*) and water hyacinth (*Eichhornia crassipes*) as a result of narrowly focused, enabling state legislation. Water hyacinth cover has been kept in check for over 20 years, and recent (2007/2008) optimal applications of the systemic herbicide fluridone has significantly reduced biovolume of egeria in Franks Tract. However, increased spread of waterprimrose (*Ludwigia* spp.) and native pennywort (*Hydrocotyle* spp.) suggests that these (and other) species may be "released" as a consequence of the successful, but narrow objectives of the programs. To restore and sustain suitable habitat for native aquatic species and waterfowl, a much more robust and comprehensive approach is needed. This will require amending currently legislation and increasing coordination among state resource agencies and federal partners to craft and implement a holistic management plan for the Delta. The advantages of this multi-species management approach should accrue to existing program objectives, as well as to the success of future early detection and rapid response actions for new pests such as the South American sponge plant (*Limnobium laevigatum*). An approach and rationale for Delta-wide, multi-species aquatic plant management will be presented.

CALFED Statement of Relevance
A major concern in restoring Delta habitats is the management of exotic and invasive aquatic species, including plants. Currently, California expends about $5 million annually to control two targeted species, but has virtually no plans or resourced dedicated to management of aquatic vegetation in general. Direct and indirect impacts of aquatic vegetation on fish populations, waterfowl and benthic organisms necessitate a comprehensive management plan that goes well beyond the current two-species programs. The tools now exist to properly assess and quantify existing population levels; a corresponding science-based holistic plant management strategy needs to be implemented in order to improve habitat quality.

SESSION: Integrating Science and Management (II), 10/23/2008, 4:55 PM, Room 314

Hobbs, J.A.
UC Berkeley, 513 McCone Hall, Berkeley, CA 94720
hobbsja@gmail.com

Looking Back to go Forward: Stock Structure Dynamics Revealed with Otolith Geochemistry for an Endangered Estuarine Fish

Problem Statement: The delta smelt population has experienced dramatic declines in the past and has continued to precipitously drop in recent years. The cause(s) of the decline have yet to be determined, and is likely the result of multiple impacts on the population (e.g. food limitation, contaminants, freshwater exports from the estuary), which can operate spatially. Approach: To look back on the processes that result in poor recruitment, we are investigating the spatial extant of the population structure through otolith geochemistry for juvenile and adults collected during monitoring surveys. In addition we are investigating the relative impact that the freshwater exports may have on the delta smelt population structure. Results: In this study we investigated the spatial and temporal variability in delta smelt recruitment from 1999-2007 and for exported larvae in 2000 and 2001. Overall, a majority of fish originated from Sacramento River water, while a small proportion originated in San Joaquin River water and the low-salinity zone. Juvenile rearing habitats varied with X2, with most of the successful recruits using the freshwater delta when X2 was at the confluence. Fishes residing in San Joaquin River water during the juvenile stage showed relatively poor growth and recruitment from summer to fall. During wet years (e.g. 2000), the exports preferentially effect early born San Joaquin River cohorts, while in dry years (e.g. 2001) the exports have a larger relative impact on the entire population by entraining water and smelt from the Sacramento River. Conclusion: This study provides important information regarding the spatial variability associated with recruitment and infers a potential problem with fishes residing in San Joaquin River water. In addition we show that exports can have qualitative impacts on the population structure, which may result in impacts beyond absolute entrainment loss.

CALFED Statement of Relevance
This research reveals new insights into the population dyanamics of the endangered delta smelt and may have overarching implications for the health of the delta ecosystem and role the freshwater exports may play in the qualitative impact on fish populations.

SESSION: Estuarine Species, 10/24/2008, 8:20 AM, Room 306

Malamud-Roam[1], F.P., C. Phillis[1], L. Ingram[1], P.K. Weber[2]
[1]University of California, Berkeley, Earth and Planetary Sciences Department, Berkeley, CA 94720
[2]Lawrence Livermore National Laboratory, Chemical Sciences Department
fmalamud@eps.berkeley.edu

San Francisco Bay Estuary Habitat Use Determined by Otolith Stable Isotopes

Determining the life history of fish populations of special concern in the San Francisco Bay Estuary (SFBE) is a priority goal CALFED in order to protect and preserve these fish populations. This research investigates the use of stable isotopes for tracing the occupation history of fish as they move through the estuary, particularly distinguishing residence in the parts of the Bay between the western edge of the Delta and the ocean. We present data on SFBE water oxygen isotopic composition (ä18O) and temperature, which control otolith ä18O. These environmental factors can be directly tied to salinity and therefore related to location in the SFBE. The range of water ä18O in the SFBE is about -11‰ (parts per thousand relative to a standard) for fresh water entering from the Delta to about 0‰ at the Golden Gate (marine), and the expected range in otoliths for fish in the estuary is approximately -7.5‰ (near Port Chicago) to 2.7‰ (beyond the Golden Gate). This range provides significant dynamic range because measurement precision is typically 0.1‰. We also present data for otolith carbon isotopes (ä13C). Otolith ä13C is a more complex function of water bicarbonate, diet, and temperature. ä13C of the dissolved inorganic carbon in the estuary has a slightly smaller range, about 9‰ and is closely related to salinity as well. We have measured O and C isotopes in otoliths of Striped Bass and Chinook Salmon, sampling incrementally along the growth axis and used the isotope data to determine where the fish spent time in the estuary. We compare these data to earlier 87/86Sr data collected to elaborate the Bay portion of the fish life history. The ä13C and ä18O data in the otoliths are highly correlated (r2 = ~0.67), suggesting that both can be used as potential markers of residence history.

CALFED Statement of Relevance
Determining the life history of fish populations of special concern in the San Francisco Bay Delta system is a priority goal CALFED in order to protect and preserve these fish populations.

SESSION: Estuarine Species, 10/24/2008, 8:40 AM, Room 306

Dendy, W.M.*
University of Maryland, 9457 White Horse Way, Elk Grove, CA 95624
wmdendy@umd.edu

The Impact of Pinnipeds on the Anadromous Fish Populations and Recreational Fisheries of the Sacramento Delta

For decades, there has been competition between marine mammals and commercial fisheries worldwide. Anadromous fishes found in the Sacramento Delta are part of commercial and recreational fisheries, an important economic element for the local populations from the coastal regions to the breeding habitats far inland. Since the enactment of the federal Marine Mammal Protection Act in 1972, the populations of California sea lions (*Zalophus californianus*) and Pacific harbor seals (*Phoco vitulina*), both opportunist feeders known to prey on salmonids, have grown at rapid rates, while the anadromous fish populations which migrate inland throughout the Sacramento Delta have declined dramatically.. The population explosion of these marine mammals has resulted in increased foraging competition. As sea lions and harbor seals increase their foraging range into the river system where their natural predators are not present, their main competition for resources is humans, particularly recreational fishermen. The current abundance and distribution of pinnipeds in the Sacramento River was examined from Rio Vista, CA to the confluence of the American River. The sampling area was divided into five strata and using a random sampling schedule, observations were made from a powerboat in the river and dockside surveys were conducted. Additionally data was collected from boaters and fishermen through web and fax surveys. Five individual sea lions (identified through markings) were in the confines of the sampling area throughout the sampling period of September 15, 2007 to January 15, 2008. Individual sea lions were sometimes observed catching and consuming adult salmon at rates of as many as five per hour. No harbor seals were observed. The impact of these marine mammals on anadromous fish populations could not be determined. The presence of a few voracious feeders could however severely impact fish populations, especially if egg bearing females were being consumed.

CALFED Statement of Relevance
The study gives marine resource managers and other stakeholders baseline data for which to compare future pinniped abundance and distribution studies in an effort to manage the marine mammals and fish populations which are impacted.

SESSION: Estuarine Species, 10/24/2008, 9:00 AM, Room 306

Schroeter, R.E., P.B. Moyle
University of California, Davis
reschroeter@ucdavis.edu

The Importance of Shallow Water Habitat for Striped Bass Young-of-Year

It is well known that striped bass juveniles, along with other pelagic fishes, have significantly declined in abundance over the last 3 decades in the rivers, tidal channels and bays of the San Francisco Estuary (SFE). However, the historical trends of striped bass juveniles using shallow water areas and smaller tidal channels are less well understood. This is problematic because striped bass young-of-the-year (YOY) in some estuaries preferentially use and in general, increasingly favor shallow water habitats. In this study, we examine striped bass abundance patterns in Suisun Marsh, a brackish tidal marsh in the middle SFE, using data from a long-term (1980 to 2005) otter trawl survey. Our primary objective was to examine for depth related changes in striped bass YOY abundance. In addition, the YOY abundance response to changing prey densities and abiotic conditions were also investigated. The results indicate that striped bass YOY declined significantly only in the deep water sites. The YOY decline was significantly correlated with the decline in abundance of pelagic prey including copepods and mysid shrimps, which suggests that prey limitation in deep water sites is a likely factor. Abiotic conditions (temp, pH, and turbidity) had little affect on striped bass abundance in both deep and shallow water sites. However, the average April to June distance of X2 from the downstream opening to Suisun Marsh was negatively correlated with YOY abundance in the shallow water sites, indicating the importance of flow related effects. The continued moderate to high catch of striped bass YOY in the shallow tidal channels of Suisun Marsh and presumably other shallow water areas in the brackish region of the SFE, has likely buffered the SFE population from a more catastrophic decline by providing the suitable conditions and prey resources needed for striped bass to survive and recruit to an older age class. These results provide evidence that habitat complexity is a key element in changing ecosystems, by helping to ensure persistence and stability of populations of striped bass and other species.

CALFED Statement of Relevance
This study complements the ongoing POD investigations by providing information on the trends in abundance for striped bass YOY in a key habitat (shallow water) that is not well represented in the current SFE monitoring studies. In addition, the results further improve our understanding of the potential contribution of shallow water tidal habitats to estuarine fishes in the SFE, which is critical for an improved understanding of how ecosystem restoration may affect fishes in the system.

SESSION: Estuarine Species, 10/24/2008, 9:20 AM, Room 306

Ostrach[1], D.J., J.M. Groff[1], E.D. Durieux[1], J.L. Spearow[1], J.H. Walsh[2], P.S. Fitzgerald[1], K.J. Eder[1], C.C. Chin[1], G.E. Whitman[1], F.J. Loge[1]
[1]John Muir Institute of the Environment, Center for Watershed Sciences, Dept. of Civil & Environmental Engineering, UC Davis, One Shields Ave, Davis, CA 95616
[2]Moss Landing Marine Lab., 8272 Moss Landing Rd, Moss Landing, CA 95039
djostrach@ucdavis.edu

Striped Bass a Sentinel of San Francisco Estuary Ecosystem Health: How Much Stress Can Young Stripers Endure?

The Interagency Ecological Program (IEP) reported a sharp decline in populations of pelagic fish in the San Francisco Estuary in 2001. IEP abundance indices calculated for pelagic fish over the past five years suggest that significant declines in these populations are continuing. Here we report on current potential factors contributing to the decline of this striped bass population. Current investigations focused on determining the health and condition of striped bass collected during the summers of 2005 - 2007 and developmental studies related to the maternal transfer of xenobiotics. Findings indicate that the striped bass collected in 2005 surveys were severely compromised as a result of infective disease processes. In 2006 & 2007 findings were similar although not as severe. Results from 2005 -2007 indicate the vast majority of these juvenile fish were under sub-lethal contaminant exposure as measured by P4501A1 induction and vitellogenin expression. Induction of P4501A1 indicates that these fish may be immuno-compromised which provides a possible explanation of the high incidence of disease and parasitism observed. Results from the 2006 maternal transfer study corroborate earlier findings from 1999 & 2001. Significant levels of PCB, PBDE and pesticides were found in eggs from river collected striped bass. This complex xenobiotic mixture caused developmental abnormalities and significant lesions associated with contaminant exposure. Extremely low abundance indices during all three years coupled with the histopathological and positive P450 findings infers that this population of striped bass is compromised and that the fish collected in the fall may be the robust survivors of an epizootic and/or contaminant exposure. These results suggest that multiple stressors are adversely affecting this population of striped bass. This investigation presents new information that can help understand the role of contaminants and manage their effects on pelagic fish populations in the San Francisco Estuary.

CALFED Statement of Relevance
Striped bass is an important sentinel species in the San Francisco Estuary. It is one of the four POD species of great interest to those managing the San Francisco Estuary and its watershed. The results of this study can help to better understand how multiple stressors and contaminants affect the health of this population and other local fish species which is essential for managing water quality and ecosystem restoration.

SESSION: Estuarine Species, 10/24/2008, 9:40 AM, Room 306

Cohen[1], R.A., A.E. Parker[2], J. Tirindelli[2]
[1]Georgia Southern University, Department of Biology, Statesboro, GA, 30460
[2]Romberg Tiburon Center for Environmental Studies, San Francisco State University, 3152 Paradise Dr., Tiburon, CA 94920
rcohen@georgiasouthern.edu

CALFED Foodweb Project: Phytoplankton-derived DOC Enhances Bacterial Biomass and Production in the Low Salinity Zone of the Upper San Francisco Estuary

Phytoplankton production is the dominant source of organic matter to the foodweb of the low salinity zone (LSZ) of the San Francisco Estuary. In addition to local phytoplankton production, a relatively large influx of phytoplankton biomass can be delivered into the LSZ from rivers and saline regions of the estuary. The fate of the transported phytoplankton is presently unknown; however, phytoplankton arriving intact may be used to support higher trophic levels directly through the grazer food web. Alternatively, when phytoplankton adapted to oceanic or freshwater conditions are advected into the LSZ, they may experience damage due to osmotic stress. Degraded phytoplankton may release dissolved organic carbon (DOC) enhancing bacterial production and the microbial loop, resulting in lower overall foodweb efficiency. Experiments were conducted to determine how salinity change affects phytoplankton biomass and DOC release in the LSZ to begin to assess pathways of organic matter flow among lower trophic levels. Results show that phytoplankton adapted to 5 psu exhibited declines in biomass when exposed to LSZ conditions (0.5 psu). Concurrent with the phytoplankton declines, bacterial production increased, suggesting a link via production of DOC, likely due to phytoplankton lysis. These findings indicate that organic matter supplied to the LSZ through transported saline phytoplankton may be processed by the microbial loop and result in lower foodweb efficiency.

CALFED Statement of Relevance
Our findings identify potential sources of energy to the foodweb of the upper San Francisco Estuary that supports Delta Smelt. Understanding the pathways by which energy reaches zooplankton eaten by the fish is essential for successful decision-making in protecting native fish species, and restoring their habitat and ecosystem functions.

SESSION: Estuarine Food Webs, 10/24/2008, 10:20 AM, Room 306

Gould, A.L.*, W.J. Kimmerer
Romberg Tiburon Center, SFSU, 3150 Paradise Drive, Tiburon, CA 94920
alg5m@mac.com

CALFED Foodweb Project: Growth and Fecundity of the Most Abundant Copepod in the Upper San Francisco Estuary

Limnoithona tetraspina is a small cyclopoid copepod that was introduced to the San Francisco Estuary (SFE) in 1993 and quickly became the most abundant copepod species in the Low Salinity Zone (LSZ). Two previous studies have shown that it feeds only on motile prey, predominantly ciliates. However, little is known of its biology, and we are trying to determine its role in the estuarine foodweb. To better understand the carbon transfer between trophic levels we calculated the specific growth and fecundity rates of L. tetraspina in 2006 and 2007. Egg production rates in 2007 of *L. tetraspina* reached a maximum of 2.9 eggs/female/day, similar to the maximum fecundity (Fmax = 2.5 eggs/female/day) for closely related *Oithona* spp., but lower than rates for other sac spawners such as the calanoid *Pseudodiaptomus* sp., (Fmax= 7.8 eggs/female/day). A mean egg production rate of 1.9 eggs/female/day in 2007 corresponds to a specific production rate of approximately 10%/day. Whereas specific growth rates of juvenile stages averaged 10%/day and 5%/day in 2006 and 2007, respectively. Chlorophyll levels and microflagellate abundance were much higher in 2006 than in 2007, suggesting higher food availability for growth, and peak abundance of *L. tetraspina* was twice as high in 2006. With low to moderate growth and fecundity rates typical for a small cyclopoid copepod, the success of *L. tetraspina* is apparently due to low mortality. *L. tetraspina* may avoid certain mortality agents, such as visual predation, to which larger, more visible copepods are susceptible in the SFE.

CALFED Statement of Relevance
This research helps to describe trophic interactions and carbon transfer within the foodweb of the Low Salinity Zone and has implications as to why fish species have declined in the area.

SESSION: Estuarine Food Webs, 10/24/2008, 10:40 AM, Room 306

Thompson[1], J.K., F. Parchaso[1], K. Gehrts[2], D. Messer[2]
[1]U.S. Geological Survey, 345 Middlefield Rd., Menlo Park, CA 94025
[2]California Department of Water Resources, Sacramento, CA
jthompso@usgs.gov

Bivalves as Ecosystem Engineers: Before and After the Invasion of Corbula amurensis in the Northern San Francisco Estuary

It has been hypothesized that phytoplankton biomass in the northern San Francisco Estuary is at least partially controlled by bivalve filter feeders. Before *Corbula amurensis* appeared in the northern estuary in the 1986 there were periods when other filter-feeding bivalves dominated the benthic community, such as during droughts (*Mya arenaria, Musculista senhousia*) and floods (*Corbicula fluminea*). We examined time series of biomass and grazing rates of bivalves in the shallow water of the northern estuary from 1977 through 2006 for two reasons. First, there has yet to be a definitive analysis of the food needed to support the populations of bivalves compared to the carbon available from the phytoplankton. Second, recent theories on the effect of nutrient changes in the water column on phytoplankton growth rate have brought into question the relative importance of bivalve grazing and ammonium on limiting phytoplankton biomass. We have found that periods of low phytoplankton biomass were coincident with (1) elevated carbon consumption by the transient filter-feeding bivalves prior to 1986 (calculated using estimates of secondary production and carbon assimilation rates), (2) elevated carbon consumption by *Corbula*, or (3) high freshwater flow rates that resulted in very low residence time and thus a poor growth climate for phytoplankton. Both grazing rates and carbon consumption by bivalves that preceded *Corbula* and by *Corbula* in the northern estuary support the hypothesis that bivalve grazing is contributing to the control of phytoplankton biomass in the system. It is also possible that the bivalves are utilizing other sources of carbon such as bacteria which would reduce their dependence on phytoplankton. These findings support restoration concerns that the low productivity in the system will continue as long as *Corbula* are present or conditions are conducive to invasions by estuarine bivalves such as Mya.

CALFED Statement of Relevance
Much of our success in restoring this system will be dependent on our ability to maintain if not improve the primary productivity of the estuary and delta. One important variable in phytoplankton growth rates is the loss of phytoplankton biomass to bivalve grazers. Recently there have been questions about the relative importance of bivalve grazing and ammonium concentrations as limits on net phytoplankton growth rates. Our comparison of historical bivalve data to current bivalve data, in addition to the calculation of carbon needed to support the bivalves throughout the time period, helps define the importance of bivalve grazing in phytoplankton primary productivity from 1977 through 2006.

SESSION: Estuarine Food Webs, 10/24/2008, 11:00 AM, Room 306

Kleckner, A.E.*, F. Wilkerson
Romberg Tiburon Center, San Francisco State University, Tiburon, CA 94920
amyk777@sfsu.edu

The Influence of an Invasive Clam, Corbula amurensis, on Nutrients and Dissolved Organic Matter, in Northern San Francisco Estuary

The Asian clam, *Corbula amurensis*, has been generally accepted as the cause of a significant decline in phytoplankton biomass that has been observed in the San Francisco Estuary since the clam's introduction in the fall of 1986. However, much less is known about additional ecosystem changes as a result of the establishment of *C. amurensis* in the estuary. As a consequence of their high grazing rate and potential uptake of dissolved organic nitrogen, these clams may have a strong influence on the nitrogen cycle. A time series of nutrients, chl-a, dissolved organic matter (DOM) and *Corbula* biomass from September 2006 to December 2007 was examined. In parts of northern San Francisco Estuary, high densities of *Corbula* may influence the nutrient regime as a result of ammonium excretion. An average ammonium excretion rate of 5.17 µmol/hr/gm AFDW, was determined in laboratory experiments by incubating clams in artificial seawater at ambient temperature and salinity. Experiments were also conducted to assess the ability of *Corbula* to assimilate DOM during periods of low food availability. Comparisons of how clams lost weight when starved of food in water containing ambient DOM compared to controls lacking DOM were made. Similar experiments done with zebra mussels supported the hypothesis that assimilation of natural DOM contributes to their metabolism and improves their ability to withstand starvation. The ability of *Corbula* to persist at high densities, even in conditions of low phytoplankton food, can cause long-term changes to this ecosystem. These results will help determine a nutrient budget for the clam as well as provide additional information on the total nitrogen budget for Northern San Francisco Estuary.

CALFED Statement of Relevance
Information on how *Corbula* influences the nutrient and dissolved organic matter dynamics in the northern estuary will help to determine a total nutrient budget for the clam as well as the ecosystem. This novel impact of an invasive bivalve on the nutrient ecosystem may have management implications.

SESSION: Estuarine Food Webs, 10/24/2008, 11:20 AM, Room 306

Brown, C.L., M. Croteau, A. Stewart, S.N. Luoma
US Geological Survey, 345 Middlefield Rd. MS 496, Menlo Park, CA 94025
clbrown@usgs.gov

Explaining Species-specific Differences in Cu Accumulation Using Biodynamics

Copper concentrations differ significantly among two co-existing bivalve species in the San Francisco Bay/Delta. *Corbula amurensis*, an euryhaline species (salinities 1-32 ppt) accumulates lower Cu concentrations (14 – 34 µg g-1) than *Corbicula fluminea* (35 – 195 µg g-1), a freshwater species (salinities 0-14 ppt). We determined whether these species-specific differences in Cu concentrations are due to different exposures (i.e., dissolved concentrations, food source, trophic position), or to physiological differences (i.e., dissolved uptake rates, loss rates, ingestion rates, assimilation efficiencies). Stable nitrogen and carbon isotope data suggest the two species have different food sources: *C. amurensis* feeds on the flood tide and *C. fluminea* feeds on the ebb tide. These differences in diet are likely to explain, in part, the species-specific differences. We also conducted biodynamic experiments to determine rate constants for Cu uptake and loss. Dissolved Cu uptake rate constant (ku) was higher for *C. amurensis* than for *C. fluminea* (1.76 L g-1 d-1 vs. 0.224 L g-1 d-1, resp.). Therefore, uptake from solution cannot explain the differences seen in the field. The Cu efflux rate constant (ke) is 10-times higher in *C. amurensis* than *C. fluminea* (0.035 d-1 vs. 0.004 d-1, resp.). Thus, *C. amurensis* loses Cu at a faster rate than *C. fluminea*, which explains, in part, the lower Cu concentrations in *C. amurensis*. The food ingestion rate of *C. amurensis* is 10-times higher than that of C. fluminea (0.370 g g-1 d-1 vs. 0.028 g g-1 d-1, resp.), yet Cu concentrations in *C. amurensis* are lower that those in *C. fluminea*. This suggests that *C. fluminea* food items are more contaminated than those consumed by *C. amurensis*, or that *C. fluminea* assimilates Cu more efficiently than *C. amurensis*, or both. Rate constants of loss and uptake are crucial factors to consider when explaining species-specific differences in metal concentrations.

CALFED Statement of Relevance
Understanding species-specific differences in accumulated metals of key monitoring species advances the understanding of their ecological function and use in determining processes that drive the fate, transport and effects of metals in the Estuary.

SESSION: Estuarine Food Webs, 10/24/2008, 11:40 AM, Room 306

Wintzer, A.P.*, P.B. Moyle
Center for Watershed Sciences, UC Davis, 1 Shields Avenue, Davis, CA 95616
alpa@wintzer.us

The Secret Lives of Polyps: Ecological Insights into the Benthic Stage of Non-native Jellyfish in the San Francisco Estuary

Jellyfish populations appear to be increasing globally in response to anthropogenic alterations of the ocean environment. Many species are also broadening their ranges and becoming disruptive in their new habitats. Yet, it can be difficult to predict the impacts of these species and to create effective management plans, as we know so little about them. The polyp phase of jellyfish has been especially little studied, because it is often difficult to find in the wild. We present the first field-derived ecological information for the non-native hydrozoan polyps, *Cordylophora caspia, Blackfordia virginiCA* and *Moerisia* sp., found in the San Francisco Estuary. Fouling plates were hung throughout Suisun Marsh and in the Napa and Petaluma Rivers. These plates were collected monthly between July and October 2007, and the settled polyps were identified and enumerated in the laboratory. Patterns of distribution and abundance were related to water quality parameters and differed between species and life stage (polyp vs medusae). Additionally, preliminary gut contents revealed that polyps consumed a variety of invertebrate species, including some prey items that were much larger than themselves. This study has taken the first steps towards understanding the basic ecology of this mysterious life stage, and may aid in developing ways to minimize negative impacts of non-native hydrozoans.

CALFED Statement of Relevance
This study has taken the first steps towards understanding the basic ecology of the little studied polyp life stage and may aid in developing ways to minimize negative impacts of non-native hydrozoans in the San Francisco Estuary.

SESSION: Species and Communities, 10/24/2008, 1:00 PM, Room 306

Meek, M.H.*, B. May
UC Davis, Department of Animal Science, One Shields Ave., Davis, CA 95616
mhmeek@ucdavis.edu

The Effects of Temperature and Salinity on Survival and Feeding in a Trio of Invasive Hydrozoan Jellyfish in the San Francisco Estuary

Three species of hydrozoan jellyfish (*Maeotias marginata, Blackfordia virginiCA Moerisia sp*.) have invaded the San Francisco Estuary. These understudied species are novel predators in the system and are potentially negatively impacting fish species through resource competition and predation. In order to understand and potentially manage this invasion, it is important to identify the range of conditions inhabitable by these species. Additionally, it is important to know how environmental conditions may affect feeding rates, and subsequently the jellies' ability to crop prey resources in the system. We conducted laboratory experiments to determine ecophysiological tolerances of all three species and to quantify feeding rates on prey species under various thermal and salinity regimes. This included conducting a 3x3 factorial experiment, using three temperature and salinity conditions found in Suisun Marsh, and recording growth and survival over a 20 day period. Additionally, we quantified clearance rates for all three species using *Artemia nauplii* and rotifers, a mixed assemblage of naturally available prey, and pure copepods cultures as prey treatments. We found temperature and salinity to have an effect on survival and growth. Additionally, conditions had a strong affect on feeding rates. The results of this work have strong implications for management and planning in the Bay-Delta system. Water use and management actions in the area have the potential to alter the system and salinity conditions, possibly creating new habitat for the jellyfish and allowing for the expansion of the invasive populations. Additionally, this work is important in understanding how the invasions may change under predicted scenarios of climate change in the Bay-Delta region. While it may not be possible to rid the system of these disruptive invaders, by incorporating these data we may be able to better manage the system to contain and limit the expansion of the invasions.

CALFED Statement of Relevance
Water use and management actions have the potential to alter the San Francisco Estuary ecosystem and salinity conditions. The results of this study can inform management strategies to help contain and limit the expansion of these invasive species.

SESSION: Species and Communities, 10/24/2008, 1:20 PM, Room 306

Wainwright-De La Cruz[1], S.E., J.Y. Takekawa[1], A. Miles[1], J.M. Eadie[2], E.C. Palm[1], M.T. Wilson[3]
[1]USGS, WERC, San Francisco Bay Estuary Field Station, Vallejo, CA 94592
[2]UC Davis, Dept. Wildlife, Fish, & Cons. Bio., One Shields Ave, Davis, CA 95616
[3]UC Davis, Dept. of Avian Science, One Shields Ave, Davis, CA 95616
susan_wainwright@usgs.gov

The Influence of Winter Habitat Use and Diet on Selenium Risks for Surf Scoters (Melanitta perspicillata) in the San Francisco Bay Estuary

The San Francisco Bay (SFB) estuary is a critical wintering area for nearly half of Pacific Flyway surf scoters (*Melanitta perspicillata*); a sea duck species that has declined as much as 60% in the past 30 to 50 years. Poor winter habitat quality may contribute to population decline by decreasing winter survival, compromising body condition, or causing cross-seasonal effects on reproduction. Scoters wintering in SFB accumulate high concentrations of selenium (Se), resulting in oxidative stress and low body mass, and prompting human consumption advisories. We studied SFB scoters to: 1) measure spatial and temporal variability of Se in scoter tissues; 2) examine how regional habitat use and diet influence Se concentrations; 3) evaluate the potential for cross-seasonal effects on reproduction. During winters 2004-2006 we radio-marked 160 scoters to examine site fidelity and foraging areas. We collected 159 scoters, preserved gastrointestinal tracts for diet analysis, and measured liver Se. We satellite-marked 22 SFB scoters to find them on breeding grounds in Canada. Liver Se ranged from 7.4 to 119 µg/g dw and was at concentrations associated with reproductive impairment (98% of scoters), sublethal effects (i.e. oxidative stress, 56%), and mortality in laboratory mallards (16%). Concentrations were significantly higher throughout winter in San Pablo and Suisun Bays compared to the Central Bay (ANOVA: $F_{2,154}=35.18$, $P<0.001$). The Se enriched invasive clam, *Corbula amurensis*, dominated diets in Suisun (100% occurrence) and San Pablo (52% occurrence) through late winter. In contrast, Central Bay diets consisted of soft bodied prey items and the clam *Venerupis philippinarum*. Radio-marked scoters displayed high site fidelity and small kernel home ranges, providing evidence that Se was accumulated near scoter collection sites. Scoter use of San Pablo and Suisun Bays declined by 80% between November and March, and by late January most radio-marked scoters had moved to the Central Bay where their Se exposure was lowered. Mean Se concentrations in eggs collected from SFB scoters was 1.71 ± 0.122 µg/g dw, and below concentrations of concern for waterfowl.

CALFED Statement of Relevance
Our study elucidates the pathways and implications of selenium bioaccumulation in a declining Bay-Delta species, and thus aids in meeting Calfed objectives to manage, restore and protect native species.

SESSION: Species and Communities, 10/24/2008, 1:40 PM, Room 306

Athearn, N.D., J.Y. Takekawa, J.M. Shinn
U.S. Geological Survey, 505 Azuar Dr., Vallejo, CA 94592
nathearn@usgs.gov

Bird Abundance and Composition Changes at Breached Salt Ponds in the San Francisco Bay Estuary

Restoration of former commercial salt evaporation ponds in the San Francisco Bay estuary is intended to reverse a severe decline (>80%) in tidal salt marshes. San Francisco Bay is a critical migratory stopover site and wintering area for shorebirds and waterfowl, and salt ponds are important high tide roosting and foraging areas. Conservation of past bird abundance is a stated goal of area restoration projects, and early adaptive management will be critical for achieving this objective. However, initial avian response at sites restored to tidal flow may not be indicative of long-term results. For example, Pond 3 is a 529 ha pond in the Napa-Sonoma Marshes that was breached in 2002. Winter shorebirds at Pond 3 showed a marked increase in abundance following breaching. Shorebirds comprised 1% of area totals during 1999-2002 and increased to 47% during 2003-2007. These changes accompanied increased tidal range and sedimentation, but minimal vegetation establishment. Conversely, Pond 2A, a fully-restored 216-ha pond in the same system, supported less than 1% of all waterbirds in the region. Early restoration may temporarily increase habitat, but managed ponds will be needed for long-term waterbird abundance within a restored pond system.

CALFED Statement of Relevance
San Francisco Bay estuary is recognized for its importance to migratory birds, and large numbers use salt ponds for roosting and foraging. Understanding the effects of habitat changes on these species is essential to assess habitat quality and guide adaptive management for pond restoration.

SESSION: Species and Communities, 10/24/2008, 2:00 PM, Room 306

Schacter, C.R., S. Hudson, D. LeFer
San Francisco Bay Bird Observatory, 524 Valley Way, Milpitas, CA 95035
cschacter@sfbbo.org

Landfill Use by Rising Population of California Gulls

The California gull population has increased dramatically in the South Bay from <200 breeding birds in 1982 to over 30,000 in 2008. This increase may have negative effects on other ground-nesting birds through harassment, encroachment on nesting sites, and predation on eggs and chicks. The exponential increase in California gull populations may be related to use of landfills and other human sources of food. However, we do not have much information on how much feeding time the gulls spend on landfills, and if trash actually plays an important role in their ability to successfully reproduce. In April 2006 the San Francisco Bay Bird Observatory began conducting a study to identify how many gulls are using local landfills: the Newby Island landfill in Milpitas, the Tri-Cities landfill in Fremont and the Palo Alto landfill. Gull counts and behavior surveys were performed at least once a month at each site. We also did walkthroughs of all known California gull colonies in the South Bay to obtain a peak nest count from which to estimate total numbers of breeding gulls. The greatest numbers of gulls were counted at the Tri-Cities and Newby Island landfills, which are very close to several large California gull colonies. Monthly counts at the Palo Alto Landfill (which does not take in much food refuse) were consistently low. Behavior surveys also confirmed that over 75% of gulls in the exposed refuse areas (and over 65% in the partially exposed areas) were actively foraging. The influx of gulls feeding at the landfills may be displacing other species, including the threatened Western snowy plover, especially when the largest colony is flooded for salt pond restoration. Efforts will need to be made to reduce gull impacts on other breeding birds if the diversity of the watershed's ecosystem is to be maintained.

CALFED Statement of Relevance
The rising population of California gulls breeding in the South Bay has the potential to seriously affect the balance of the local ecosystem. We begin to investigate the extent to which this population explosion may be aided by easy access to food at local landfills.

SESSION: Species and Communities, 10/24/2008, 2:20 PM, Room 306

Mueller-Solger[1], A.B., S. Waller[1], A. Liston[2], M. Dempsey[1], M. Winder[2], D. Kaff[1]
[1]CA DWR, 901 P Street, Sacramento, CA 95814
[2]UC Davis TERC, 1 Shield Ave., Davis, CA 95616
amueller@water.ca.gov

FluoroProbing Bay-Delta Phytoplankton: Beyond Chlorophyll a

Phytoplankton provides the most important food resource for invertebrates and fish in the San Francisco Estuary (SFE). Some phytoplankton species can also adversely affect water quality. Accurate monitoring of phytoplankton species composition, biomass, and distribution is difficult because of the highly dynamic nature of the estuarine environment and estuarine phytoplankton communities. The primary purpose of our study is to evaluate a new tool for in situ high-frequency monitoring of phytoplankton biomass associated with different taxonomic groups using a submersible spectrofluorometer, the bbe FluoroProbe. This instrument measures relative contributions of four algal "classes" (diatoms, blue-green algae, green algae, cryptophytes/other) to total chlorophyll a (chl a) fluorescence along with water transparency and colored organic matter fluorescence. We tested the instrument in the laboratory with algal cultures and found very good class assignments for some species, but not for all. We also extensively deployed the instrument in the field during regular monthly monitoring cruises starting in February 2008 and additional field sampling events. Discrete samples were also collected during most of the field deployments for comparison with the FluoroProbe results. Among the observed patterns were abrupt, large changes in chl a composition between adjacent waterbodies, gradual changes along river corridors, localized diatom blooms in very different environments, and strong increases in diatoms and green algae toward the landward sides of Suisun marsh. Many of these features were observed repeatedly in different months. None of them, especially none of the more local-scale features, would be apparent with discrete sampling or conventional fluorometers. These initial tests of the FluoroProbe indicate that the FluoroProbe is indeed a promising new tool for phytoplankton monitoring and research in the SFE. In addition, it may help "ground truth" hydrodynamic models that involve water sources with different fluorescence "fingerprints" and help gain a better understanding of habitat heterogeneity and connectivity.

CALFED Statement of Relevance
The modern ecosystem-based resource management strategies espoused by CALFED place more, not less, demand on monitoring of community composition and spatial and temporal species distributions. New monitoring tools such as the FluoroProbe tested in this study are essential to fulfill these demands.

SESSION: Phytoplankton, 10/24/2008, 3:00 PM, Room 306

Luengen[1], A.C., N.S. Fisher[1], B.A. Bergamaschi[2]
[1]School of Marine and Atmospheric Sciences, Stony Brook University, Stony Brook University, Stony Brook, NY 11794
[2]USGS California Water Science Center, California State University, Placer Hall MS 6129, 6000 J Street, Sacramento, CA 95819-6129
aluengen@notes.cc.sunysb.edu

Effects of Dissolved Organic Matter on Methyl Mercury Uptake by Phytoplankton

Mercury, in the chemical form of methyl mercury (MeHg), biomagnifies in the food chain, reaching concentrations that pose a threat to both humans and wildlife. Despite the threat, little is known about the factors controlling MeHg uptake by phytoplankton at the base of the food chain. Our goal is to understand how dissolved organic matter (DOM) affects MeHg uptake by phytoplankton in the San Francisco Bay Delta. To evaluate the effects of DOM, we are using isolates of organic matter collected from various sites in the Delta. We reconstitute the isolates in controlled conditions, varying only the type and concentration of added organic matter. Then, we use the radioisotope 203MeHg to follow the movement of 203MeHg from water to phytoplankton. Results show that the concentration of organic matter is the primary factor controlling MeHg bioaccumulation. Volume concentration factors (VCFs), or the concentration of MeHg in cells divided by the amount of MeHg in an equivalent amount of water, are highest when concentrations of organic matter are low. For example, after 24 hours, cells grown in water without any added organic matter had VCFs as high as 300,000. When cells were grown in water with low organic matter concentrations (150 - 250 ìM DOC), VCFs ranged from 30,000 to 80,000. With high concentrations of organic matter (500 to 850 ìM DOC), VCFs were generally < 20,000. These results indicate that, at high concentrations, MeHg is complexed to organic matter and is not readily available for uptake by phytoplankton. Understanding how DOM affects MeHg bioavailability in the Delta will help regulators identify areas with high MeHg bioaccumulation potential and understand the impacts of changes in the DOM supply in the estuary, such as from restoration of wetlands.

CALFED Statement of Relevance
CALFED's management cue on mercury calls for an approach that will allow regulators to predict bioaccumulation. This research focuses on a bioavailable form of mercury: MeHg, and expands the focus on bioaccumulation by demonstrating that DOM is also an important controller of bioavailability and may limit algal uptake of MeHg.

SESSION: Phytoplankton, 10/24/2008, 3:20 PM, Room 306

Lidstrom, U.E.*, E.J. Carpenter
Romberg Tiburon Center for Environmental Studies, SFSU, 3152 Paradise Drive, Tiburon, CA 94920
lidstrom@sfsu.edu

CALFED Foodweb Project: Phytoplankton Community Composition in the Low Salinity Zone of the Northern San Francisco Bay Estuary

Phytoplankton play important biological, geological and chemical roles in aquatic systems. In the San Francisco Bay Estuary (SFBE), the low salinity zone (LSZ; between 0.5 to 5 psu), is an important habitat for many estuarine organisms, including the threatened delta smelt. Reports of severe pelagic organism declines have increased the need to identify the factors controlling this ecosystem. Earlier evidence showed food limitation could be a factor in the failing LSZ ecosystem, suggesting a link between organism decline and changes at lower trophic levels. Long term phytoplankton monitoring in the SFBE includes chlorophyll measurements (biomass) but rarely species identification. The few studies published in the past decade on phytoplankton community structure were over short time periods or very large areas. This is the first study of phytoplankton community structure in the LSZ that includes continuous monitoring over two seasons, for two years. We collected samples from three salinities (0.5, 2 and 5 psu) between March and August, weekly in 2006 and biweekly in 2007. Phytoplankton were identified and enumerated using light and epifluoresence microscopy of preserved samples. Results showed differences in species abundance and composition between the two years, most likely associated with the extremely different water years and subsequent geographic location of the LSZ. Samples from the three salinities within the LSZ were similar in phytoplankton composition. Picoplankton and small flagellates were present in large numbers throughout both seasons and years. Peaks in biomass corresponded with increases in diatoms; small centrics in 2006 and a large pennate in 2007. The prevalence of small cells suggests a continued community shift from large diatoms to small flagellates and picoplankton. Data presented here was collected as part of a CALFED funded collaborative study aimed to characterize the LSZ foodweb.

CALFED Statement of Relevance
These results help to characterize the foodweb of the low salinity zone, an important habitat for many estuarine organisms, including the threatened delta smelt.

SESSION: Phytoplankton, 10/24/2008, 3:40 PM, Room 306

Labiosa[1], R.G., M.L. MacWilliams[2], C.E. James [1]
[1]U.S. Geological Survey, 345 Middlefield Rd., Menlo Park, CA 94025
[2]Rivermodeling Environmental Consulting, P.O. Box 225174, San Francisco, CA 94122
rlabiosa@usgs.gov

The TRoUBLE Project: Trends in Rising and Unexpected Bloom Levels in the Estuary (San Francisco Bay): The Role of Ocean Exchange

San Francisco Bay is a complex, urbanized ecosystem with significant seasonal and interannual variability in its pelagic biota. In recent years a new trend has emerged, whereby phytoplankton biomass and primary productivity (PP) have been increasing and previously absent autumn blooms have developed in marine regions of the Bay. What is controlling these contemporaneous changes at the food web base, and, in turn, what is the influence of these changes on upper trophic levels? Here we use the first 3D hydrodynamic-biological coupled model of San Francisco Bay, together with remotely sensed and in situ data, to discriminate between the potential effects of physical and biological controls on phytoplankton trends. Ocean-Bay exchange can be a source of phytoplankton to the Bay during some times of year and a net sink during other times of year. Because tidal pumping dominates dispersion throughout the year, the gradient in chlorophyll a between the coastal ocean and Bay likely controls its net flux into or out of the Bay. However, we have found that the difference in chlorophyll a between the coastal ocean and Bay displays dramatic interannual variability, including a relatively weak summer gradient during the1998-1999 El Nino/La Nina and a much stronger gradient in summer of recent years. Thus the direction of this flux and its importance to the Bay has varied widely over the last decade. The effect of the open ocean exchange on the Bay will be explored further with multiple scenarios using the 3D model, including a strong and weak gradient in chlorophyll a across the ocean-Bay boundary.

CALFED Statement of Relevance
This work is relevant to CALFED's interest in long term changes in the ecology of the San Francisco Bay and Delta, including alterations in the base of the food web which may play a role in the pelagic organism decline (POD).

SESSION: Phytoplankton, 10/24/2008, 4:00 PM, Room 306

Schraga[1], T.S., J. Thébault[2], J.E. Cloern[1], E.G. Dunlavey[3]
[1]US Geological Survey, 345 Middlefield Road, MS 496, Menlo Park, CA 94025
[2]Johannes Gutenberg University, Institute of Geosciences, Johann-Joachim-Becher-Weg 21, 55099 Mainz, Germany
[3]City of San Jose, Environmental Services Department, 700 Los Esteros Road, San Jose, CA, USA 95134
tschraga@usgs.gov

Primary Production and Carrying Capacity of a Former South San Francisco Bay Salt Pond

Over 6110 ha of the commercial production salt ponds surrounding South San Francisco Bay, CA have been decommissioned and reconnected to the Bay, most as part of the South Bay Salt Pond Restoration Program. These open water ponds are critical habitat for millions of birds annually and restoration program managers must determine the appropriate management of ponds that will not be re-converted tidal salt marsh. This study describes the ecosystem metabolism of these new systems and their ecological value as feeding habitats for birds. We determined metabolic parameters in one pond from high resolution timeseries of dissolved oxygen concentration. Areal gross primary production (8.17 g O2 m-2 d-1) was roughly double the world's most productive estuaries. High rates of phytoplankton photosynthesis were balanced by high rates of community respiration (8.25 g O2 m-2 d-1), revealing a rapid biomass producing and consuming system. Metabolic equilibrium was delicately poised, sharp irradiance and temperature shifts triggered short term photosynthesis reduction resulting in oxygen depletion. The result of all primary production routed though simple food webs was high potential forage production and energy supply to waterbirds, equivalent to 11-163 million planktivorous fish or 19-78 billion small estuarine clams within the pond between May and November. Food quantity does not necessarily equal quality and these systems have the potential to produce toxic or inedible algae. Our study provides the first measurement of primary production in the open water ponds of San Francisco Bay and presents a novel approach for transforming primary production into forage production as a metric of an ecosystem's energetic carrying capacity.

CALFED Statement of Relevance
This study contributes to scientific advances in ecosystem restoration of the Bay-Delta System with findings relevant to adaptive management of former salt ponds. We demonstrate these habitats have beneficial food supply function, but may be detrimental because of their potential to produce toxic or inedible algae and susceptibility to hypoxia.

SESSION: Phytoplankton, 10/24/2008, 4:20 PM, Room 306

Huggins, D.L.
Central Valley Regional Water Quality Control Board, 11020 Sun Center Drive #200
Rancho Cordova, CA 95670-6114
dhuggins@waterboards.ca.gov

Monitoring Irrigated Agriculture – Strategy and Results

The Central Valley Regional Water Quality Control Board has undertaking challenging steps to more rigorously address water quality issues related to nonpoint source pollution through enhanced regulatory and monitoring programs. This presentation will summarize the Irrigated Lands Program Conditional Waiver regulatory framework, its collaborative approach to problem solving and the findings of the first three years of Program monitoring being implemented in an estimated 7.5 million acres of irrigated agriculture. The Central Valley region stretches from the Oregon border to the northern tip of Los Angeles County and includes all or part of 38 of the State's 58 counties. Three major watersheds have been delineated within this region, namely the Sacramento River Basin, the San Joaquin River Basin, and the Tulare Lake Basin. The three basins cover about 40% of the total area of the State (over 60,000 square miles) and approximately 75% of the irrigated acreage. Of the 30 sub-watersheds that comprise the Sacramento River, San Joaquin River, and Tulare Lake Basins, 12 are listed as impaired due to agriculture. The emerging partnerships, through the formation of Coalition Groups that have been established by growers to comply with the regulations are key aspects of the program. The collaborative process is also used extensively in order to facilitate the development and evolution of the program. Characterization of water quality was an important development for the Program, and it was accomplished with involvement from various participants including Coalition Groups, Irrigation Districts, Federal, State and local agencies, analytical laboratories, Resource Conservation Districts, individual growers and other interested stakeholders. Data gathered between May 2004 and October 2006 included measurements from various sources for water column and sediment toxicity, pesticide, salinity, metals, pathogens, nutrients, flow, and other general field parameters. The results were summarized in 2007 and the results informed about water quality conditions, data gaps and identified areas where water quality problems occur and will require further action. Based on the monitoring summary findings, programmatic changes were made including modifications to the Coalition Group monitoring requirements, and expectations for Management Practice development to address water quality problems. The program is currently working with the Coalition Groups and developing strategies to prioritize water quality concerns, to implement management practices, and to measure effectiveness in the areas where water quality standards have been exceeded.

CALFED Statement of Relevance
Using effective collaborative processes, we have been able to identify and prioritize water quality concerns in specific areas design a management plan strategy based on prioritization of areas and constituents. The same strategy is expected to be applicable to other areas that also have been assessed for water quality.

SESSION: Watershed Assessment, 10/24/2008, 8:20 AM, Room 307

Swanson, J.E.
Central Valley Regional Water Quality Control Board, 11020 Sun Center Drive, Suite 200, Rancho Cordova, CA 95670
jswanson@waterboards.ca.gov

Water Quality Monitoring for the Irrigated Lands Regulatory Program in the Central Valley

The monitoring data collected under the Irrigated Lands Regulatory Program (ILRP) provides an overview of the baseline water quality conditions within specific Central Valley subwatersheds that are affected by irrigated agriculture (data gathered between May 2004 and October 2006). Analysis of the data provided us with information about data gaps, such as monitoring locations that require further investigation, and also about areas that warrant additional management practice implementation. The approach for the analysis of the monitoring results was to divide the Central Valley Region into four "Zones," with multiple monitoring sites. These Zones are generally based on distinctions that are geographic and that result in variations in topography, hydrology, and crop type. Data was collected by monitoring for water column and sediment toxicity, pesticides, salinity, metals, pathogens, and other constituents. The standard freshwater test species for water column and sediment toxicity testing utilized in the ILRP are minnow, water flea, algae, and Hyalella. The data for water column and sediment toxicity are described as a percent of significant toxic tests based on the total number of tests. The toxic effects of organophosphate pesticides, such as diazinon and chlorpyrifos, are found in all Zones. Predominant pesticides detected in water throughout the Central Valley monitoring sites include chlorpyrifos, diazinon, simazine, diuron, and DDT/breakdown products. Based on these results, the program is currently analyzing different strategies to prioritize water quality issues and implement management practices, as well as measure effectiveness. These strategies are being developed through the Management Plans process in collaboration with the Coalition Groups.

CALFED Statement of Relevance
Analyzing and assessing different areas throughout the Central Valley based on extensive monitoring for water column and sediment toxicity, pesticides, salinity, metals, pathogens, and other constituents has allowed us to identify and prioritize water quality problems in specific areas.

SESSION: Watershed Assessment, 10/24/2008, 8:40 AM, Room 307

Trask[1], J.R., M. Williams[1], R. Vamshi[1], J. Wrysinski[2], D. Denton[3], M. Cheplick[1]
[1]Waterborne Inc, 897-B Harrison Street S.E, Leesburg, VA, 20175
[2]Yolo RCD, Woodland, CA
[3]USEPA, Sacramento, CA
traskj@waterborne-env.com

Development of a Simulation Model to Evaluate, Design, and Implement Vegetated Agricultural Drainage Ditches

A water quality model was developed to simulate pesticide fate and transport from agricultural fields through a vegetated agricultural drainage ditch (VADD). The model can be used as a design tool to calculate the optimum dimensions of a vegetated ditch for a particular farm system to reduce the transport of pesticides into receiving waters or as an evaluation tool to predict the efficacy of pesticide reduction for a ditch of known dimensions. Water mass balance for the model includes inflow, precipitation, evaporation, seepage, and controlled overflow or drainage from the system while sediment mass balance incorporates settlement, resuspension, and overflow. Pesticide mass balance accounts for dilution, outflow, degradation, and partitioning between water, sediment, and foliage. This paper provides an overview of model algorithms and model performance against field study data.

CALFED Statement of Relevance
A model to assist in the design of vegetated ditches to reduce pesticide runoff into waterways.

SESSION: Watershed Assessment, 10/24/2008, 9:00 AM, Room 307

Lee, G.F., A. Jones-Lee
G. Fred Lee & Associates, 27298 E. El Macero Drive, CA 95618
gfredlee@aol.com

Delta Nutrient Water Quality Problems

The Delta experiences highly significant water quality problems that are caused by excessive discharge of nutrients (N and P) from urban and agricultural sources in the Delta watershed and within the Delta. These problems include impairment of the use of Delta water as a domestic water supply source through causing tastes and odors that require additional treatment; excessive growths of invasive plants (hyacinth and egeria) that impair aquatic life habitat and recreational use; and low DO in some Delta channels caused by decomposition of algae that develop in the Delta watershed. While these problems have been well-known for many decades, little attention has been devoted to controlling nutrient discharges that cause them. To provide information on the magnitude and significance of these problems, the authors organized a California Water and Environmental Modeling Forum (CWEMF)-sponsored Delta Nutrient Water Quality Modeling Workshop in March 2008. That one-day workshop provided information on the occurrence, magnitude, and significance of nutrient-related water quality problems in the Delta. It also provided information on the potential impact of controlling phosphorus inputs to the Delta on planktonic algal biomass in the Delta, and described a conceptual model of Delta nutrient sources. Regulatory agency activities regarding nutrient control to address these problems were reviewed. The workshop agenda, PowerPoint presentations, and a synopsis of the workshop is available at http://www.cwemf.org/workshops/NutrientLoadWrkshp.pdf and http://www.members.aol.com/GFLEnviroQual/CWEMF_WS_synopsis.pdf. This presentation will summarize what is known about water quality problems in the Delta caused by aquatic plant nutrients, and their potential control.

CALFED Statement of Relevance
Excessive Fertilization of the Delta is one of the most significant causes of water quality problems in the Delta

SESSION: Watershed Assessment, 10/24/2008, 9:20 AM, Room 307

Bay[1], S.M., K. Gehrts[2], S. Lowe[3], C. Beegan[4]
[1]Southern California Coastal Water Research Project, 3535 Harbor Blvd., Suite 110, Costa Mesa, CA 92626
[2]Department of Water Resources, Sacramento, CA
[3]San Francisco Estuary Institute, Oakland, CA
[4]State Water Resources Control Board, Sacramento, CA
steveb@sccwrp.org

Relationships among Sediment Quality Indicators in the Lower Delta

Little is known about sediment contamination in the tidal freshwater habitats of the lower Delta, and whether sediment quality plays a significant role in the condition of benthic and aquatic communities in the region. The State Water Board, in collaboration with the California Dept. of Water Resources, examined sediment contamination, toxicity, and benthic invertebrate community condition at 75 locations. Sampling was based on a stratified randomized design and was conducted in Fall 2007 and Spring 2008. Preliminary results from 2007 indicate a low frequency of toxicity to amphipods (*Hyalella azteca*) and midges (*Chironomus dilutus*). Sediment contamination was widespread within the study area, with a high frequency of detection of both legacy contaminants (e.g, DDTs, PCBs) and current use pesticides (e.g., pyrethroids and carbamates), although concentrations were relatively low. Benthic community composition varied among the study sites. This presentation will describe the patterns of contamination and biological condition among subregions and habitats of the Delta. The level of correlation between chemical parameters will also be described and compared to other regions. The results of preliminary analyses of the association between sediment contamination indicators or other environmental factors and biological responses (toxicity or biological community condition) will also be described. The implications of these results for the development of a Delta sediment quality assessment framework will be discussed.

CALFED Statement of Relevance
This project has high relevance to the CALFED's objectives for ecosystem restoration. These data provide the only integrated investigation of sediment quality in the Delta and will of critical importance for determining the health of the benthic ecosystem, potential relationship to POD, and in prioritizing regions for restoration.

SESSION: Watershed Assessment, 10/24/2008, 9:40 AM, Room 307

Donigian Jr[1], A.S., B.R. Bicknell[1], K.S. Rosselot[2]
[1]AQUA TERRA Consultants, 2685 Marine Way, Suite 1314, Mountain Vew, CA 94043
[2]Process Profiles, P.O. Box 8264, Calabasas, CA 91372
donigian@aquaterra.com

Watershed Modeling of Copper Loads to San Francisco Bay from Brake Pad Wear Debris

This watershed modeling effort was conducted as part of a larger study by the Brake Pad Partnership (BPP) that examines the potential impact of copper from brake pad wear debris released to the environment in the San Francisco Bay Region. The BPP is mulitstakeholder effort of manufacturers, regulators, stormwater management agencies and environmentalists working together to better understand the impacts of this source of copper on water quality. The watershed model provides runoff loads to a Bay modeling effort to assess resulting concentrations in SF Bay. The BPP has sponsored studies of copper source releases, water quality monitoring, and air deposition monitoring studies specifically to provide input data for these watershed and Bay modeling efforts. Other Brake Pad Partnership studies, such as air deposition monitoring, procurement of a representative sample of brake pad wear debris, and physical and chemical characterization of brake pad wear debris, indirectly provided information that supported these modeling efforts. The objective of the environmental transport and fate modeling components of the BPP studies is to predict the relative contribution of copper released from brake pads in the Bay area and how the contribution from brake pads affects both the short-term and long-term concentrations of copper in the Bay. This paper describes the model application process, including model conceptualization, parameterization, calibration, and scenario analyses. Also presented is the GIS processing of relevant data layers to produce watershed modeling inputs for the U.S. EPA BASINS model system that was used for the watershed modeling. With local data for land use, soils, topography, and meteorology, the U.S. EPA's Hydrological Simulation Program-FORTRAN (HSPF) model , as part of the BASINS system, was set up for each of the 22 Brake Pad Partnership modeled sub-watersheds that drain to the San Francisco Bay. Model parameters and copper sources associated with deposition of copper onto landscape surfaces were obtained from the results of atmospheric deposition modeling and from release inventory values of brake and non-brake sources conducted for the BPP. HSPF Model runs were performed for each sub-watershed for the entire time period of water year 1981 through water year 2005, i.e. October 1980 through September 2005. Model results were processed for flow, sediment and copper loads; annual and mean annual loads were tabulated; and daily flows and concentrations (both sediment and copper, total and dissolved) were reviewed as a quality assurance confirmation. Thus, three cases of copper release (flux) scenarios were modeled, one called brakes-high, one called brakes-low, and one called median estimate. These three scenarios were selected because results based on them approximate the range of relative contribution of copper released from brakes, and because they take the uncertainty in both brake and non-brake releases into account. Among the Brake Pad Partnership modeled watersheds, the total contribution from brake pad wear debris towards total anthropogenic loads of copper to the Bay for the median estimate case varies from 15% to 57%. As expected, the brake pad contribution is much lower for the rural sub-watersheds than for the heavily urbanized sub-watersheds, reflecting alternative human activity and traffic levels. The model results show a wide variation across the Bay Region in source loadings among the modeled watersheds -- some of these sub-watersheds have their largest contribution from sediment/background sources, some have their largest contribution from non-brake pad anthropogenic sources, and one has its largest contribution from brake pad sources.

CALFED Statement of Relevance
Copper is a significant contaminant to SF Bay, especially in the South Bay region, and brake pad wear debris has been implicated as a major source. This effort assesses the contributions of copper from brake pads and attempts to evaluate impacts from alternative mitigation measures.

SESSION: Watersheds, 10/24/2008, 10:20 AM, Room 307

Drexler[1], J.Z., C.S. de Fontaine[1], T.A. Brown[2]
[1]U.S. Geological Survey, California Water Science Center, 6000 J Street, Sacramento, CA 95819-6129
[2]Center for Accelerator Mass Spectrometry, Lawrence Livermore National Laboratory, L-397, P.O Box 808, 7000 East Ave., Livermore, CA 94551
jdrexler@usgs.gov

Peat Accretion Rates, Carbon Storage, and Carbon Loss during the Past 6000+ Years in the Sacramento-San Joaquin Delta

The 1400 km2 tidal marsh that formed during the Holocene in the Sacramento-San Joaquin Delta was largely drained and reclaimed for agriculture 100–150 years ago. The remaining peat constitutes a large archive of environmental conditions and peat formation processes through the millennia. The CALFED-funded REPEAT (Rates and Evolution of Peat Accretion through Time) project is a multi-disciplinary effort aimed at determining past rates and processes of peat accretion in order to benefit future wetland restoration efforts. Peat cores were collected in 2005 from both reclaimed farmed islands and remnant marsh islands in the Delta. Radiocarbon analyses were conducted on macrofossils in the peat, and age models were constructed from the results. The radiocarbon data from Venice Island (central Delta), Webb Tract (western Delta), and Browns Island (far west Delta) show that the extensive tidal marsh started forming approximately 6600 years ago. The age models reveal that peat accretion has ranged from < 1 mm to over 1 cm per year during the history of the Delta. Loss on ignition tests showed that the relative contribution of organic material vs. inorganic material that was incorporated into the peat varied throughout the millennia, suggesting that there may have been concomitant variability in climate, fire frequency, and/or flooding. Since reclamation approximately 2/3 of the stored carbon in the Delta, which took almost 7000 years to form, has been lost, mainly through microbial oxidation of the peat. For the center regions of the reclaimed farmed island sites (i.e., areas not adjacent to levees) this translates into an estimated loss of between 2900–5700 metric tons of organic carbon/hectare.

CALFED Statement of Relevance
The REPEAT project is aimed at determining the rates and processes of peat accretion through time in the Delta. Results from this project will aid managers in choosing wetland restoration sites that have the best potential for success within acceptable time-frames.

SESSION: Watersheds, 10/24/2008, 10:40 AM, Room 307

Alpers, C.N., J.Z. Drexler
U.S. Geological Survey, California Water Science Center, 6000 J Street, Sacramento, CA 95819
cnalpers@usgs.gov

Trace Metals in Peat Deposits of the Sacramento–San Joaquin Delta: A 6000+ Year Record of Pre-Anthropogenic, Baseline Conditions and Anthropogenic Effects

The original 1,400 square kilometer marsh located at the confluence of the Sacramento and San Joaquin rivers (the Delta) started forming approximately 7000 years ago. Analysis of major and trace elements in peat from Browns Island has revealed two major patterns in the peat profile: one for contaminants and one for elements associated with salinity. Depth profiles of contaminant metals such as lead (Pb) and mercury (Hg) in Delta peat indicate significantly higher concentrations in the upper, more recently deposited peat compared with lower, older deposits. In the top 55 cm of peat, where deposits are less than approximately 100 years of age, average concentrations of Pb were 45 parts per million (ppm, dry basis) with a standard deviation (SD) of 14 ppm. Lower in the section, in peat deposited between about 2350 and 6300 calibrated years before present (cal yr BP), average Pb was 9 ppm (SD 2 ppm). Mercury concentrations in the top 55 cm of peat at Browns Island averaged 0.34 ppm (SD 0.22 ppm), compared with concentrations of 0.042 ppm (SD 0.002 ppm) in the older material. Titanium (Ti) resides exclusively in the inorganic fraction of the peat and therefore can be used as a proxy for total inorganic material. Normalizing Pb concentrations by Ti leads to a depth profile that shows near-constant values of Pb/Ti between about 6300 and 2000 cal yr BP and an increase in Pb/Ti values beginning about 2000 cal yr BP. These results are consistent with studies elsewhere that report an increase in global Pb atmospheric contamination around 2000 cal yr BP, associated with an increase in base-metal mining and smelting by Greek and Roman civilizations. Work in progress using Pb isotopes will attempt to quantify proportions of anthropogenic Pb from leaded gasoline and mining sources.

CALFED Statement of Relevance
The REPEAT project is aimed at determining the rates and processes of peat accretion through time in the Delta. Results from this project will aid managers in choosing wetland restoration sites that have the best potential for success within acceptable time-frames.

SESSION: Watersheds, 10/24/2008, 11:00 AM, Room 307

Deverel, S.J., D.A. Leighton
HydroFocus, Inc., 2727 Del Rio Place, Davis, CA 95618
sdeverel@hydrofocus.com

Modeling of Accretion of Tidal and Managed Wetlands, Sacramento-San Joaquin Delta

Prior to 1850, the Delta was a freshwater tidal wetland. Farmers and laborers drained Delta soils for agriculture in the late 1800's and early 1900's resulting in subsidence on over 60 islands from 1 to over 8 m below sea level. The organic or peat deposits of the Delta formed during the past 7,000 years from decaying wetland plants. The State of California is interested in promoting managed wetlands for reversing the effects of subsidence on Delta islands. Better understanding of peat accumulation rates and processes affecting accumulation will aid in the development of wetlands for mitigating subsidence on Delta islands. We attempted to better understand wetland accretion by modeling wetland processes using data for channel islands and managed wetlands on Twitchell Island. . We developed a predictive and synthesis tool, a modified cohort accounting model to simulate long-term (several thousand years) and recent (the last 300 years) accretion on four channel islands in the Delta. We have also used the model to simulate accretion rates in the Twitchell Island demonstration wetland since 1997. We used data collected during the course of the project (organic matter content, peat geochemistry, bulk density, porosity and Carbon-14 and Cesium-137 age dating) and the scientific literature for model inputs, development and validation. Model results reveal different processes affecting managed and channel-island wetlands. Channel island wetland slowly accreted over geologic time under dynamic conditions in which organic accumulation rates were low and accretion rates were about 1 mm/year. In contrast, managed wetlands accrete under relatively stable hydrologic conditions at rates in excess of 2 to 3 cm per year with high rates of organic matter accumulation. Results of future simulations for deeply subsided Delta islands indicate time periods of several decades to several hundred years for accretion in managed wetlands to current sea level.

CALFED Statement of Relevance
A key element of CALFED's objectives is ecosystem restoration in the Delta. This paper provides important information about possibilities for restoration of Delta islands through managed wetlands.

SESSION: Watersheds, 10/24/2008, 11:20 AM, Room 307

Miller, R.L., R. Fujii
U.S.G.S. California Water Science Center, 6000 J Street, Placer Hall, Sacramento, CA 95819
romiller@usgs.gov

Accretion Rates and Decomposition Dynamics in Re-established Marshes to Reverse Subsidence in the Sacramento-San Joaquin Delta

Subsidence in the Sacramento-San Joaquin Delta, caused by drainage of organic soils, poses a number of problems, including increased levee maintenance costs and a continued threat of levee failure and flooding. In 1997, the U.S. Geological Survey re-established wetlands, with shallow water depths of 25 and 55 cm, on Twitchell Island to investigate the potential to reverse subsidence of delta islands by recreating conditions under which the deep organic soils developed. Ten years after flooding, elevation gains in the wetlands ranged from approximately 30 to 60 centimeters, with accretion rates averaging 4.8±0.3 cm/year in marsh areas of the 55 cm deep wetland and 3.5±0.2 cm/year in the 25 cm deep marsh. Despite these differences in accretion rates, carbon storage rates were about 1 kg/m2/year in both wetlands. Also, in both wetlands, accretion rates were greater during the last five years of the study than in the first five years. However, in areas without marsh vegetation, land surface elevations showed little change. Differences in rates of land surface elevation gain in areas of marsh appeared to result from temporal and spatial variability in decomposition rates rather than inputs from primary production. Plant litter decomposition studies showed that decomposition rates slowed as the wetlands matured. Furthermore, spatial variability in decomposition rates appeared to be related to differences in hydrologic conditions between the wetlands, and among sites within the wetlands, such that marsh areas most isolated from the river water inputs, with longer water residence times, had slowest decomposition rates. Differences in location within the marshes influenced a number of hydrologic factors that can affect decomposition dynamics, including temperature, pH, dissolved oxygen concentration, and the availability of alternate electron acceptors. These results indicate that managing wetland hydrology can be used to maximize the subsidence reversal potential of re-established delta marshes.

CALFED Statement of Relevance
The study of carbon dynamics in Delta wetlands is directly related to several important issues confronting California water and resource planners and managers, including levee stability, carbon losses from current land use, and C storage in wetlands.

SESSION: Watersheds, 10/24/2008, 11:40 AM, Room 307

Loyo-Rosales[1], J.E., R. Lavado[2], E. Floyd[2], D. Schlenk[2], D.L. Sedlak[1]
[1]University of California, Berkeley, Civil and Environmental Engineering, Berkeley, CA 94720-1712
[2]University of California, Riverside
jloyo@berkeley.edu

Estrogenic Contaminants in the Sacramento and San Joaquin River System

The presence of chemical contaminants capable of inducing feminization of male fish has been observed in municipal wastewater effluent, grazing rangelands and concentrated animal feeding operations. Because many of these sources are present in the Sacramento and San Joaquin river system, researchers and resource managers have expressed concern about the potential for estrogenic contaminants to impact sensitive fish species, such as Chinook salmon. To assess the presence and sources of estrogenic contaminants, 115 samples from 16 locations in the Central Valley were analyzed for known estrogenic compounds (steroid hormones and alkylphenols) using GC/MS-MS and for estrogenicity with in vivo and in vitro vitellogenin bioassays. Chemical analysis showed that concentrations of the estrogenic compounds were below the threshold levels for vitellogenin induction, even if additive effects were considered. In contrast, bioassays consistently showed estrogenic activity at 6 of the sites. When expressed in estradiol equivalents, estrogenicity was often over an order of magnitude higher than levels reported in wastewater effluent. Although estrogenic activity was consistently observed at specific sites over an entire year, the type of activity was not: 2 sites showed high estrogenicity both in vivo and in vitro, 2 presented high estrogenicity in vivo only, and 2 showed high estrogenicity in vitro only, suggesting that more than one compound caused the activity. Attempts to identify the compound through toxicity identification analysis (TIE) have provided insight into the chemical properties of the compound(s), but the identity of the compound is still unknown.

CALFED Statement of Relevance
These findings address the water quality and ecosystem restoration objectives of the CALFED Program; they show that parts of the Sacramento and San Joaquin River system are impacted by unknown estrogenic compound(s) that may affect Chinook salmon reproduction. The results provide a basis for developing strategies to identify and minimize the release of estrogenic compounds in California's inland waters.

SESSION: Water Quality (I), 10/24/2008, 1:00 PM, Room 307

Kunz[1], P.Y., P. Wu[2], S.J. Teh[1]
[1]Aquatic Toxicology Program, Department of Anatomy, Physiology, and Cell Biology, School of Veterinary Medicine, University of California Davis, 1211 Haring Hall, Davis, CA 95616
[2]Department of Mathematics, Lehigh University, Christmas-Saucon Hall, 14 E. Packer Ave., Bethlehem, PA 18015
pykunz@ucdavis.edu

Novel Screening Tool of Multiple Endocrine Disrupting Chemicals in Environmental Water Samples with a Medaka Fish Model

Understanding the impact and interaction of endocrine disrupting chemicals (EDC) present in the aquatic ecosystem by assessing and understanding potential effects on vulnerable receptor organism, like fish, is crucial. The Japanese Medaka (*Orzyias latipes*) is a well-studied, highly-responsive model organism, and the ideal fish species to screen natural waters for their EDC potential. Especially the Qurt Medaka strain has been used successfully to characterize toxicity, carcinogenesis, and endocrine disruption elicited by exposure to both environmental and pharmaceutical chemicals and has several advantages for this type of study. First, our in-house Medaka microarray (gene) chip which includes 1600 uniquely and significantly EDC-affected genes identified from a total of originally 9379 DNA probes, allows us to identify and separate distinct EDC induced gene expression patterns for (anti)estrogenic, (anti)androgenic and (anti)thyroid activities. Second, the short lifespan of Medaka enables us to test EDC and toxicity endpoints in real time. Third, the fact that 2-day-old medaka embryo can be visually separated by gender before gonad development, allows us to ask specific questions concerning gender-specific effects of EDCs. These qualities result in a unique tool to screen, characterize and understand the endocrine disrupting properties of single compounds and mixtures thereof present in environmental water samples. Because of the rapid sexual maturation of Medaka (8-10 weeks), we can combine our findings on EDC induced gene expression patterns during embryonic development with alterations in gene patterns and histopathology at sexual maturation, thereby linking gene expression at different life stages with reproductive fitness at the individual and population level. Qurt Medaka is an especially well-suited experimental species for EDC, carcinogenesis and toxicity testing of natural water samples or single environmental contaminants and here we would like to present this novel and fast screening tool and its applications for ground- and surface water samples of the San Francisco estuary.

CALFED Statement of Relevance
Ongoing research is being conducted on the EDC effects of waste water and ground water in the San Francisco estuary. These results have important ramifications for water quality monitoring in drinking and surface water.

SESSION: Water Quality (I), 10/24/2008, 1:20 PM, Room 307

Kelley[1], K.M., J.A. Reyes[2], R. Fairey[3], A.L. Jeffrey[4]
[1]Environmental Endocrinology Laboratory, Dept. Biological Sciences, California State University, Long Beach, CA 90840
[2]Pacific Coast Environmental Conservancy, 214 Fifth Street, Taft, CA 93268
[3]Marine Pollution Studies Laboratory, Moss Landing Marine Laboratories, 7544 Sandholdt Rd., Moss Landing, CA 95039
[4]Environmental Laboratory and Ocean Monitoring Division, Orange County Sanitation District, 10844 Ellis Avenue, Fountain Valley, CA 92708
kmkelley@csulb.edu

Endocrine Disruption Occurring in Wild Fish of San Francisco Bay and Coastal California

San Francisco Bay (SFB) includes a diversity of estuarine and inshore marine environments that are well documented to be contaminated with chemicals derived from the activities of large coastal human population centers. Different locales within the SFB, as well as along coastal California (CC), can be characterized by distinct chemical contamination histories and signatures, with the resident fish accumulating the contaminants. Therefore, phenotypic analyses of fish residing in different local environments can provide insight into the potential biological impacts of different chemical signatures. Using biochemical and molecular probes to measure effects on different endocrine and physiological parameters in fish is elucidating the types of phenotypic impacts and their likely underlying mechanisms of action. Altered ("disrupted") levels of endocrine factors related to thyroid, stress (adrenal), and growth and reproduction have all been documented concomitantly with measures of physiological performance in fish sampled from different SFB and CC environments. Additional proteomic analyses of tissues have pointed to a host of associated toxicological and metabolic alterations. Correlating these alterations to specific chemical concentrations accumulated in the fish, combined with an overall integrative "systems" interpretation of these data, is shedding light on potential cause-and-effect relationships and to mechanisms of action underlying the observed effects. (Support by San Francisco Estuary Institute's Regional Monitoring Program for Water Quality, Pacific Coast Environmental Conservancy, Orange County Sanitation District, NOAA-Southern California Sea Grant Program).

CALFED Statement of Relevance
These are studies working to tie presence of environmental chemicals in the environment and in fish tissues to impacts on the physiological performance and well-being of resident fish in SF Bay. An important aspect of the work is the extent to which the native fish are "endocrine disrupted" by their environment, and on related phenotypic impacts in the animals. There is very little understanding of exposure and effects in San Francisco Bay wildlife. The scientific approaches used in these studies are state of the art (endocrine, molecular and proteomic analyses) and have provided novel insight on impacts of water quality on SF Bay wildlife.

SESSION: Water Quality (I), 10/24/2008, 1:40 PM, Room 307

Watanabe[1], N.N., T.H. Harter[1], B.A. Bergamaschi[2]
[1]UC Davis, Dept. of LAWR, Veihmeyer Hall, Davis, CA 95616
[2]USGS California Water Science Center, 6000 J St., Sacramento, CA 95819
naowatanabe@ucdavis.edu

Environmental Occurrence of Antibiotics in Dairy Farming

Intense animal husbandry is of growing concern as a potential contamination source of a variety of emerging contaminants including pathogens, naturally occurring and synthetic steroid hormones, and various pharmaceuticals, particularly antibiotics. For example, more than twenty million pounds of antibiotics are sold for use in animal husbandry with 95% going towards therapeutic use. Here, we focus on the application and potential environmental occurrence of pharmaceuticals on dairies. Using two dairy farms in California as study sites, we conducted four seasonal samplings along three environmental pathways – 1) from flush lanes to lagoon waters to shallow groundwater, 2) from manure application to shallow groundwater beneath the associated fields, and 3) through leaching from surface soil to soil cores to shallow groundwater beneath the dairies. Concentrations of pharmaceuticals were determined using solid-phase extraction and liquid chromatography – tandem mass spectrometry with positive electrospray ionization. In the wastewater stream, sulfonamides, tetracyclines and their degradation products, lincomycin, trimethoprim, and ibuprofen were detected. Along the pathway 1), in groundwater immediately downgradient of the lagoons, sulfonamides and lincomycin were present. Along the pathway 2), in groundwater beneath the associated fields that receive manure, sulfonamides were detected. Along the pathway 3), in surface solid samples, sulfonamides, tetracyclines and their degradation products, and erythromycin were detected, and deeper in soil cores from 0 to 30 cm, sulfonamides and tetracycline were detected. In groundwater beneath dairy facilities, sulfonamides and lincomycin were detected. Sulfonamides were most frequently detected in groundwater immediately downgradient of lagoons, the field that receives manure, and wells in corral area indicating that they reach shallow groundwater through all of the three pathways.

CALFED Statement of Relevance
This study assesses the impacts of dairy farming on water quality in the Central Valley. The objective of this research is to measure the occurrence of veterinary pharmaceuticals along environmental pathways in dairy farms, and to assess the potential to enter the shallow groundwater.

SESSION: Water Quality (I), 10/24/2008, 2:00 PM, Room 307

Oram[1], J.J., L.J. McKee[1], C.E. Werme[2], M.S. Connor[1], D.R. Oros[1], R. Grace[3], F. Rodigari[4]
[1]San Francisco Estuary Institute, 7770 Pardee Lane, Oakland, CA 94621
[2]Consultant
[3]AXYS Analytical Ltd.
[4]EBMUD
joram@sfei.org

A Mass Budget of Polybrominated Diphenyl Ethers in San Francisco Bay, CA

A mass budget of polybrominated diphenyl ethers (PBDEs) in San Francisco Bay is developed as a first step towards understanding the local sources and transport processes controlling PBDE fate in a highly urbanized estuary. Extensive monitoring of PBDEs in estuarine water and sediment, freshwater tributaries, air, and wastewater effluents and sludges were integrated with a mass budget model to provide a synthetic view of these emerging contaminants. The Bay inventories of BDE 47 and BDE 209 in 2006 were estimated to be 33 ± 3 kg and 153 ± 45 kg, respectively. Empirically derived estimates of annual inputs of BDE 47 and BDE 209 from all quantifiable external sources ranged from 11 to 28 kg/yr and 22 to 24 kg/yr, respectively. BDE 47 loads were dominated by wastewater while runoff from local tributaries represented the largest contributor to BDE 209 loads. Model results suggest the Bay PBDE inventory is highly sensitive to changes in external loads, with degradation and outflow being the major processes governing PBDE fate. The mass budget presented provides a framework for integrating future monitoring and modeling efforts.

CALFED Statement of Relevance
This mass budget of PBDEs in San Francisco Bay represents a first-of-its-kind study of these emerging contaminants in an urbanized estuary. The study identifies the pathways responsible for transporting PBDEs from watersheds to the Bay and the processes controlling their fate within the Bay. A model is used to estimate plausible future water quality conditions and potential effects of management actions.

SESSION: Water Quality (I), 10/24/2008, 2:20 PM, Room 307

Durieux, E.D., K. Eder , P. Fitzgerald, D.J. Ostrach
Pathobiology, Conservation & Population Biology Laboratory, John Muir Institute of the Environment, Center for Watershed Sciences, UC Davis, One Shields Ave, Davis, CA 95616
eddurieux@ucdavis.edu

Natural Changes in the Acetylcholinesterase Activity of Striped Bass (Morone saxatilis) Larvae and Juveniles in the San Francisco Estuary: Factors to Consider when using this Common Neurotoxicity Biomarker

Acetylcholinesterase (AChE) activity is one of the most common biomarkers of neurotoxicity used in aquatic organisms. Very few studies have analysed the effects of natural factors on AChE activity especially in estuarine fish. In the present study we investigated the effects of natural factors on AChE activity such as development, size, water temperature and conductivity in larvae (i) and juveniles (ii) of striped bass (Morone saxatilis) a sentinel species in the San Francisco Estuary. (i) We analyzed the change in AChE activity during early larval development of domestic (control) vs river females' progeny to test for potential effects caused by maternal transfer of contaminants. AChE activity displayed a strong significant increase throughout the developmental period but no significant differences between domestic vs river larvae were detected. (ii) In a laboratory experiment using juvenile striped bass an inhibition of AChE of up to 62 % was seen after an intra-peritoneal exposure of the organophosphate Diazinon. AChE activity was measured in juveniles collected in the estuary sampled monthly from August 2007 to January 2008. The spatial-temporal variability of AChE was analysed relative to water temperature and conductivity, and fish size. AChE activity was strongly positively correlated to water temperature and to a lesser extent negatively to fish size due to the negative covariation of size with temperature. Monthly, AChE appeared regularly correlated to temperature whereas it was found periodically negatively correlated to size and water conductivity. In striped bass, the major factor influencing AChE activity in larvae is age/developmental stage, whereas for juveniles it is temperature and to a lesser extent size and conductivity. Taking into account these natural factors when using AChE as a neurotoxicity biomarker can help to determine and understand the role of contaminants, and manage their effects on pelagic fish populations in the San Francisco Estuary.

CALFED Statement of Relevance
Striped bass is an important sentinel species in the San Francisco Estuary. The results of this study can help to better understand contaminant effects on local fish species which is essential for managing water quality and ecosystem restoration.

SESSION: Water Quality (II), 10/24/2008, 3:00 PM, Room 307

Weston, D.P.
University of California, Dept. Integrative Biology, Berkeley, CA 94720-3140
dweston@berkeley.edu

Identifying the Cause of Toxicity using a New Toxicity Identification Evaluation Approach with Pesticide-specific Carboxylesterase Enzymes

An esterase enzyme developed for hydrolysis of chlorpyrifos, diazinon, methyl parathion and other organophosphate insecticides has recently become commercially available in the U.S. Although the product, produced by genetically engineered E. coli, is intended for treatment of runoff, it can be used in a novel Toxicity Identification Evaluation (TIE) approach to eliminate toxicity when that toxicity is due to organophosphate insecticides. In tests with chlorpyrifos, we observed full survival of *Hyalella azteca* even at chlorpyrifos concentrations that were 40 times the acutely toxic chlorpyrifos concentrations in the absence of the enzyme. Enzymes targeting other pesticide groups are currently in development, and trials were also conducted with esterase enzymes designed to degrade the pyrethroid insecticides, permethrin and bifenthrin. These enzymes were less effective than the organophosphate-degrading variant, and resulted in about a 2-fold reduction in toxicity. However, even this reduced efficacy may be sufficient for TIE application. Both the organophosphate and pyrethroid-degrading enzymes were tested for their specificity within and between these pesticide classes, and were evaluated with field-contaminated samples. This new approach shows considerable promise in identifying the specific pesticide class that is contributing to toxicity, and in addition, is applicable to TIEs conducted with either water or sediment samples.

CALFED Statement of Relevance
Identifying the cause of toxicity when observed in toxicity tests is crucial to mitigating water quality impacts. If organophosphate or pyrethroid pesticides are responsible for that toxicity, the new approach described in this presentation can help establish that and identify the pesticide class involved.

SESSION: Water Quality (II), 10/24/2008, 3:20 PM, Room 307

Acuna[1], S.C.*, D. Deng[1], P. Lehman[2], F. Teh[1], S.J. Teh[1]
[1]VM:APC UC Davis, 1330 Haring Hall,1 Shields Ave, Davis, CA 95616
[2]Department of Water Resources, California, 1416 9th Street, Sacramento, CA 95814
scacuna@ucdavis.edu

Dietary Effects of Microcystis on Sacramento Splittail, Pogonichthys macrolepidotus

In the upper San Francisco Estuary (the Delta and Suisun Bay), the presence of the toxic algal bloom *Microcystis aeruginosa* (MC) may endanger fish populations. Blooms of MC are a major concern of Interagency Ecology Program Management Team, and have been suggested as one of the possible causes of fish decline in the San Francisco Estuary (SFE). The MC bloom contains the toxin microcystins-LR (MC-LR), a hepatotoxic protein that may have direct and indirect impact on the survival of fish. Sacramento splittail, *Pogonichthys macrolepidotus* a native opportunistic benthic forager, may have been exposed to *M. aeruginosa* through their diet by consumption of detrital material. In this study, the concentration of MC-LR in MC from the SFE was determined by HPLC and then dietary ingredients were added to produce diets with 5, 10, and 20 mg/L of MC-LR. Juvenile splittail were then exposed to these diets at 10 fish per tank for three replicate tanks per concentration for 28 days. The treatments were compared to two controls of 0 MC-LR (MC0) and a positive control with purified MC-LR at 5 mg/L (MC5R). Gross examination revealed increased incidents of clinical signs of stress, internal and external hemorrhaging, discoloration and fin damage, for MC5, MC5R, MC10 and MC20 when compared to MC0. Histopathology was used to identify tissue damage and tumor formation. HPLC was used to determine the level of MC-LR within the tissues of exposed fish. Stress indicators of elevated RNA:DNA ratios and expression of protein phosphorylase 1A and 2A which are known to be expressed during exposure to MC-LR were also determined.

CALFED Statement of Relevance
Blooms of MC are a major concern for the estuary because they may be a contributing factor to the recent decline in pelagic organisms in the San Francisco Estuary. They are particularly important for the recent decline because both the fishery decline and the large-scale blooms of MC began around 2000.

SESSION: Water Quality (II), 10/24/2008, 3:40 PM, Room 307

Beckon, W.N.
US Fish and Wildlife Service, 2800 Cottage Way, Suite W-2605, Sacramento, CA 95825
William_Beckon@fws.gov

Toxicity of Selenium to Salmonids

A review and reanalysis of data from the 1980's indicates that Central Valley Chinook salmon are not protected by national criteria (current or proposed) that are intended to protect aquatic life from the toxic effects of selenium. Young salmon suffer 10% mortality due to selenium at a fish tissue concentration of about 1.8 µg/g (whole body dry wt.), far below the 7.9 µg/g tissue criterion proposed by EPA. This finding accords with studies of the toxicity of selenium to rainbow trout. Site- and species-specific bioaccumulation data indicate that this LC10 (1.8 µg/g) in young salmon corresponds to about 3.3 µg/L selenium in water, well below EPA's current national criterion of 5 µg/L. These data suggest that selenium may have killed about one quarter of the young Chinook salmon migrating down the San Joaquin River.

CALFED Statement of Relevance
This study shows that, although discharges of selenium to the San Joaquin River have been reduced over the last 15 years, selenium will pose a substantial risk to Chinook salmon that are reintroduced to restored middle reaches of the river unless selenium loads are further reduced and/or sufficient dilution flows are provided.

SESSION: Water Quality (II), 10/24/2008, 4:00 PM, Room 307

Hunt[1], J.A., K. Harrold[1], J.H. Walsh[2], D.J. Ostrach[3], M. Gassel[4], R. Brodberg[5], G. Ichikawa[2], A. Bonnema[2], W. Heim[2], D.A. Jay[1]
[1]San Francisco Estuary Institute, 7770 Pardee Ln., 2nd Flr., Oakland, CA 94621
[2]Moss Landing Marine Lab., 7544 Sandholt Rd., Moss Landing, CA 95039
[3]John Muir Institute of the Environment, Center for Watershed Sciences, Dept. of Civil & Environmental Engineering, UC Davis, 1 Shields Ave, Davis, CA 95616
[4]Office of Environmental Health Hazard Assessment, 604 Masonic Ave, Albany, CA 94706
[5]CA EPA-Environmental Health, PO BOX 4010, Sacramento, CA 95812-4010
jennifer@sfei.org

Mercury in Striped Bass in San Francisco Bay

Striped bass, *Morone saxatilis*, are one of the most popularly consumed sport fish species in the San Francisco Bay and Delta and also have high mercury levels. There are several California sport fish consumption advisories in effect with special provisions for this high mercury species including in the San Francisco Bay and Delta, the South Delta, and the Sacramento River/North Delta. CalFed has funded the Fish Mercury Project (FMP), a three-year study to assess mercury levels in sport fish from Central Valley Rivers and the Delta. In year two, 100 striped bass were collected from multiple locations in the Delta and the Sacramento River and analyzed for mercury. Otoliths were also analyzed for all legal sized striped bass (with funding from the Regional Monitoring Program) in order to determine habitat use of each individual fish. Otolith analysis used a ratio of 87Sr/86Sr and was able to delineate habitat in different salinity regimes: including marine (west of Carquinez Strait), east of Suisun Bay, Delta, and fresh. Habitat use will be analyzed in conjunction with mercury levels to determine if this explains some of the variation in mercury bioaccumulation. Striped bass mercury levels ranged from 0.07 ug/g ww (Big Break) to 1.85 ug/g ww (Cosumnes River), with average concentrations across the study area of 0.38 ug/g ww. Otolith data suggest that some individual striped bass remain in particular habitats (fresh and delta) over long periods of time, while other individuals make use of multiple habitats (ocean, fresh, Delta) over their lifetime.

SESSION: Water Quality (II), 10/24/2008, 4:20 PM, Room 307

Ejeta, M.Z., M. Roos, T. Kadir, M. Anderson, J. Galef, F. Chung, J. Anderson, M. Mierzwa, B. Coleman, K. Kao
California Department of Water Resources, 1416 Ninth Street, Sacramento, CA 95835
mejeta@water.ca.gov

Analysis of Historical Data for Climate Change Trend in California

This paper examines various long-term historical data to find out if there are more reasons to believe that a trend of climate change has started to occur in California. The analysis uses 1) temperature, snow, and precipitation data from a cross-section of locations throughout California; 2) natural runoff, also called unimpaired flow, data of over 100 years for eight river locations in the Sacramento and San Joaquin Valleys; 3) sea level change in the San Francisco Bay; and 4) paleoclimate data derived based on tree ring research. The data is available from various sources including the National Weather Service's Cooperative Observer Program (COOP), the California Cooperative Snow Surveys program, and the National Oceanic and Atmospheric Administration (NOAA). Potential evidence of climate change trend embedded in each data type as well as any correlations between these data are closely examined. The results of this analysis are used to gain more insight about the invalidity under climate change of the assumption of statistically stationary hydrological data. Because the invalidity of this assumption is bound to change the traditional approach of water resources planning, this analysis is relevant to the effort to develop a new approach for water resources planning that incorporates climate change.

CALFED Statement of Relevance
The analysis highlights the impact of climate change on water supply reliability, water quality, and levee system integrity.

SESSION: Climate Change Science and Water Resources Management, 10/24/2008, 8:20 AM, Rooms 308-310

Anderson[1], J.D., F. Chung[1], T. Kadir[1], L.L. Dale[2], C. Brush[1], E. Dogrul[1], J. Galef[1], E. Reyes[1], H. Yin[1], N. Miller[2], S. Vicuna[3]
[1]California Department of Water Resources, 1416 Ninth Street, Sacramento, CA 95814
[2]Lawrence Berkeley National Laboratory, 1 Cyclotron Road, Berkeley, CA 94720
[3]University of California, Berkeley
jamiea@water.ca.gov

Modeling Climate Change Impacts on California's Water Resources

Problem Statement: Future projections for warming air temperatures, changes in precipitation patterns and snow levels, and increased sea levels are expected to impact management of California's water resources. California's water supply may be vulnerable to these changes since it relies on winter snowfall for much of its summer water supply. About two-thirds of Californians and millions of acres of farmland rely on water from the state and federal water projects. Much of that water flows through the Sacramento-San Joaquin Delta which is considered the hub of the water supply system. Shifts in precipitation and runoff patterns due to climate change could effect reservoir operations, Delta inflows and exports, and groundwater supplies. Rising sea levels could lead to salinity intrusion into the Delta, which could require additional freshwater releases from upstream reservoirs to maintain water quality standards. Increased water levels could threaten Delta levee stability. This talk presents an overview of several modeling projects that examine a wide range of potential climate change impacts on California's water resources including changes in snowpack, surface and groundwater supplies, flood management, hydropower, water quality, agriculture, and ecosystem health. Approach: Four modeling studies investigated a range of potential climate change impacts to California's water resources: 1) runoff and streamflows in the Feather River Basin in Northern California which supplies the State Water Project's (SWP) largest reservoir, Lake Oroville, 2) SWP and Central Valley Project (CVP) operations, 3) Delta flows, water levels and water quality, & 4) sustained droughts in the Central Valley. For the first three studies, twelve climate change scenarios were examined based on the recommendation of the Governor's Climate Action Team. The scenarios were generated by six global climate models (GCM) under two assumed greenhouse gas emission scenarios. The GCM outputs were translated to the regional level using two downscaling techniques. The regional data were then used to estimate stream flows into reservoirs. For the project operations and Delta studies, effects of sea level rise were also considered. Various computer models were then used to assess potential water resources impacts of these climate change scenarios. Impacts on runoff, baseflow, and streamflow at different locations in the Feather River basin were assessed using applications of the Precipitation-Runoff Modeling System (PRMS) model developed by the USGS. Changes in SEP and CVP operations were analyzed using the CalSimII model. Resulting changes in Delta flows, water level, and water quality were then assessed using the Delta Simulation Model 2 (DSM2). Potential impacts of climate change on groundwater were examined using a separate approach. Specified drought scenarios were selected as an analogue to projected reductions in snowpack and surface flows. The California Central Valley Groundwater-Surface Water Simulation Model (C2VSIM) was used to assess groundwater changes due to reductions in net surface flow from reservoirs and Central Valley precipitation. The model also evaluates changes in crop acreage occurring during a prolonged drought. Thus corresponding changes in groundwater levels due to changes in cropping patterns can be estimated. Results: Climate change impacts assessment will be presented for 1) runoff, baseflow, and inflows to Lake Oroville, 2) SWP and CVP operations with a focus on project deliveries and end-of-year storage, 3) Delta inflows, exports and water quality compliance, and 4)effects of long period droughts on cutbacks of surface water diversions, groundwater elevations, and crop water demands for four different regions in the Central Valley, including the Sacramento Basin, Eastside, the San Joaquin Basin, and the Tulare Basin for light, moderate, and severe droughts. Relevance: Quantifying potential impacts of climate change on California's water resources is relevant to the CALFED objectives of water supply reliability, water quality, and levee system integrity.

SESSION: Climate Change Science and Water Resources Management, 10/24/2008, 8:40 AM, Rooms 308-310

Brekke, L.D.
Bureau of Reclamation, Denver Federal Center, Bldg 67, Rm 506, Denver, CO 80225
lbrekke@do.usbr.gov

Climate Change Analysis in the CVP OCAP: Methods, Results, and Reactions

The CVP "Operations Criteria and Plan Biological Assessment" (BA) provides an analysis of the continued long-term operations of the CVP and SWP and the effects of those operations on federally listed species and designated Critical Habitat. On the incorporation of climate change into the BA analysis, three scoping issues emerged: (1) level of analysis; (2) framework for scenario-impacts analysis; and, (3) rationalizing a set of regional climate change scenarios to feed that framework. The approach for issue (1) was influenced by climate's relevance to the BA, its consultation horizon, and time scale climate change. The approach for issue (2) combined peer-review methods for relating regional climate change to water resources impacts with an approach to incorporate sea level rise in the Delta. The approach for issue (3) involved selecting four contemporary climate projections to bracket future possibilities, given plan-specific considerations: look-ahead period, relevant climate change metrics, location of climate change, and subjective decision on what portion of contemporary projections to represent. Findings were summarized for surface water hydrology, CVP-SWP operations, Delta flows and velocities, and cold-water stocks in Lake Shasta, Lake Oroville, and Folsom Lake. Findings were consistent with previous studies. Surface water hydrologic responses were not found to be highly sensitive to choice among two runoff models used in the analysis. At the time of this abstract submission, peer review comments had been incorporated while public reactions remained to be assessed. Conclusions suggest that: (1) precipitation change dominates CVP-SWP operations response related to water supply reliability, (2) sea level rise affects Delta operations leading to a comparably negative impact on water supply operations under the regional climate change scenarios considered, and (3) temperature change dominates CVP-SWP operational ability to support cold-water fisheries habitat during summer and autumn.

CALFED Statement of Relevance
The methodology for addressing scoping issues (1) through (3) may is relevant to other prospective planning efforts supported by the CALFED program and may be applied to support those efforts. For the OCAP BA, the methodology served to integrate climate change considerations into the BA analysis while representing considerations relevant to the OCAP process.

SESSION: Climate Change Science and Water Resources Management, 10/24/2008, 9:00 AM, Rooms 308-310

Groves[1], D.G., D. Yates[2], D. Purkey[3], B. Joyce[4], A. Draper[5]
[1]RAND Corporation, 371 60th Street, Oakland, CA 94618
[2]National Center for Atmospheric Research, P.O. Box 3000, Boulder, CO 80307
[3]Stockholm Environment Institute-US Center, 133 D St., Ste. F, Davis, CA 95616
[4]Stockholm Environment Institute, 11 Curtis Ave., Somerville, MA 02144
[5]MWH, 3321 Power Inn Road, Suite 300, Sacramento, CA 95826
groves@rand.org

Evaluating Climate Change and Management Strategies for the California Water Plan

The California Water Plan (CWP) Update 2009 is making a major effort to incorporate climate change into its analyses of future water conditions in California. One key analytic objective of the CWP is to evaluate the performance of regional and statewide water management response packages against a large set of future scenarios reflecting climate change and other uncertainties. This presentation will describe how the Water Evaluation and Planning (WEAP) model will be used as an engine for this analysis at two scales: (1) California wide, defined by the State's hydrologic regions and (2) for the Sacramento and San Joaquin River Hydrologic Regions, disaggregated at the planning level. To evaluate a wide range of future climate impacts on the California water system, downscaled monthly weather time series, corresponding to individual global circulation model climate projections will be used as model inputs. WEAP's built-in rainfall-runoff and soil moisture algorithms will then translate these plausible sequences of weather parameters into projected hydrologic flows and evapotranspiration-driven irrigation demands. The presentation will present interim results and describe the decision-analytic framework to be used to evaluate the response packages against the climate scenarios.

CALFED Statement of Relevance
This presentation will describe on-going climate impacts and adaptation research for the California Water Plan Update 2009. The work seeks to inform water resources planning at the state, regional, and local level in California.

SESSION: Climate Change Science and Water Resources Management, 10/24/2008, 9:20 AM, Rooms 308-310

Roos, M.
CA Department of Water Resources, PO Box 219000, Sacramento, CA 95821
mroos@water.ca.gov

Sea Level Rise: What is the Water Engineer to do with all Those Projections?

Sea level rise would have profound impacts on low lying coastal and estuary regions and especially the Sacramento-San Joaquin Delta. The effect depends greatly on the amount of such rise. Historically the West Coast rise has been fairly slow; a rate of about 0.7 foot per century has been measured at the San Francisco Golden Gate tide gage since the 1920s. During the past 10 years this rate has slowed. Meanwhile, projections of much greater rises are being made, from the relatively conservative 0.6 to 1.9 foot range in 2100 by the Intergovernmental Panel on Climate Change (IPCC) to the 4.6 feet promoted by the Delta Vision task force, with even higher ranges being considered by researchers. The two main factors in rising sea levels are thermal expansion and melting of land based ice. Primary reasons for differences are variations in forecasts of the amount of global warming and, therefore, the amount of ocean warming, and the amounts of future melting of the Greenland and West Antarctica ice caps. These will be discussed by the author. For the water engineers and planners, the question is what to do during the next 20 to 30 years in the face of so much uncertainty. Should we retreat in the face of rising sea level or fight? Structural defense could be costly. For the Delta, with much land already below sea level, relative small rises threaten the weak levee system. Higher ocean levels cause more salinity intrusion which threatens water quality of exports or requires higher releases of precious fresh water from reservoirs in dry times. Is there a reasonable “no regrets” strategy for the Delta and other low California coastal areas? Some considerations on these matters will be discussed by the author in the proposed paper.

CALFED Statement of Relevance
Climate change, including sea level changes, will have large impacts on the Delta and other regions of California

SESSION: Climate Change Science and Water Resources Management, 10/24/2008, 9:40 AM, Rooms 308-310

Dettinger, M.D.
US Geological Survey, Scripps Institution of Oceanography, UCSD, La Jolla, CA 92093
mddettin@usgs.gov

The CASCaDE Project—Overview and Climate-change Scenarios

To address the complex challenges in the Bay-Delta, multifaceted, multidisciplinary tools for prediction of changes in the estuary and watershed due to external forces and management decisions are needed. Climate change, in particular, threatens delicate balances in the Delta through potential impacts on local air temperatures, timing and amounts of freshwater inflows and outflows, water temperatures, and sea level rise. The Computational Assessments of Scenarios of Change in the Delta Ecosystem (CASCaDE) project is a research effort to link predictive models of a full suite of Bay-Delta processes, from climate to watershed and water-resources management responses, to Delta hydrodynamics and water quality, to sediment transports and geomorphological change, to phytoplankton, contaminants, invasive species, and fisheries. This session will describe the linking of predictive models and early results from each of these disciplines. Several climate-change scenarios are being considered by the project. Scenarios have been developed by extracting daily nationwide climate series from historical-period and 21st Century simulations under two different greenhouse-gas emissions scenarios from two different climate models. The nationwide climate series have been downscaled to a 12 km grid over the study region (and beyond) by a new method called the constructed analogues method, which retains direct links to the daily progress of the weather in the various simulations and which allows downscaling both onto regular grids and to station locations. The downscaled, projected climate changes will be described. In the CASCaDE study, these scenarios will be used to force models of runoff generation, water temperatures, Delta flow regimes, geomorphological change, ecosystem processes and constraints, and fisheries.

CALFED Statement of Relevance
CASCaDE is a CALFED-funded research project that is trying to develop the kinds of linked multidisciplinary models that CALFED will need to balance the many competing objectives and threats that the Delta presents. This presentation is an overview of the project goals and methods, along with a presentation of the kind of climate-change scenario that CASCaDE is initially focusing on. The issues being addressed by this phase of CASCaDE are directly in line with the overall conference theme (global perspectives and challenges--climate change in this case--and regional physical, ecosystem AND management results--the rest of the cascade of models and sub-studies).

SESSION: CASCaDE Studies (I), 10/24/2008, 10:20 AM, Rooms 308-310

Cayan[1], D.R., N. Knowles[2], M.D. Dettinger[2], M. Tyree[1]
[1]Scripps Institution of Oceanography, 9500 Gilman Drive, La Jolla, CA 92093
[2]U.S. Geological Survey, 345 Middlefield Rd., MS 496, Bldg. 15, McKelvey Bldg., Rm. 3024, Menlo Park, CA
dcayan@ucsd.edu

Sea Level Change in San Francisco Bay during the 21st Century: The CASCaDE Study

Recent scenarios of future global sea level rise (SLR), predicated on global climate change simulations, project increases that are considerably greater than historical rates of global sea level rise estimated—globally and regionally--from observations along the California Coast. Here we describe a set of sea level rise scenarios derived using the Rahmstorf (2007) scheme applied to global surface air temperature changes taken from a set of global climate model (GCM) climate change simulations. Using the assumption that the SLR at San Francisco will proceed at the same rate as is projected globally, and using predicted tides at San Francisco along with weather and El Nino/Southern Oscillation measures taken from each GCM, an hourly record of sea level for the 21st Century is derived. Guided by this simulated record for San Francisco, observed water level records from a set of San Francisco Bay and Delta locations, and estimated fresh water inflows from the upstream Sacramento and San Joaquin watersheds, hourly records of water levels at selected locations in the Bay and Delta are estimated. The changes, relative to a historical climatology, particularly in the extreme high water levels from this set of scenarios, are then discussed.

CALFED Statement of Relevance
Accelerated sea level rise will be a challenge to Bay/Delta ecosystems, water quality, and levees--all of these elements are central to CALFED goals.

SESSION: CASCaDE Studies (I), 10/24/2008, 10:40 AM, Rooms 308-310

Knowles, N.
USGS, Menlo Park, 345 Middlefield Rd., MS 496, Menlo Park, CA 94025
nknowles@usgs.gov

Projected Hydrologic Changes and Management Challenges Under CASCaDE Climate Change Scenarios

As part of the CASCaDE Project, four scenarios of climate change, corresponding to different climate models and emissions scenarios, were selected to represent a range of possible futures. The goal of the hydrologic modeling component of CASCaDE is to assess the response of hydrology and management in the Sacramento and San Joaquin basins to each of these scenarios, and to provide plausible translations of the climate model outputs into managed Delta inflows and water temperatures for use by other components of the CASCaDE study. To this end, downscaled versions of the corresponding daily meteorology from each of these scenarios were used to drive a hydrology model, resulting in 100-year projections of snowpack and unimpaired streamflow. These outputs were aggregated to the monthly scale and used to drive modified versions of the CALSIM reservoir operations model and the U.S. Bureau of Reclamation managed stream temperature model. The results demonstrate potential management challenges associated with each of the climate projections over the next century. In particular, impacts of extreme or multi-year events such as very wet years or prolonged droughts become more difficult to mitigate as snowpacks diminish under a warmer climate. Projected impacts on headwater hydrology, reservoir storage, and downstream flows will be discussed.

CALFED Statement of Relevance
The results demonstrate potential management challenges associated with each of the climate projections over the next century. In particular, impacts of extreme or multi-year events such as very wet years or prolonged droughts become more difficult to mitigate as snowpacks diminish under a warmer climate.

SESSION: CASCaDE Studies (I), 10/24/2008, 11:00 AM, Rooms 308-310

Monsen, N.E.
U.S. Geological Survey, 345 Middlefield Road MS/496, Menlo Park, CA 94025
nemonsen@usgs.gov

How Do Transport Timescales in the Delta Change under the CASCaDE Climate Scenarios?

Water transport time scales characterize the physical processes that can govern ecological function in some regions of the Delta. For example, in positive growth conditions (rate of loss due to grazing is slower than the growth rate), longer transport time means more algal biomass. Because of the complex nature of the Delta's interlaced channels and flooded islands, standard methods for calculating "residence time" do not necessarily apply or accurately represent this system. Here, transport timescales are calculated from a multi-dimensional hydrodynamic model, Delta TRIM, at key locations throughout the Delta including major flooded islands in the Central Delta (Mildred Island, Franks Tract) and critical junctions (Delta Cross Channel, Three Mile Slough, Sherman Island). The transport timescales are calculated using particle tracking based approaches. I will discuss transport timescales calculated from representative base line simulations (dry year: 1992, wet year: 1999) and simulations driven by the CASCaDE climate scenarios. Because the time of the year plays an essential role in transport timescales, the transport timescales in each simulation are divided into four key periods: wet winter, spring runoff, summer, and fall. The goal is to quantify how climate change will alter the timing and magnitude of flows throughout Delta. Some key findings: 1) Significant mixing occurs at tidal junctions. Accurate, multi-dimensional bathymetric representation of these junctions is essential to calculate relevant transport timescales. 2) The bathymetry representation of narrow channels in a numerical model can regionally alter distribution of flows and transport timescales. 3) Climate change will alter baseline flows in the Delta which, in turn, will alter transport timescales.

CALFED Statement of Relevance
Transport time scales determine how long chemical and biological constituents (e.g. phytoplankton) have to respond to environmental conditions. We need methods to characterize transport timescales for both flooded islands and complex channel junctions in the Delta. In addition, we need to parameterize how flows altered by climate change will transform the Delta ecosystem.

SESSION: CASCaDE Studies (I), 10/24/2008, 11:20 AM, Rooms 308-310

Wagner, W.*, M.T. Stacey
University of California, Berkeley, 205 O'Brien Hall, Berkeley, CA 94720-1712
waynestock19@hotmail.com

Statistical Models of Temperature and Salinity in the Sacramento-San Joaquin Delta under Climate-Change Scenarios: A CASCaDE Project

The impact climate change will have on the water temperatures in California's Sacramento-San Joaquin Delta will affect the ecosystem through fish and invertebrate life functions. How large an effect climate change will have on water temperatures is, however, unknown. This study presents statistical models created in an effort to model water temperature and salinity within the Delta as a response to atmospheric conditions and riverine flows. Other portions of the CASCaDE project address how these temperature changes will affect the ecosystem over timescales of decades to a century. We modeled daily average water temperature and daily water temperature range at locations around the Delta. The daily average model performs well, with r2 values during verification periods greater than 0.9 for all stations within the Delta and San Francisco Bay provided at least one year of calibration data. If less than one year of calibration data is available, the predictive capability of the model is greatly reduced due to the dominance of the seasonal cycle. Predictions of temperatures at stations upstream of the Delta are less reliable, most likely due to the influence of reservoir releases on river water temperatures. Extension of the statistical approach to the daily temperature range, defined as the maximum temperature minus the minimum temperature on a given day, is based on air temperature, insolation, and modeled daily water temperature. Preliminary evaluation of this daily range model indicates less predictive skill than the daily average temperature model. We propose using a similar approach to forecast salinity distributions in the Delta under future climate scenarios.

CALFED Statement of Relevance
The impact climate change will have on the water temperatures in California's Sacramento-San Joaquin Delta will affect the ecosystem through fish and invertebrate life functions. This study presents statistical models created in an effort to model water temperature and salinity within the Delta as a response to atmospheric conditions and riverine flows.

SESSION: CASCaDE Studies (I), 10/24/2008, 11:40 AM, Rooms 308-310

Ganju[1], N.K., D.H. Schoellhamer[1], M. van der Wegen[2], B.E. Jaffe[1]
[1]U.S. Geological Survey, 384 Woods Hole Road, Woods Hole, MA, 02543
[2]UNESCO-IHE, PO Box 3015, 2601 DA Delft, The Netherlands
nganju@usgs.gov

CASCaDE Hindcast of Bathymetric Change in Suisun Bay, 1867-1990: Model Uncertainty and Parameter Selection

Simulations of estuarine bathymetric change over decades (e.g. climate-change response) require conceptual and numerical simplifications of input data and boundary conditions. These simplifications, along with idealized algorithms for sediment transport processes, make model results uncertain. Simulation methods are rarely evaluated with real bathymetric change data, which are temporally and spatially sparse in most cases. Bathymetric data for Suisun Bay, California, however, spans the 1867-1990 period, with five bathymetric surveys during that period. To understand the magnitude of uncertainty of a bathymetric change model, we hindcast bathymetric change in Suisun Bay. The four periods of bathymetric change were modeled using a coupled tidal-timescale hydrodynamic and sediment-transport model. The 1867-1887 period, used for calibration of wave energy and sediment parameters, was modeled with an average error-to-depth ratio of 5%, while the remaining validation periods were modeled and had ratios ranging from 12% (1922-1942) to 37% (1942-1990). Performance was improved by 8% and 10% respectively, by reducing suspended-sediment concentration at the seaward boundary (maximum reduction of 75%), and increasing wave energy by 15%. Degradation of post-calibration performance is attributed to non-stationary parameters (such as sediment characteristics) and lack of bathymetric and configuration data for portions of Suisun Bay. Sediment parameters are non-stationary and specified values for simulation of future scenarios should be considered part of the scenario. Simulation of the time period between the most recent surveys is sufficient to establish reasonable parameters for simulations of future scenarios. Results were sensitive to boundary conditions representing San Pablo Bay at the western boundary of the model because, except during exceptionally wet years, dispersive sediment flux from San Pablo Bay to Suisun Bay is 2/3 of the seaward advective flux. A model with a Bay-wide domain (van der Wegen et al. this session) improves specification of seaward boundary conditions but requires more computational resources.

CALFED Statement of Relevance
To help CALFED accurately anticipate and plan for climate change, the CASCaDE project is using numerical models to develop climate change scenarios. Hindcasts of bathymetric change in Suisun Bay are used to evaluate parameter selection and model uncertainty. These results will improve accuracy and interpretation of scenario simulations.

SESSION: CASCaDE Studies (II), 10/24/2008, 1:00 PM, Rooms 308-310

Wegen[1], M.V., D. Roelvink[2], B. Jaffe[3], N. Ganju[4], D. Schoellhamer[5]
[1]UNESCO-IHE, PO Box 3015, Delft, NL, 2601 DA
[2]UNESCO-IHE & Deltares
[3]USGS Santa Cruz
[4]USGS Woods Hole
[5]USGS Sacramento
m.vanderwegen@unesco-ihe.org

CASCaDE Research on Hindcasting Bathymetric Change in San Pablo Bay, 1856-1983: A Step towards Assessing Likely Geomorphic Change in Response to Climate Change

Morphodynamic conditions in the northern part of the San Francisco Estuary changed considerably over the past centuries. Major anthropogenic influences include hydraulic mining about 150 years ago and dam construction in the last century. These activities impacted sediment supply and the river hydrograph and continue to have impact today. Climate change will further perturb the morphodynamics as sea level rises and the river discharge regimes are altered by warming and precipitation changes. The objectives of the study are to address these long-term morphodynamic developments in the northern part of San Francisco Estuary and to assess likely geomorphic response to climate change. Use will be made of a 3D, process-based numerical model (DELFT3D) that includes hydrodynamics (flow, salinity and waves), sediment transport and morphodynamic updating. Since significant sediment exchange between sub-embayments of the estuary makes accurately specifying a sub-embayment boundary condition difficult, the model domain includes the complete San Francisco Estuary. The model domain extends from 20 km offshore of the Golden Gate to Sacramento and Vernalis at the landward side and includes South Bay, Central Bay, San Pablo Bay, and Suisun Bay as well as a schematized river section. Based on a calibrated model, we present a morphodynamic hindcast for mid- to late 1800s when there was a large sediment supply from hydraulic mining. The hindcast applies watershed sediment supply estimated by earlier research and is calibrated using measured historical bed level changes. Finally, using the knowledge gained from the hindcast and model comparisons to present-day morphodynamics, estimates are made of future geomorphic evolution based on climate change scenarios that include sea level rise and altered river discharge regime.

CALFED Statement of Relevance
The study contributes to a better understanding of (long-term) San Francisco Bay morphodynamics. As such, it is related to the (long-term) characterisation of hydrodynamics, salt intrusion and sediment suspension in the past centuries and in case of future scenarios of climate change.

SESSION: CASCaDE Studies (II), 10/24/2008, 1:20 PM, Rooms 308-310

Lucas, L.V., J.K. Thompson, F. Parchaso
U.S. Geological Survey, 345 Middlefield Road, MS #496, Menlo Park, CA 94025
llucas@usgs.gov

Assessing San Francisco Bay-Delta Phytoplankton and Clams for CASCaDE Scenarios of Change

Two closely linked components of the ongoing CASCaDE (Computational Assessments of Scenarios of Change for the Delta Ecosystem) project are the phytoplankton and benthic bivalve (clam) components. Phytoplankton represents a critical though usually limiting food source for pelagic and benthic primary consumers in the Delta. The non-native freshwater (*Corbicula fluminea*) and estuarine (*Corbula amurensis*) clams represent a significant sink for phytoplankton biomass in the San Francisco Bay-Delta (Delta) ecosystem. We will present our approaches for modeling and assessing potential future changes in these important ecosystem players' distributions and biomass and how these models link to other CASCaDE models. A simple conceptual model of algal sources, losses, and transport will be employed as a first step in semi-quantitatively assessing potential changes in phytoplankton biomass in the Delta for a future scenario. As a necessary step in assessing possible changes in phytoplankton, we will also present an assessment of changes in distributions of the two clam species and consequent changes in the clam grazing rates of phytoplankton for that scenario.

CALFED Statement of Relevance
Phytoplankton biomass is now known to be a critical but usually limiting food source at the base of the planktonic food web supporting threatened fish in the Delta. Invasive clams are known to be a dominant sink for phytoplankton biomass in parts of the Delta, consuming food that could otherwise be available to the planktonic food web. Thus, understanding the dynamics of phytoplankton and their benthic consumers is fundamental to assessing possible future ecological scenarios of change for the Delta.

SESSION: CASCaDE Studies (II), 10/24/2008, 1:40 PM, Rooms 308-310

Stewart, A.R., S.N. Luoma
U.S. Geological Survey, 345 Middlefield Rd. MS496, Menlo Park, CA 94025
arstewar@usgs.gov

Modeling Selenium and Mercury in Food Webs of the San Francisco Estuary in Response to CASCaDE Scenarios of Change

Selenium (Se) and mercury (Hg) are naturally occurring trace elements that when mobilized by human activities in sufficient quantities can pose a threat to fish, wildlife and humans that consume fish. In the San Francisco Bay and Delta Se and Hg are recognized as two potentially significant contamination issues that have not been resolved. These contaminants originate from multiple sources in the Bay-Delta and have complex biogeochemistries and species-specific uptake processes. Changes in water management operations and climate also could influence their impacts. As part of the CASCaDE (Computational Assessments of Scenarios of Change for the Delta Ecosystem) project we are developing models that quantify critical processes controlling the fate and effects of Se and biologically available methylmercury (MeHg) in food webs and species of concern of the Bay and Delta. By incorporating output from other CASCaDE models we test responses of these contaminants to specific climate change scenarios. For example, the model allows quantification of the changes in Se concentrations and toxicological threats to sturgeon and diving ducks based on a scenario of increasing water inflows to the Delta and the Bay from the San Joaquin River. Increased loads of Se into the Bay; changes in phytoplankton production and changes in the distribution of invasive bivalves in the Bay and Delta all could affect Se in the food web and the spatial distribution of the contamination. These models provide a novel means to evaluate potential changes in contaminant stress as conditions and management changes occur in the Delta and the Bay.

CALFED Statement of Relevance
This work represents a tool that could be used to inform managers about the potential ecological impacts of changing environmental conditions resulting from climate and those resulting from management actions. The work is highly relevant to Calfed's Water Quality Program goals to meet drinking water standards and demands for agriculture use without compromising goals of the Ecosystem Restoration Program to maintain and promote ecosystem health in the Delta.

SESSION: CASCaDE Studies (II), 10/24/2008, 2:00 PM, Rooms 308-310

Brown[1], L.R., W. Bennett[2], C. Woodley[2]
[1]U.S. Geological Survey, Placer Hall, Sacramento, CA 95819
[2]U.C. Davis, Bodega Marine Laboratory, Bodega Bay, CA 94923
lrbrown@usgs.gov

Increased Water Temperatures from CASCaDE Climate-change Scenarios: Implications for California Fishes

We evaluated the possible effects on fishes of monthly mean water temperature (MMWT) changes generated by four 100-year scenarios of climate change. Mean monthly water temperatures were generated using management and temperature models developed by California Department of Water Resources and U.S. Bureau of Reclamation for the Sacramento, Feather, American, and Stanislaus Rivers. Input data were from two regionally downscaled climate models at two levels of greenhouse gas emissions. The model runs assumed a year 2020 level of water demand with current water operations. There were significant increasing trends in MMWT for all the rivers, but only in some months—generally summer and early fall. We compared projected MMWT from each model scenario to temperature requirements of selected fishes. For example, we counted how many years MMWT exceeded 18ºC at Balls Ferry in the reach of the Sacramento River between Red Bluff Diversion Dam and Keswick Dam. We assumed a monthly mean temperature above 18ºC would result in high mortality of incubating Chinook salmon eggs and pre-emergent fry. During the first third of the warmest scenario, MMWT exceeded 18ºC in July (1 year), August (3 years), and September (4 years). During the second third of the scenario, temperature exceedances occurred in July (1 year), August (3 years), and September (8 years). During the final third of the scenario, exceedances occurred in June (2 years), July (10 years), August (21 years), September (26 years) and October (4 years). Under this scenario, maintaining populations of winter-run and spring-run Chinook salmon, which spawn from July to mid-October, will become extremely difficult in the latter third of the century. Projections like these provide managers with a useful tool for anticipating long-term challenges to managing fish populations in the San Francisco Estuary and watershed.

CALFED Statement of Relevance
Projections of changes in water temperature associated with scenarios of climate change provide managers with a useful tool for anticipating long-term challenges to managing fish populations in the San Francisco Estuary and watershed.

SESSION: CASCaDE Studies (II), 10/24/2008, 2:20 PM, Rooms 308-310

Dudas, J.S.
California DWR, 1416 9th Street, Sacramento, CA 95814
jdudas@water.ca.gov

Uses of LIDAR in Support of DWR Delta Levee Program Goals

The DWR Delta Levee program works to improve flood system reliability, emergency response, and ecosystem resources within the Sacramento-San Joaquin Delta. Given the sensitivity of flood and habitat project cost feasibility and success potential to land surface elevations, topographic information is a critical data requirement when working on Delta projects. As a result, the Program worked to obtain a high-accuracy, high-resolution elevation survey covering the entire estuary using LIDAR. That survey is now being used to support a variety of Program needs, ranging from project site assessments, subsidence monitoring, and levee system-wide analysis. The survey will also be used on an ongoing manner to support Delta management alternative analyses going forward. Methodological approaches to using the survey data and specific examples of how the data are used in support of flood risk management and ecosystem enhancement goals will be discussed. In addition, how the survey fits into the broader scope of ongoing Delta terrain monitoring will be described.

CALFED Statement of Relevance
The availability of the LiDAR survey dataset will greatly benefit interested parties who are working on all of CALFED's program goal areas. The benefits specific to the levee program for flood protection and ecosystem enhancement are illustrative of methods and uses for these parties, not exclusive to the levee program.

SESSION: Flood Management, 10/24/2008, 3:00 PM, Rooms 308-310

Hultgren[1], E.M., R. Martin[2]
[1]Hultgren - Tillis Engineers, 2221 Commerce Avenue, Concord, CA 94520
[2]Contra Costa Water District, 2411 Bisso Lane, Concord, CA 94524
edhultgren@hultgrentillis.com

Setback Levees in Exhausted Peat Areas

Setback levees may be used to create more robust levees, to protect high-value or critical structures, and/or to create enhanced flood plains. The goal of this presentation is to share the practical aspects of constructing a setback levee in those large portions of the Delta where the peat is exhausted or nearly so. A small (1,000-feet-long) setback levee was constructed in the South Delta in the spring and summer of 2008. This presentation describes the approach used to develop and restore local borrow areas as fill material sources, design of levee sections that utilize available materials, and construction sequence to maintain flood protection and foundation stability. Levels of effort in terms of man-power and equipment to construct the levee and cost estimates of levee construction are presented. Both reliability of existing levees and developing shaded water habitat remain key issues in the Delta. Many widely ranging estimates have been assigned to the costs of setback levees and other levee improvements in the Delta. The data from this short section of setback levee is extrapolated to a per-mile basis of setback levee.

CALFED Statement of Relevance
Both reliability of existing levees and developing shaded water habitat remain key issues in the Delta. This presentation describes recent experience on constructing a setback levee. Setback levees can be used to improve levee reliability and create opportunities for shaded riverine habitat.

SESSION: Flood Management, 10/24/2008, 3:20 PM, Rooms 308-310

Kavvas[1], M.L., Z. Chen[2], H. Bandeh[1], N. Ohara[1], E. Tan[1], K. Maher[1], S. Lorenzato[2], T. Frink[2], J. Carlon[3], T. Griggs[3]
[1]UC Davis JA Hydraulics Lab., Department of Civil & Environmental Engineering, Engineering Bldg III, Davis, CA 95616
[2]Department of Water Resources, Resources Bldg., Sacramento, CA
[3]River Partners, Chico, CA
mlkavvas@ucdavis.edu

Hydraulic Characteristics of Sacramento River Riparian Plant Species under Flood Conditions at a Large Flume: Sandbar Willow and Mule Fat

A study of the hydraulic response of Bay-Delta rivers' native riparian plant species is being performed by means of experiments within a Large Flume at UC Davis J. Amorocho Hydraulics Laboratory. Replicates of a bare soil floodplain surface, a Sandbar Willow canopy covered floodplain surface, and a Mule Fat canopy covered floodplain surface were obtained from a Sacramento River flood plain, and were reconstructed in the flume. Velocity distributions, hydraulic head profiles, and streambed erosion were measured under various flow regimes with the bare soil surface, a Sandbar Willow surface and a Mule Fat surface. Responses of Sandbar Willow's and Mule Fat's stems and branches were observed under various flood conditions. From the collected data of Sandbar Willow tests and Mule Fat tests, we were able to quantify the vegetation response to flood flows and to estimate the Manning's roughness coefficients under various flow conditions for various plant species. Experimental data suggest that the Manning's roughness coefficients vary depending on the vegetation response to varying flow conditions, and that the vegetation cover alters the velocity profile near the floodplain dramatically, which results in the reduction of surface erosion over the floodplain.

CALFED Statement of Relevance
Native riparian vegetation at the flood plains of the rivers that drain to Bay-Delta may have significant positive impacts on the flood management in these rivers. This presentation will show the behavior of Manning's roughness under various flow conditions in the presence of riparian vegetation, and the significant impact of riparian vegetation on erosion control.

SESSION: Flood Management, 10/24/2008, 3:40 PM, Rooms 308-310

Strub, I.S.*, P. Julie, M.T. Stacey, A.M. Bayen
University of California, 604 Davis Hall, Berkeley, CA 94709-1710
strub@ce.berkeley.edu

Data Assimilation Algorithms for the Estimation of Boundary Conditions

Predictions of flows and transport in the Sacramento-San Joaquin Delta typically rely on numerical models that are thoroughly calibrated with extensive historical data sets. The motivation for our work lies in developing a method that will allow flows and transport to be predicted in regions of the Delta using only rapidly deployed sensors that are integrated into a rapid response modeling system. The immediate objective for our work is to estimate open boundary conditions for a model of flows in tidal channels of the Sacramento San-Joaquin Delta. To this end, we develop variational data assimilation techniques in which a cost function measuring the L2 norm of the difference between observations gathered by drifters and model predictions, subject to constraints given by the discretized model equations. Since the cost function is quadratic, this problem can be solved as a quadratic program provided the constraints are linear. At first, a linearized two dimensional shallow water model was chosen but did not bring added accuracy and increased substantially the size of the problem; therefore a one dimensional model was preferred. Twin experiments in the Sacramento River were implemented to evaluate the efficiency of this method. Given that tidal forcing is dominant, the focus was placed on identifying the main frequencies and then estimating the corresponding amplitudes. Using 50 hours of DSM2 data, the flow in the Sacramento River was simulated using TELEMAC and drifter trajectories were simulated in a reversing tidal flow as well as one where the flow does not reverse. The velocities of the drifters along the trajectories are used to estimate the amplitude of the main 3 or 4 modes and enable us to generate a reconstructed flow which is compared to the original DSM2 data. The relative root mean square error varies from 15 % to 10 % depending on whether a flow reversal occurs and on the number of modes estimated. Finally, an attempt is made to evaluate the predictive capabilities of the algorithm by comparing the reconstructed flow and DSM2 data over a period of one week.

CALFED Statement of Relevance
Predictions of flows and transport in the Sacramento-San Joaquin Delta typically rely on numerical models that are thoroughly calibrated with extensive historical data sets. The motivation for our work lies in developing a method that will allow flows and transport to be predicted in regions of the Delta using only rapidly deployed sensors that are integrated into a rapid response modeling system.

SESSION: Flood Management, 10/24/2008, 4:00 PM, Rooms 308-310

Collison[1], A.J., E.M. Ginney[2]
[1]Philip Williams & Associates, 550 Kearny St., San Francisco, CA 94108
[2]Philip Williams & Associates, 928 Second St., Ste. 300, Sacramento, CA 95814
a.collison@pwa-ltd.com

Using the "Floodplain Activation Flow" Concept as a Restoration Design Tool on the Feather River Levee Setback

Levee setbacks are emerging as one of the most promising ways of reducing flood hazards alongside large rivers while restoring some of the active floodplain that has been lost because of flow regulation, levee construction, and other factors such as channel incision. Over a mile of setback levee was recently constructed at the confluence of the Bear and Feather Rivers, and an additional seven miles of levee setback is under construction on the east bank of the Feather River between Marysville and the Bear River. The Feather River has previously been identified as a potential site for restoration of floodplain that meets the criteria for “Floodplain Activation Flows” (see companion paper by Andrews et. al.). FAFs are flows that inundate floodplain frequently enough, for long enough and at the right time of the year to support salmonid rearing via increased nutrient exchange, food web creation, and increased habitat. A FAF analysis of the proposed Feather River levee setback area has identified locations that would be most productive for salmonid rearing. Combined with two-dimensional hydrodynamic modeling of channel-floodplain interactions, the analysis suggests key areas where additional FAF-floodplain habitat could be created that would increase fish utilization and aquatic ecosystem health. The analysis also highlights the fact that while levee setbacks can create a significant first step in floodplain restoration they are not fully effective on their own. Much greater habitat benefits could be achieved if setbacks were combined with modified flow releases and/or physical floodplain improvements to increase floodplain inundation to support key ecosystem functions.

CALFED Statement of Relevance
This paper supports two CALFED goals: ecosystem restoration and levee integrity. The original FAF concept was developed with CALFED funding, and this project is the second (and by far the largest) application of the concept to a levee setback implementation.

SESSION: Flood Management, 10/24/2008, 4:20 PM, Rooms 308-310

Foe, C.A.
Central Valley Regional Water Quality Control Board, 11020 Sun Center Dr. Suite #200, Rancho Cordova, CA 95670
cfoe@waterboards.ca.gov

Methyl Mercury Concentrations and Loads in the Central Valley and Freshwater Delta

The Sacramento and San Joaquin Rivers and the Sacramento-San Joaquin Bay Delta Estuary are on the federal Clean Water Act 303d list because of elevated mercury concentrations in fish. The California office of Environmental Health Hazard Assessment has issued fish advisories for both Rivers and the Delta. Statistically significant positive correlations have between observed in the Delta and elsewhere between average annual unfiltered methyl mercury concentrations in water and fish. This relationship suggests that aqueous methyl mercury may be an important factor in controlling methyl mercury bioaccumulation in the aquatic food chain. This study attempts to identify the primary sources and sinks of aqueous total and methyl mercury in order to understand the contamination problem and to develop control programs to reduce risk.

CALFED Statement of Relevance
It is important to understand the factors in controlling methyl mercury bioaccumulation in the aquatic food chain. This study estimates the mass balance of methyl mercury in the Delta including all inputs and exports. It also estimates losses due to in Delta processes.

SESSION: Mercury — Linking Effects of Land Use and Habitat with Wildlife and Human Health: (I) Methylmercury Fate and Transport, 10/24/2008, 8:20 AM, Rooms 311-313

Stephenson[1], M.D., W. Heim[2], K. Coale[2]
[1]Department of Fish and Game, 7544 Sandholt Rd, Moss Landing, CA 95039
[2]Moss Landing Marine Labs, 7544 Sandholdt Rd, Moss Landing, CA 95039
mstephenson@mlml.calstate.edu

Investigating the Fate of Methyl Mercury in the Delta using a Particle Tracking Model

Managers and researchers involved with mercury issues in the Delta face the problem that the hydrology is very complex and the travel times are not well know outside the main stem Sacramento River. In particular, it is difficult predict the effect of photodemethylation, a mechanism of loss, on MMHg concentrations in the Delta because the amount of photodemethylation is dependent of the rate of water transport through the Delta system. Trends in MMHg loss terms (photodemethylation and other losses) followed patterns consistent with environmental conditions. The photo-demethylation loss term was more prominent in summer months. This loss was highly dependent on solar radiation which was higher in the summer because of the longer day length and the lack of clouds. It was also dependent on other factors such as travel time of water across the Delta which increases in the summer due to low flows giving more time for photodemethylation to occur. In fact, the photodemethylation loss term in the summer at the pumps (DMC and SWP) far exceeded other net loss processes and was the dominant loss term for water traveling to the pumps where about 1/3 to 1/2 of the water ended up. There was not as much of a photodemethylation loss in the water traveling to Mallard presumably due to shorter travel times and larger flows. One of the most interesting outcomes of using the transport model is that the Delta was separated into different flow paths and it is apparent that different processes dominate in each. For example, the photodemethylation loss term dominates in the center of the Delta (near the pumps) whereas the unknown loss term (probably due to particle settling) dominates in the Sacramento River flow path. This has never been shown before in the Delta.

CALFED Statement of Relevance
Methyl Mercury Contamination in Sports Fish in the Delta is a serious problem. It is important to understand the processes that could lower methyl mercury in the Delta. The particle tracking model estimates the loss of methyl mercury in the Delta and distinguishes the loss due to different processes.

SESSION: Mercury — Linking Effects of Land Use and Habitat with Wildlife and Human Health: (I) Methylmercury Fate and Transport, 10/24/2008, 8:40 AM, Rooms 311-313

Gill[1], G.A., A.A. Byington[2], K. Coale[3], M. Stephenson[4]
[1]Pacific Northwest National Laboratory / Battelle Marine Sciences Laboratory, 1529 West Sequim Bay Road, Sequim, WA, 98382
[2]Marine Pollution Studies Laboratory / Moss Landing Marine Laboratories, 7544 Sandholdt Rd., Moss Landing, CA 95039
[3]Moss Landing Marine Laboratories / San Jose State University, 8272 Moss Landing Rd., Moss Landing, CA 95039
[4]Marine Pollution Studies Laboratory – California Department of Fish and Game, 7544 Sandholdt Rd., Moss Landing, CA 95039
gary.gill@pnl.gov

Photo-degradation of Methyl Mercury in the Sacramento-San Joaquin Delta

Degradation of methyl mercury (MMHg) by sunlight could be the most effective mercury detoxification mechanism to reduce MMHg levels in the surface waters of the Sacramento – San Joaquin Delta Estuary (Delta). MMHg photo-degradation was investigated using in situ bottle incubation experiments. Photo-degradation in the Delta is found to be abiotic and mediated by sunlight. Light-exposed samples demonstrated that wavelengths in the PAR spectrum degraded MMHg in surface waters, and comparable rates of MMHg-degradation were observed in unfiltered and filtered samples. The change in MMHg concentration was assessed relative to total light exposure and to the initial MMHg concentration. A MMHg degradation rate (ng m2 L-1 mol-1) = 0.0137 [MMHg, ng/L] dissolved was used to estimate MMHg degradation for the Delta. The estimated loss of MMHg to photo-degradation in the Delta is 3.1 ± 1.1 g d-1.

CALFED Statement of Relevance
Degradation of methyl mercury (MMHg) by sunlight could be the most effective mercury detoxification mechanism to reduce MMHg levels in the surface waters of the Sacramento – San Joaquin Delta Estuary (Delta). Knowledge about MMHg photo-degradation gives us a greater quantitative understanding of one more process that is controlling methylmercury cycling in surface waters and may help to mitigate elevated MMHG levels in Bay-Delta.

SESSION: Mercury — Linking Effects of Land Use and Habitat with Wildlife and Human Health: (I) Methylmercury Fate and Transport, 10/24/2008, 9:00 AM, Rooms 311-313

Heim[1], W.A., M. Stephenson[2], A. Byington[1], K.H. Coale[1]
[1]Moss Landing Marine Laboratories, 8272 Moss Landing Road, Moss Landing, CA 95039
[2]California Department of Fish and Game, 7544 Sandholdt Rd, Moss Landing, CA 95039
wheim@mlml.calstate.edu

Changes in Methylmercury and Suspended Sediment Concentrations Observed during Transects down the Lower San Joaquin River, California

The San Joaquin River (SJR) is the second largest source of freshwater to the Sacramento-San Joaquin Bay Delta Estuary (Bay-Delta). The SJR has been identified as a source of methylmercury (MMHg) to the Bay-Delta and the Bay-Delta has been identified as a net MMHg sink. Samples collected downstream of the SJR deep water ship channel spring and summer, 2005 had lower MMHg and suspended sediment concentrations than upstream collections. During spring and summer, 2006 we conducted a series of five Lagrangian drift trips on the lower SJR to investigate loss of MMHg and suspended sediment. Samples were collected for unfiltered and filtered methylmercury, suspended sediment, chlorophyll a, biological identifications, and size analysis of suspended material, at eight locations along the SJR starting above the deep water ship channel. Water flow on the SJR is regulated by Friant Dam except in very wet years when uncontrolled releases may occur. Uncontrolled releases of water from Friant Dam occurred spring and summer of 2006. The large decrease in unfiltered MMHg concentrations between upstream and downstream sites observed during 2005 was not observed during the Lagrangian trips, possibly due to uncontrolled releases of water. Concentrations of suspended sediment typically decreased from 20-30 mg L-1 at the upstream site to 10-15 mg L-1 at the furthest downstream site. Concentrations of MMHg on suspended particulates increased moving downstream. We observed a settling out of particles and an enrichment of MMHg on remaining suspended particulates as water moved into the SJR deep water ship channel.

CALFED Statement of Relevance
This work is directly related to mercury mass balance as it is focused on understanding processes related to the loss of methylmercury in water moving down the San Joaquin River.

SESSION: Mercury — Linking Effects of Land Use and Habitat with Wildlife and Human Health: (I) Methylmercury Fate and Transport, 10/24/2008, 9:20 AM, Rooms 311-313

Wood, M.L., C.G. Foe, J.B. Cooke
Central Valley Water Board, 11020 Sun Center Drive #200, Rancho Cordova, CA 95670
mlwood@waterboards.ca.gov

Linkage between Methylmercury in Water and Fish in the Sacramento-San Joaquin River Delta Estuary

The Central Valley Water Board determined that the Delta is impaired by mercury because of elevated fish methylmercury levels that pose a risk for human and wildlife consumers and is therefore required by the Clean Water Act to develop a Total Maximum Daily Load program to eliminate the impairment. Safe fish mercury levels are nearly met in the central Delta but are greatly exceeded in the periphery of the Delta. A linkage is needed to mathematically relate aquatic biota methylmercury levels to the methylmercury sources that cause the impairment. The Delta TMDL linkage focuses on the relationship between methylmercury levels in ambient water and fish. The relationship has not previously been evaluated in the Delta, but statistically significant, positive correlations have been reported between methylmercury in water and aquatic biota elsewhere in the Bay-Delta region and nationwide, indicating that methylmercury concentrations in water are one of the primary factors determining methylmercury concentrations in fish. The relationship is used to determine a methylmercury goal for ambient Delta water that, if met, is predicted to produce fish methylmercury levels safe for human and wildlife consumption. The goal is used to allocate reductions for within-Delta and tributary methylmercury sources. The regression between methylmercury concentrations in standard 350 mm largemouth bass and unfiltered water collected in different areas of the Delta is significant ($p<0.05$). A bass methylmercury concentration of 0.24 mg/kg is equivalent to methylmercury levels in other fish species that are safe for fish-eating wildlife and humans. Substitution of 0.24 mg/kg bass mercury into the water-bass regression equation results in a predicted, safe water methylmercury concentration of 0.066 ng/l. The recommended implementation goal of 0.06 ng/l for methylmercury in water (which includes a 10% safety margin) is currently met in the Central Delta but is exceeded by 40-80% in the Delta periphery.

CALFED Statement of Relevance
The Delta mercury TMDL control program seeks to improve water quality by restoring the beneficial use of safe fish consumption by humans and wildlife while retaining ecosystem benefits. Delta ecosystem restoration (particularly seasonal wetlands) may significantly increase methylmercury.

SESSION: Mercury — Linking Effects of Land Use and Habitat with Wildlife and Human Health: (I) Methylmercury Fate and Transport, 10/24/2008, 9:40 AM, Rooms 311-313

Alpers[1], C.N., J.A. Fleck[1], P. Bachand[2], C.A. Stricker[3], M. Stephenson[4], R.C. Antweiler[5], H.E. Taylor[5], M. Marvin-DiPasquale[5]
[1]USGS, California Water Science Center, 6000 J Street, Sacramento, CA 95819
[2]Bachand & Associates, Davis, CA 95616
[3]USGS, Geologic Discipline and Biological Resources Discipline, Denver Federal Center, Denver, CO 80225
[4]California Dept. of Fish & Game, Moss Landing Marine Lab., Moss Landing, CA 95039
[5]USGS, Water Resources Discipline, 3215 Marine St., Suite E-127, Boulder, CO 80303
cnalpers@usgs.gov

Mercury Cycling in Agricultural and Non-Agricultural Wetlands in the Yolo Bypass Wildlife Area, California: Concentrations and Loads of Inorganic Surface-water Constituents

Different wetland types in the Yolo Bypass Wildlife Area (YBWA) provide ecological benefits within a flood conveyance zone designed to protect urban areas. Principal habitats in the YBWA are permanently flooded wetlands and seasonally flooded wetlands managed for white and wild rice production (flooded during May/June through Sept./Oct.), shallow-flooded fallow fields (flooded during July/August), and non-agricultural natural wetland habitats (flooded commonly during October-April). Sediments in YBWA are contaminated with mercury (Hg) from historical gold mining in the Sierra Nevada and Hg mining in the Coast Range. The juxtaposition of Hg and wetlands can pose threats to human and ecosystem health because the environmental conditions that prevail in wetlands convert inorganic Hg(II) to methylmercury (MeHg), a more toxic form that bioaccumulates in food webs. During June 2007 - April 2008 we measured concentrations of total Hg (THg), MeHg, major and trace elements, and numerous ancillary parameters in three agricultural wetland types (wild rice, white rice, shallow-flooded fallow) and two managed non-agricultural wetlands (seasonally and permanently flooded) in the YBWA. Inflows, outflows, and water levels were monitored at each field so that loads could be calculated. Outflows varied greatly between the fields, ranging from about 5 to 40% of the applied irrigation waters. During summer 2007, agricultural fields (rice and fallow) showed increases in THg and MeHg concentrations (in filtered waters) from inflows to outflows, whereas the permanently flooded wetland showed no differences. The agricultural fields were consistently higher in aqueous THg and MeHg concentration than the permanently flooded wetland. Effects of sulfate reduction were apparent in all wetlands based on temporal trends in sulfate/chloride ratio and sulfur isotopes of aqueous sulfate, but there was no apparent impact of sulfate-bearing fertilizers on aqueous MeHg concentrations. This is probably because sulfate is not limiting the activity of sulfate reducing bacteria in this system.

CALFED Statement of Relevance
This research quantifies mercury cycling on and off various wetland types in the Yolo Bypass, a known “hot spot” for mercury in the Delta, and is the first study to assess sulfate-bearing fertilizers in agricultural wetlands with regard to possible stimulation of sulfate-reducing bacteria and related effects on rates of mercury methylation.

SESSION: Mercury — Linking Effects of Land Use and Habitat with Wildlife and Human Health: (II) Yolo Bypass Wetlands, 10/24/2008, 10:20 AM, Rooms 311-313

Fleck[1], J.A., G.R. Aiken[2], C.N. Alpers[1], P. Bachand[3], M. Marvin-DiPasquale[4], L. Windham-Myers[4], M. Stephenson[5], B.A. Bergamaschi[1]
[1]US Geological Survey CWSC, 6000 J St, Sacramento, CA 95819
[2]US Geological Survey NRP, 3215 Marine Street, Boulder, CO 80303
[3]Bachand and Associates, Davis, CA
[4]US Geological Survey WBRR, Menlo Park, CA
[5]California Department of Fish and Game, Moss Landing, CA
jafleck@usgs.gov

Mercury Cycling in Agricultural and Non-Agricultural Wetlands in the Yolo Bypass Wildlife Area, California: The Influence of Organic Matter in the Water Column

Organic matter (OM) composition plays a significant role in mercury (Hg) cycling in natural systems. Aromatic dissolved OM can enhance Hg solubility leading to greater cycling in the water column, whereas bioavailable forms of OM may enhance methylmercury (MeHg) production by increasing the activity of Hg(II)-methylating bacteria. Differences in wetland management (e.g. fertilization, plant type, water depth, and residence time) can influence the composition of OM within the wetland, and thus affect Hg cycling. We measured total Hg and MeHg concentrations, OM concentration and composition, and numerous ancillary parameters in three agricultural wetland types (wild rice, white rice, shallow-flooded fallow) and two managed non-agricultural wetlands (seasonally and permanently flooded) in the Yolo Bypass Wildlife Area (YBWA). Results suggest that while OM plays a significant role in Hg cycling in YBWA wetlands, its relative influence is spatially and temporally variable. Despite high dissolved organic carbon (DOC) concentrations normally associated with wetlands (up to 30 mg/L as C), the dissolved OM at the YBWA was low in aromaticity and hydrophobicity relative to other wetland environments. Based on measured optical properties, OM in the YBWA wetlands appears to be derived from a mixture of algal sources, plant exudates, and diffusion from the flooded soils, with the proportion of each source dependent on the specific land use management practices. All wetlands that were subjected to prolonged wet-dry cycles, both agricultural and non-agricultural, exhibited similar trends in organic matter properties and in Hg partitioning to the dissolved fraction, whereby the soluble Hg fraction increases with duration of inundation. The permanently flooded wetland was unique in its lack of variability in organic matter and mercury trends.

CALFED Statement of Relevance
This research addresses the role of dissolved organic matter as it impacts Hg cycling in different wetland types. Achieving CALFED objectives of restoring wetland ecosystems in the Bay-Delta watershed while improving water quality requires a process-level understanding of the synergistic and/or competing factors influencing methylmercury production and export.

SESSION: Mercury — Linking Effects of Land Use and Habitat with Wildlife and Human Health: (II) Yolo Bypass Wetlands, 10/24/2008, 10:40 AM, Rooms 311-313

Marvin-DiPasquale, M.C., J.L. Agee, E. Kakouros, P. Heredia-Middleton, L. Windham-Myers, M.H. Cox, C.N. Alpers, J.A. Fleck, C. Coates
U.S. Geological Survey, 345 Middlefield Rd, Menlo Park, CA 94025
mmarvin@usgs.gov

Mercury Cycling in Agricultural and Non-agricultural Wetlands of the Yolo Bypass Wildlife Area, California: Sediment Biogeochemistry

As part of a larger investigation into mercury (Hg) cycling as a function of habitat type in the Yolo Bypass Wildlife Area, we examined the factors controlling benthic methylmercury (MeHg) production in three types of agricultural fields (white rice, wild rice and fallow) and two types of non-agricultural managed wetlands (permanently and seasonally flooded). Sediment total Hg (THg) concentrations were consistently elevated in the agricultural fields, compared to the managed wetlands. It is unclear if this trend reflects a general east-west THg gradient in the Bypass, historic deposition patterns, or current land use practices. Geochemical data for sediment sulfur and iron suggest that agricultural fields were generally more poised for microbial Fe(III) reduction than for sulfate reduction, whereas permanently flooded wetlands were more poised for sulfate reduction. The addition of sulfate-bearing fertilizers to agricultural fields did not stimulate sulfate reduction (nor Hg(II)-methylation) because this microbial process was not sulfate limited in these fields. The pool of microbially available inorganic 'reactive' mercury (Hg(II)R) was inversely related to sediment total reduced sulfur concentration, closely tracked sediment redox conditions, and was lowest when sediment was most reducing. The permanent wetland exhibited the highest activity of Hg(II)-methylating bacteria, but had comparatively low concentrations of Hg(II)R. Agricultural fields had comparatively lower activities of Hg(II)-methylating bacteria but generally higher concentrations of Hg(II)R. MeHg concentrations and production rates were highest in fallow agricultural fields compared with rice-sown fields and the permanent wetland during rice-growing season (June – August). There was a significant increase in MeHg concentrations in agricultural fields, post-harvest (December – February), possibly linked to the release of labile organic matter from decaying plant remains. These results imply that MeHg production varies as a function of wetland habitat type, hydrology (wetting-drying cycles), and land use practices, and may be enhanced in agricultural rice fields during the post-harvest period.

CALFED Statement of Relevance
This research addresses the factors that control microbial methylmercury production in both agricultural and non-agricultural wetland settings in the northern Delta region. Specifically it distinguishes factors that mediate the activity of Hg(II)-methylating bacteria from those that mediate the availability of Hg(II) to those bacteria.

SESSION: Mercury — Linking Effects of Land Use and Habitat with Wildlife and Human Health: (II) Yolo Bypass Wetlands, 10/24/2008, 11:00 AM, Rooms 311-313

Windham-Myers, L., M. Marvin-DiPasquale, J. Agee, E. Kakouros, M. Cox, P. Heredia-Middleton, C. Coates
United States Geological Survey, 345 Middlefield Road, MS 480, Menlo Park, CA 94025
lwindham@usgs.gov

Mercury Cycling in Agricultural and Non-agricultural Wetlands of the Yolo Bypass: Plant Influences on Biogeochemistry

Wetlands of the Yolo Bypass differ profoundly in their hydroperiod and vegetation structure. From June 2007 to February 2008, we examined mercury (Hg) cycling as related to vegetation metrics in 5 habitat types, including three types of agricultural fields (white rice, wild rice, and fallow) and two types of managed wetlands - permanently flooded (tule and cattail-dominated) and seasonally flooded. We compared vegetated and devegetated sites in all the wetlands. Within the permanent wetland, open water sites were also compared to the cattail- and tule-vegetated sites. Plants appear to have active and passive roles in supplying labile organic carbon that fuels microbial Hg(II)-methylation, and in reoxidizing Fe(II) for reuse by iron-reducing bacteria. Within the permanent wetland, open water habitats had 20-50% lower microbial biomass, lower MeHg production rates and lower MeHg concentrations, compared to vegetated sites. Devegetation reduced methylmercury sediment concentrations and production rates in all wetlands studied. From June-August 2007, root density was correlated with microbial Hg(II)-methylation in the sediments in agricultural fields, but not in managed wetlands. However, despite lower root densities in winter, the highest MeHg concentrations and production rates were observed in agricultural fields in February 2008 (post-rice harvest), when aboveground tissues were in various states of decay. Estimated pools of surficial detritus in agricultural fields were correlated with sediment MeHg concentrations in February 2008, suggesting a seasonal shift in carbon supply to the Hg(II)-methylating bacterial community, from belowground sources (via active plant exudation of labile organic matter) during the growing season, to aboveground sources (via plant decomposition) during winter months.

CALFED Statement of Relevance
This research addresses structural and functional differences between wetlands that influence microbial rates of mercury methylation. Achieving CALFED objectives of restoring and enhancing wetland ecosystems in the Bay-Delta watershed while also maintaining and improving water quality requires process-level understanding of factors controlling methylmercury production and export, such as vegetation and carbon supply.

SESSION: Mercury — Linking Effects of Land Use and Habitat with Wildlife and Human Health: (II) Yolo Bypass Wetlands, 10/24/2008, 11:20 AM, Rooms 311-313

Ackerman, J.T., C.A. Eagles-Smith, K. Miles, M. Ricca
US Geological Survey, Davis Field Station, 1 Shields Ave, Davis, CA 95616
jackerman@usgs.gov

Mercury Cycling in Agricultural and Non-Agricultural Wetlands in the Yolo Bypass Wildlife Area, California: Bioaccumulation in Small Fish and Invertebrates

Agricultural and non-agricultural wetlands provide both economic and ecosystem benefits, however they also are thought to increase methylmercury production – the most bioavailable and toxic form of mercury (Hg) to wildlife and humans. Currently, it is unclear which wetland habitats produce the most methylmercury. We examined the bioaccumulation of mercury in small fish and invertebrates within white rice, wild rice, and permanent wetland habitats at the Yolo Wildlife Area. We introduced 30 Western mosquitofish in cages placed at the inlet, center, and outlet of each wetland habitat type in June (18 cages total), immediately after the white rice fields were flooded. After 60-days of exposure, Hg concentrations in caged mosquitofish had increased by 12, 6, and 3 times over reference fish levels (from the same fish stock originating at Sacramento County Vector Control) in white rice, wild rice, and permanent wetland outlets, respectively. Hg concentrations and Hg burdens differed among wetland habitats, with white rice and wild rice having significantly elevated Hg in caged mosquitofish. Caged mosquitofish at the outlets had much higher Hg concentrations and body burdens than fish at the inlets for white rice, but not permanent wetlands. Hg in caged moquitofish was elevated at all sites in wild rice. We found similar patterns of higher Hg levels in white rice and wild rice than in permanent wetlands, and higher Hg concentrations at outlets compared to inlets for wild-caught mosquitofish and Mississippi silversides which occurred naturally in the agricultural fields at high densities. Our results indicate that methylmercury bioaccumulation is higher in agricultural wetlands than permanent wetlands, and small fish at the outlets of white rice fields in the Yolo Bypass have Hg concentrations averaging 1.78 µg/g dry wt – well above the TMDL target level of 0.15 µg/g dry wt (0.03 µg/g wet wt) for the Delta.

CALFED Statement of Relevance
Improving water quality is one of CALFED's primary goals, and our results are directly applicable to managing water from agricultural and natural wetlands with respect to mercury contamination. We show that agricultural wetlands within the region are zones of high methylmercury bioaccumulation and may be substantial sources of methylmercury to the Delta ecosystem.

SESSION: Mercury — Linking Effects of Land Use and Habitat with Wildlife and Human Health: (II) Yolo Bypass Wetlands, 10/24/2008, 11:40 AM, Rooms 311-313

Slotton, D.G., S.M. Ayers, R.D. Weyand
UC Davis, Dept. of Environmental Science and Policy, Davis, CA 95616
dgslotton@ucdavis.edu

The Role of Biosentinel Small Fish Monitoring in Identifying Factors Driving Methylmercury Exposure across the Bay-Delta Watershed

Problem Statement: The CALFED Mercury Strategy, created by a team of internationally-esteemed experts, defined the primary issue with mercury as: "biotic exposure to methylmercury." The Bay-Delta watershed is already known to be contaminated by legacy mining mercury. With large wetland restorations and changes to water conveyance underway or planned, the concern is that methylmercury exposure may increase, both locally and regionally. It is critical that we track natural and man-made changes to methylmercury exposure and identify the key factors driving it. Approach: A centerpiece of the Mercury Strategy is biosentinel monitoring with small fish. As part of the Fish Mercury Project (FMP), the UC Davis Biosentinel Mercury Program has implemented a sensitive, small fish monitoring network across the watershed. The network of dozens of long term index sites and others dispersed in and around major restoration projects was implemented in 2005. The program includes over 3,000 individual mercury analyses per year and is based on 20 years of method development in the region. Results: The biosentinel monitoring program has established spatial, interannual, and seasonal patterns of methylmercury exposure to the aquatic food web. Proximity to known legacy mining sources was confirmed to increase exposure. However, perhaps the most critical factor influencing exposure was found to be the episodic flooding of previously dry, vegetated sediments. This was confirmed across the watershed in numerous, varied habitats including natural floodplains, managed seasonal wetlands, and tidal high marsh. In contrast, habitats characterized by continual inundation or wetting exhibited relatively lower exposures. Conclusions: The widespread finding of episodic flooding as a dominant factor driving methylmercury exposure suggests a variety of management alternatives to potentially lessen the effect. It also highlights a process that should be taken into account with critical, needed habitats that inadvertently create the effect.

CALFED Statement of Relevance
This program has demonstrated that small fish biosentinel monitoring provides a sensitive, fish-based measure of methylmercury exposure, directly linked to both human health and wildlife pathways. This type of monitoring network can help guide the adaptive management of individual projects and the overall watershed for mercury.

SESSION: Mercury — Linking Effects of Land Use and Habitat with Wildlife and Human Health: (III) Monitoring Mercury in Fish, 10/24/2008, 1:00 PM, Rooms 311-313

Greenfield[1], B.K., M.A. Lent[1], D.G. Slotton[2], S.M. Ayers[2]
[1]San Francisco Estuary Institute, 7770 Pardee Lane, Oakland, CA 94621
[2]Department of Environmental Science and Policy, UC Davis
ben@sfei.org

Modeling Mercury Bioaccumulation in Largemouth Bass in the Sacramento-San Joaquin River Delta and Tributaries

The Sacramento-San Joaquin River Delta (Delta) and associated tributaries have elevated methylmercury (MeHg) concentrations in largemouth bass (*Micropterus salmoides*) and other sport fish species. Strong spatial variation in MeHg concentrations in sport fish has resulted in development of region-specific consumption advisories. We used mechanistic models of largemouth bass MeHg accumulation to determine whether the observed spatial variation may result from differences in bass growth, consumption, or metabolic activity. A bioenergetics and MeHg mass balance model was parameterized with local data on MeHg in bass and prey, estimated bass growth rates, and water temperature. Calibration results indicated high variability in bass metabolic activity and prey consumption rates (expressed as proportion of maximum consumption). Modeled activity and consumption changed as a function of bass age and also the ratio between bass and prey MeHg concentrations. These findings indicate that bioenergetic and life-history differences among bass from different portions of the Central Valley may cause spatial variation in bass MeHg. However, these differences are surpassed by the five-fold variation in prey MeHg concentrations among locations.

CALFED Statement of Relevance
This study synthesizes some of the CALFED mercury monitoring results to better understand the processes influencing mercury bioaccumulation in largemouth bass, an important sport fish in the region. The model can also help evaluate the potential impact of changes in mercury management, as part of the CALFED objective to restore ecological health.

SESSION: Mercury — Linking Effects of Land Use and Habitat with Wildlife and Human Health: (III) Monitoring Mercury in Fish, 10/24/2008, 1:20 PM, Rooms 311-313

Melwani[1], A.R., S.N. Bezalel[1], J.A. Hunt[1], L.J. Grenier[1], G. Ichikawa[2], B. Jakl[2], W. Heim[2], A. Bonnema[2], M. Gassel[3], J.A. Davis[1]
[1]San Francisco Estuary Institute, 7770 Pardee Lane, Oakland, CA 94621
[2]Moss Landing Marine Lab., 7544 Sandholdt Rd, Moss Landing, CA 95039
[3]Office of Environmental Health Hazard Assessment, 1001 I Street, Sacramento, CA 95812
aroon@sfei.org

Patterns in Sport Fish Contamination in the Delta and its Tributaries

The Fish Mercury Project (FMP) is a multifaceted three-year project that is examining mercury in fish of the Bay-Delta watershed and increasing public awareness of fish contamination issues. The FMP completed its third and final round of sampling in 2007, when approximately 800 fish from 15 species were collected from 30 popular sport fishing locations in the Delta and its tributaries. Largemouth bass, channel catfish, redear sunfish, bluegill, Sacramento sucker, common carp, and spotted bass comprised the majority of fish collected. Approximately half of the locations (16 of 30) were chosen to fill data gaps necessary for advisory development on the San Joaquin River. Twelve index and intensive sites were sampled to provide overlap with other sampling years and with the biosentinel component of the project. Additionally, two restoration sites were also sampled to assess the potential changes in mercury concentrations in sport fish due to wetland restoration. The first two years of the Project identified broad spatial difference in mercury concentrations. In 2005-6, mercury concentrations were higher on the lower Sacramento River and San Joaquin River, as well as the Cosumnes River. The least contaminated sites were mainly in the central and southern Delta and secondarily in the extreme southern reaches of the San Joaquin River. Incorporation of the final year of data will help further evaluate these patterns by providing the additional data needed for the tributaries and reservoirs of the San Joaquin River and southern Delta. Overall, largemouth bass has been the most contaminated of the target species, while bluegill and redear sunfish have been the least contaminated.

CALFED Statement of Relevance
Monitoring of mercury in sport fish of the Delta and its tributaries by the Fish Mercury Project is highly relevant to CALFED's Water Quality and Ecosystem Restoration (ERP) programs. The Project has directly followed recommendations of the CALFED Mercury Strategy developed for the ERP.

SESSION: Mercury — Linking Effects of Land Use and Habitat with Wildlife and Human Health: (III) Monitoring Mercury in Fish, 10/24/2008, 1:40 PM, Rooms 311-313

Shilling, F.M.
UC Davis, Department of Environmental Science & Policy, Davis, CA 95616
fmshilling@ucdavis.edu

Developing an Integrated Model for Fish Consumption, Contamination, and Conservation

There is a glaring absence of research that can inform a balanced approach to eating fish for health benefits while both avoiding harm from contaminants and avoiding harm to "safe" fish species. Recent studies show that subsistence fishing is common throughout the Delta and San Francisco Bay regions. This has raised concern about fish contamination (e.g., with mercury and/or PCBs) causing health effects in fish consumers and their children. Current research indicates that at least 2 dozen ethnicities are participating in catching fish in the fresh and estuarine/salt waters of the Bay and Delta. Capture and consumption rates for specific species, preferred fish species, and knowledge of fish contamination as an issue are variable across all ethnicities. Fish consumption rates for many members of Bay and Delta communities are high enough to pose immediate risk to individual health from contamination. Feedback from community organizations indicate that people who are aware of warnings may disregard them because of economic and cultural imperatives to catch their own fish. In addition, these organizations say that people are having trouble balancing messages from health providers about the benefits of eating fish with contrasting messages from the state about fish contamination. Finally, people preferring fish-based diets are balancing their local catch with various fish species acquired from commercial sources (markets, restaurants, etc.). From a community and multi-ethnic point of view, these variables make a uniform message about balancing fish as a healthy choice with fish contamination very challenging to develop. From a conservation point of view, pressure on different freshwater and near-coastal marine fish will vary as different subsistence fishing communities and the general public balance their relative focus on regionally-caught fish vs. commercially-bought fish. I will develop the basis for a model balancing consumption, conservation, and contamination for Delta fish and human communities.

CALFED Statement of Relevance
Both fish contamination and fish population conservation are critical issues in the Delta and Bay. Multi-ethnic subsistence fishing populations carry out culturally and economically-determined fishing behaviors that may impact fish populations and their own health. Balancing the complex studies and messages of fish conservation, fish contamination, and fish consumption advice requires a conceptual framework to be designed to capture this complexity.

SESSION: Mercury — Linking Effects of Land Use and Habitat with Wildlife and Human Health: (III) Monitoring Mercury in Fish, 10/24/2008, 2:00 PM, Rooms 311-313

Davis[1], J.A., A.R. Melwani[1], S.N. Bezalel[1], J.A. Hunt[1], G. Ichikawa[2], A. Bonnema[2], W. Heim[2], D. Crane[3], M. Stephenson[2]
[1]San Francisco Estuary Institute, 7770 Pardee Lane, Oakland, CA 94621
[2]California Department of Fish and Game, 7544 Sandholdt Road, Moss Landing, CA 95039
[3]California Department of Fish and Game, 2005 Nimbus Rd, Rancho Cordova, CA 95670
jay@sfei.org

Mercury and Other Contaminants in Sport Fish of California Lakes and Reservoirs

The California State Water Resources Control Board's Surface Water Ambient Monitoring Program (SWAMP) has established a new statewide bioaccumulation monitoring program. The program has begun with a two-year screening survey of bioaccumulation in California's 9,000 lakes and reservoirs in 2007 and 2008. The program plans to perform a two-year survey of the coast in 2009 and 2010, and survey of rivers and streams in 2011. The cycle will then be repeated in 2012. The lakes survey includes two major components: 1) a probabilistic sampling of 50 lakes to provide a statewide assessment of condition and 2) sampling of the state's 200 most popular fishing lakes to determine the need for inclusion on the 303(d) list of impaired waters. Species targeted at each lake include a top predator as a mercury indicator and a high-lipid benthic species as an indicator for organic contaminants. Largemouth bass, carp, and catfish were the species most commonly sampled. Mercury analyses in predator species were performed on individual fish. A compositing strategy was used for other contaminants to maximize use of limited resources. Edible muscle was analyzed. Samples were collected from a single location in small lakes (< 500 ha) and multiple locations in larger lakes. Contaminants analyzed included mercury, selenium, PCBs, organochlorine pesticides, and PBDEs. Mercury was measured in individual fish from 98 lakes sampled in 2007. Eleven lakes had fish with maximum mercury concentrations above 1.5 ppm, 23 with fish above 1 ppm, 66 with fish above 0.5 ppm, 84 with fish above 0.2 ppm, and 96 with fish above 0.1 ppm. None of the lakes had an average selenium concentration above 3.9 ppm. A summary of all data from the first round of sampling in the summer of 2007 will be presented.

CALFED Statement of Relevance
Monitoring of mercury in sport fish is highly relevant to CALFED's ecosystem restoration program, and consequently is a central element of the CALFED Mercury Strategy developed for the ERP. A large fraction of the state's lakes and reservoirs are located in the Bay-Delta watershed.

SESSION: Mercury — Linking Effects of Land Use and Habitat with Wildlife and Human Health: (III) Monitoring Mercury in Fish, 10/24/2008, 2:20 PM, Rooms 311-313

Saiki, M.K., B.A. Martin, T.W. May, C.N. Alpers
U.S. Geological Survey, WFRC-Dixon Duty Station, Dixon, CA 95620
michael_saiki@usgs.gov

Mercury Contamination in Fish from a Sierra Nevada Foothill Reservoir

Mercury contamination from gold mining operations dating back to the California Gold Rush of 1848-1864 is widespread in surface waters along the western slopes of the Sierra Nevada. A preliminary survey conducted by USGS in 1999 indicated that fish from Camp Far West Reservoir on the Bear River contained especially elevated concentrations of mercury. However, little was know about mercury variation among the fish species, and if concentrations differed spatially within the reservoir. This study attempted to fill such gaps in knowledge. Two forage fish (threadfin shad and bluegill) and a top predator (spotted bass) were sampled in August 2002 and 2003 from upstream in the Bear River arm (receives drainage from a large, heavily mined watershed), upstream in the Rock Creek arm (receives drainage from a small, lightly mined watershed), and downstream near the dam. Total mercury in wholebody samples (reported as dry weight concentrations) was highest in spotted bass (mean, 0.93 µg/g; range, 0.16-4.41 µg/g), and lower in bluegill (mean, 0.45 µg/g; range, 0.22-1.96 µg/g) and threadfin shad (mean, 0.44 µg/g; range, 0.21-1.34 µg/g). Mercury concentrations also varied with fish size, with higher concentrations occurring in larger (older) fish. Fish from the Bear River arm contained the most mercury, followed by fish from the dam, and lastly by fish from the Rock Creek arm. These spatial patterns were also observed for methylmercury concentrations measured by other investigators in water and sediment, suggesting that inflows from the Bear River were mostly responsible for contaminating the reservoir ecosystem. Estimates of mercury concentrations in fillets of many spotted bass and some bluegill exceeded warning levels for human consumption, and confirmed the preliminary findings of elevated mercury reported by the earlier USGS survey.

CALFED Statement of Relevance
One management scenario related to the CALFED topic, “Habitat Availability and Response to Change,” involves dam removal to allow upstream migration by anadromous fishes. Dam removal could increase mercury exposure of fish migrating through the river reach currently occupied by Camp Far West Reservoir, and escalate mercury deposition in the Delta.

SESSION: Mercury — Linking Effects of Land Use and Habitat with Wildlife and Human Health: (IV) Food Web and Habitat Studies, 10/24/2008, 3:00 PM, Rooms 311-313

Grenier, L., J.N. Collins, A. Robinson, S. Bezalel, J. Hunt
San Francisco Estuary Institute, 7770 Pardee Lane, 2nd Fl., Oakland, CA 94621
letitia@sfei.org

Mercury Biosentinels as Tools for Adaptive Management of Wetland Restoration: the South Baylands Mercury Project

The potential to increase net methylmercury production and bioaccumulation is a concern for wetlands restoration efforts. The South Bay Salt Pond Restoration Project, one of the largest wetlands restorations on the continent, is underway in South San Francisco Bay. South Bay is already impacted by contaminants, and has the largest mercury mine in North AmeriCA the New Almaden Mine, in its watershed. The South Baylands Mercury Project is a multifaceted effort to evaluate restoration and management options for a complex of ponds at the foot of the New Almaden watershed. Water, sediment, and biota were sampled in a three-year effort to assess changes in mercury bioaccumulation that may occur when the ponds are restored to tidal action and, eventually, to tidal marsh wetlands. This presentation will focus on results from the first two years of the biota sampling, describing the development of biosentinel species that indicate mercury bioaccumulation at appropriate spatial and temporal scales, as well as with appropriate habitat specificity to answer the management and restoration-design questions. Resident native goby and brine fly sentinels indicated that pre-restoration seasonal pond habitat had greater mercury bioaccumulation than adjacent tidal marsh habitat, which is the restoration endpoint. Obligate tidal marsh sparrow sentinels indicated that variation among tidal marshes in mercury bioaccumulation was significant and increased with increasing distance from the mercury mine source. This inverse relationship is hypothesized to be attributable to a gradient in marsh characteristics, particularly marsh plain elevation and covariates, such as organic matter.

CALFED Statement of Relevance
Restoration of wetlands is a primary goal of CalFed, yet the potential for wetlands to increase net methylmercury production is an important concern. This presentation describes the development of wetland biosentinels for mercury and how they can be used for adaptive management of restoration projects.

SESSION: Mercury — Linking Effects of Land Use and Habitat with Wildlife and Human Health: (IV) Food Web and Habitat Studies, 10/24/2008, 3:20 PM, Rooms 311-313

Eagles-Smith[1], C.A., J.T. Ackerman[1], J.Y. Takekawa[1], T.L. Adelsbach[2]
[1]US Geological Survey, Davis Field Station, 1 Shields Ave, Davis, CA 95616
[2]US Fish and Wildlife Service, 2800 Cottage Way
ceagles-smith@usgs.gov

Mercury Bioaccumulation in Waterbirds: Linking Exposure to Risk, and Implications for Wetland Management

The San Francisco Bay-Delta is contaminated with mercury which bioaccumulates to high levels in wildlife. Waterbirds are of particular concern regarding mercury risk because they forage in wetland habitats where methylmercury production can be elevated, they often occupy a high trophic position in their respective food chains, and they are especially sensitive to the neurological impairment caused by mercury. Thus, understanding the processes that contribute to elevated waterbird exposure to mercury is important for evaluating populations at risk, as well as for developing management stratgedies to reduce exposure. We evaluated the bioaccumulation of mercury in San Francisco Bay-Delta waterbirds to determine relative risk among species. We also assessed the habitat, trophic, and spatial factors that were important components of mercury bioaccumulation in waterbirds using stable isotope methodology, dietary studies, and radio-telemetry. We found that mercury levels were well above those of concern for wildlife, and increased dramatically soon after birds entered the Estuary, just as they began initiating breeding efforts. We also found that fish-eating birds and birds from the South Bay were at highest risk of reproductive impairment due to mercury. Stable isotope and radio-telemetry results showed that birds exhibited high site fidelity and indicated that birds foraging in muted-tidal, pickleweed marshes, and salt ponds had higher mercury exposure than those foraging in other habitats, such as tidal mudflats and the open bay. Thus, certain waterbird species such as Forster's terns, which forage at a high trophic level, specifically in habitats associated with elevated methylmercury production, are at exceptionally high risk to deleterious effects due to mercury exposure. Our results also indicate that waterbirds are ideal bio-indicators of mercury risk in San Francisco Bay-Delta wetlands because they both provide site-specific detail on mercury exposure and bioaccumulation, and accurately convey actual risk of impairment.

CALFED Statement of Relevance
Mercury is a significant water quality concern in the region. Our work contributes to understanding how mercury moves through the Bay-Delta food web and bioaccumulates in waterbirds. We address the relationships between waterbird foraging ecology and habitats with mercury exposure which can be used in an adaptive management framework to reduce wildlife risk.

SESSION: Mercury — Linking Effects of Land Use and Habitat with Wildlife and Human Health: (IV) Food Web and Habitat Studies, 10/24/2008, 3:40 PM, Rooms 311-313

Ackerman[1], J.T., C.A. Eagles-Smith[2], J.Y. Takekawa[2], T.L. Adelsbach[4]
[1]US Geological Survey, Davis Field Station, 1 Shields Ave, Davis, CA 95616
[2]US Fish and Wildlife Service, 2800 Cottage Way
jackerman@usgs.gov

Effects of Mercury on Avian Reproduction in the San Francisco Bay-Delta Estuary

Mercury contamination in waterbirds is a significant concern in the San Francisco Bay Estuary because waterbirds rely heavily on wetland habitats that are known to produce methyl mercury, the most toxic and bioavailable form of mercury, and avian reproduction is especially sensitive to mercury's toxic effects. We examined mercury contamination in four species of waterbirds that are among the most abundant breeding waterbirds in the Estuary. We estimated that risk to reproductive impairment was 58%, 10%, 6%, and 5% for Forster's terns, Caspian terns, American avocets, and black-necked stilts based on the proportion of breeding adults whose blood mercury concentrations exceeding 6.8 µg g-1 wet wt. Mercury concentrations were higher in failed-to-hatch eggs (7.62 µg g-1 dry wt) than in randomly sampled eggs (6.36 µg g-1 dry wt) for Forster's terns, but the differences were not statistically significant for avocets and stilts. Moreover, 98% of Forster's tern eggs sampled were above the San Francisco Bay-Delta's current TMDL monitoring target for eggs of 2.50 µg g-1 dry wt. We also found that dead stilt chicks (but not avocets or Forster's terns) had higher mercury concentrations in down feathers than randomly sampled living chicks. Our results indicate that current waterbird exposure to mercury is high enough to be a cause of concern in the Estuary, and that reproduction may be impaired. Continued assessment and monitoring of waterbird mercury exposure and reproduction in the Delta are warranted.

CALFED Statement of Relevance
Thresholds of impairment are critical for evaluating current levels of mercury in the Bay-Delta within the context of ecological effects. Our work provides valuable information for refining CALFED performance measures that incorporates ecologically relevant toxicological endpoints for species residing in the region.

SESSION: Mercury — Linking Effects of Land Use and Habitat with Wildlife and Human Health: (IV) Food Web and Habitat Studies, 10/24/2008, 4:00 PM, Rooms 311-313

Woo[1], I., D. Tsao-Melcer[2], J.Y. Takekawa[1]
[1]USGS, San Francisco Bay Estuary Field Station, 505 Azuar Drive, Vallejo, CA 94592
[2]USGS Davis Field Station, One Shields Avenue, Davis, CA
iwoo@usgs.gov

Methylmercury Concentrations in the Tidal Marsh Foodweb: The California Black Rail as an Indicator Species

Though restoration efforts seek to reverse the physical loss roughly 80% of historic tidal marshes in the San Francisco Bay Estuary (SFBE), little attention has been given to the remaining threats to tidal marsh inhabitants, such as mercury contamination and foodweb uptake. The California black rail is state threatened tidal marsh obligate, and more than 80% of the western population can be found within SFBE, with breeding populations virtually confined to northern SFBE marshes. We analyzed black rails and relate methylmercury (meHg) uptake through direct samples of regurgitated items and 14C and 15N stable isotopes for a wide array of marsh invertebrates. To examine meHg bioaccumulation, we analyzed select invertebrate taxa (surface scraping gastropod, detritivore amphipod and predatory arachnid) for meHg concentrations. The marsh food web varied by site, but showed three basic trophic groups: vertebrate predators (Black Rail), invertebrate predators (spiders, predatory beetles), and herbivores (snails, detritivores, and plant hoppers). Stable isotopes revealed that black rails were generalists that fed on marsh plain invertebrates and not from invertebrates found in local channels. Diet samples yielded a high frequency of occurrence for beetles and spiders and to a lesser extent leaf hoppers, amphipods, and snails. MeHg concentrations differed by marsh taxa: California black rails had the greatest concentration of meHg: male black rails had higher MeHg blood concentrations than females (8.22 µg/g meHg and 6.63 µg/g meHg, respectively). Invertebrate meHg concentrations were approximately 10x lower than those of the black rail. Beetles (0.53+0.06 µg/g meHg, N=5) had greater meHg concentrations than spiders (0.412+0.021 µg/g meHg; N=47), which had greater meHg concentrations than snails (0.124+0.006 µg/g meHg, N=55) or amphipods (0.102+0.005 µg/g meHg; N=67). Though meHg in surface sediments were greater in interior marshes than channel edges, no difference was detected within target biota. Though no mercury toxicity thresholds are unique for each species and none exist for the California black rail, we compared our results to established risk categories for the common loon. Our results indicate that 67% of feathers and 91% of blood samples fell into the low risk range, 32% of feathers and 9% of blood in the moderate risk range, and <1% of feathers and no blood samples were in the high risk range. A substantial portion of the threatened black rail population in SFB may be at risk of adverse effects from MeHg if they have a greater sensitivity to MeHg contaminations than the common loon. With their small breeding homeranges and strong site fidelity, California black rails may be good mercury indicators of tidal marshes in the north bay.

CALFED Statement of Relevance
This presentation presents results from the CalFed Ecosystem Restoration Program 02D-P62, “Mercury and Methylmercury Processes in North San Francisco Bay Tidal Wetland Ecosystems.” Tidal marshes have elevated methylmercury production in surface sediments; however, the pathways for foodweb uptake are relatively unclear. The California black rail may be good indicators of methylmercury contamination within tidal marsh biota because of their trophic position, small breeding homeranges and strong site fidelity.

SESSION: Mercury — Linking Effects of Land Use and Habitat with Wildlife and Human Health: (IV) Food Web and Habitat Studies, 10/24/2008, 4:20 PM, Rooms 311-313

Durand, J.R.*
UC Davis, WFCB/Center for Watershed Science, Davis, CA 95616
jrdurand@ucdavis.edu

The DRERIP Delta Aquatic Foodweb Conceptual Model

The foodweb model was created to synthesize current understandings of Delta trophic linkages in a graphic and accessible way. The model has a graphical interface that allows the viewer to click trophic linkages and review referenced text passages describing these links, with the intent that management decisions could be informed by a readily accessible synthesis of information. This conceptual model suggests that phytoplankton production is largely limited by turbidity, low residence time, and high levels of ammonium. Limited primary production in turn limits secondary production, although omnivorous zooplankton may be able to supplement diets with inputs from the microbial loop. Microbial production tends to be driven by organic carbon inputs in the form of riverine, sewage and agriculturally derived detritus (as well as phaeophyton from endogenous phytoplankton and macrophyte production). Both phytoplankton and some zooplankton are heavily limited by predation by the two bivalves *Corbicula amurensis* and *Corbicula fluminea*. The ecological impact of these organisms is due to their high numbers and filtration rates, which are estimated to allow them to filter the entire water column on a timescale on the order of days (for phytoplankton) to weeks (for bacterioplankton) at existing densities. Those zooplankton not subject to direct predation are often indirectly affected by competition for phytoplankton. In summary, both bottom up and top down forces limit production within the Delta. Phytoplankton blooms are limited by turbidity, residence times and ammonium. This limited production is grazed heavily by benthic filter feeding bivalves, curtailing the availability of food for most fish. Much of the carbon in the system derives from upstream sources. Both allochthonous and autochthonous inputs of carbon are directed into the benthos and variously sequestered, advected out of the system, recycled into the microbial loop, or made available to a limited set of benthic feeding fish and birds.

CALFED Statement of Relevance
The talk describes a science-based work product for the Delta Regional Ecosystem Restoration Implementation Plan (DRERIP) being developed under the Adaptive Management Planning Team (AMPT) and coordinated by the CALFED Ecosystem Restoration Program (ERP) and the CALFED Science Program. DRERIP also provides a forum for collaboration for several planning efforts currently underway, including the Delta Vision process, the Bay-Delta Conservation Plan, a comprehensive framework for monitoring and assessment in the Bay-Delta (formerly CMARP), the pelagic organism decline (POD) investigation, and development of performance measures.

SESSION: From Concept to Utility: The Use of DRERIP Models in Ecosystem Restoration Planning, 10/24/2008, 8:20 AM, Room 314

Opperman[1], J.J., B. Andrews[2], L. Brown[3], J. Rosenfield[4]
[1]The Center for Integrated Watershed Science and Management, University of California, Davis and The Nature Conservancy's Global Freshwater Team, 91 Carriage Stone Drive, Chagrin Falls, OH, 44022
[2]PWA, 550 Kearny Street, 9th Floor, San Francisco, CA
[3]USGS, Placer Hall 6000 J Street, Sacramento, CA
[4]Aquatic Restoration Consulting, Berkeley, CA
opperman@gmail.com

A Conceptual Model for Central Valley Floodplains

Floodplains in the Central Valley provide numerous ecological benefits including essential habitat for several species of concern, such as Sacramento splittail and Chinook salmon. Algal productivity within floodplains can also provide biologically available carbon to the Delta. Thus increasing the extent of floodplains and improving their ecological function is an important component of regional restoration strategies. This conceptual model seeks to inform these restoration efforts by synthesizing current information on Central Valley floodplains and highlighting the primary processes and linkages that ultimately produce outputs of management interest. The model is divided into three primary sub-models. Model 1 (Creating the Template) captures the linkages and processes that create the habitat mosaic—the physical template of a given floodplain, such as topography and vegetative communities. Model 2 (Inundating the Template) depicts how a given floodplain, with topography and vegetation created within Model 1, is inundated by river flows and other sources of water to create specific conditions within the inundated floodplain that are important to the species or processes described in Model 3. Model 3 (Management Outputs) illustrates how the inundated habitat characteristics, developed in Model 2, interact with a few other key elements to influence the production of biota of direct interest to delta restoration planners, including algae, zooplankton, splittail, and juvenile Chinook salmon.

CALFED Statement of Relevance
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SESSION: From Concept to Utility: The Use of DRERIP Models in Ecosystem Restoration Planning, 10/24/2008, 8:40 AM, Room 314

Alpers[1], C.N., C.A. Eagles-Smith[2], C.A. Foe[3], S. Klasing, M. Marvin-DiPasquale[4], D.G. Slotton[2], L. Windham-Myers[4]
[1]USGS, California Water Science Center, 6000 J Street, Sacramento, CA 95819
[2]USGS, Davis Field Station, 1 Shields Ave, Davis, CA 95616
[3]Central Valley Regional Water Quality Control Board, 11020 Sun Center Dr., Suite #200, Rancho Cordova, CA 95670
[4]USGS, 345 Middlefield Rd MS 480, Menlo Park, CA 94025
cnalpers@usgs.gov

Mercury Conceptual Model - Delta Regional Ecosystem Restoration Implementation Plan (DRERIP)

Mercury has been identified as an important contaminant in the Delta, based on elevated concentrations of methylmercury (a toxic, organic form that readily bioaccumulates) in fish and wildlife. There are health risks associated with human exposure to methylmercury by consumption of sport fish, particularly top predators such as bass species. Original mercury sources were upstream tributaries where historical mining of mercury in the Coast Ranges and gold in the Sierra Nevada and Klamath-Trinity Mountains caused contamination of water and sediment on a regional scale. Remediation of abandoned mine sites may reduce local sources in these watersheds, but much of the mercury contamination occurs in sediments stored in the riverbeds, floodplains, and the Bay-Delta, where scouring of Gold-Rush-era sediment represents an ongoing source. Conversion of inorganic mercury to toxic methylmercury occurs in anaerobic environments including some wetlands. Wetland restoration managers must be cognizant of potential effects on mercury cycling so that the problem is not exacerbated. Recent research suggests that wetting-drying cycles can contribute to mercury methylation. For example, high marshes (inundated only during the highest tides for several days per month) tend to have higher methylmercury concentrations in water, sediment, and biota compared with low marshes, which do not dry out completely during the tidal cycle. Seasonally inundated flood plains are another environment experiencing wetting and drying where methylmercury concentrations are typically elevated. Habitat restoration projects, particularly those involving wetlands, may cause increases in methylmercury exposure in the watershed. This possibility should be evaluated. The DRERIP mercury conceptual model and its four submodels (1. Methylation, 2. Bioaccumulation, 3. Human Health Effects, and 4. Wildlife Heath Effects) can be used to understand the general relationships among drivers and outcomes associated with mercury cycling in the Delta.

CALFED Statement of Relevance
This talk describes a science-based work product for the Delta Regional Ecosystem Restoration Implementation Plan (DRERIP) being developed under the Adaptive Management Planning Team (AMPT) and coordinated by the CALFED Ecosystem Restoration Program (ERP) and the CALFED Science Program. DRERIP also provides a forum for collaboration for several planning efforts currently underway, including the Delta Vision process, the Bay-Delta Conservation Plan, a comprehensive framework for monitoring and assessment in the Bay-Delta (formerly CMARP), the pelagic organism decline (POD) investigation, and development of performance measures.

SESSION: From Concept to Utility: The Use of DRERIP Models in Ecosystem Restoration Planning, 10/24/2008, 9:00 AM, Room 314

Nobriga[1], M.L., B. Herbold[2]
[1]Department of Fish and Game, Water Branch, Sacramento, CA
[2]U.S. Environmental Protection Agency, San Francisco, CA
Matthew.Nobriga@calwater.ca.gov

A Summary of the DRERIP Conceptual Model for Delta Smelt

We provide an overview of the DRERIP conceptual model for the threatened delta smelt, *Hypomesus transpacificus*, an annual fish endemic to the San Francisco Estuary. The DRERIP conceptual models are learning tools, statements of current scientific understanding of species and processes, and a tool for vetting water management and habitat restoration strategies. Our presentation focuses on recent paradigm shifts regarding the delta smelt, including "why delta smelt aren't ever trying to get to Suisun Bay", "why the overbite clam may not have had much to do with the delta smelt decline", and "why delta smelt will not sit in the tidal marshes we build for them and stay out of our water supply."

CALFED Statement of Relevance
This talk describes a science-based work product for the Delta Regional Ecosystem Restoration Implementation Plan (DRERIP) being developed under the Adaptive Management Planning Team (AMPT) and coordinated by the CALFED Ecosystem Restoration Program (ERP) and the CALFED Science Program. DRERIP also provides a forum for collaboration for several planning efforts currently underway, including the Delta Vision process, the Bay-Delta Conservation Plan, a comprehensive framework for monitoring and assessment in the Bay-Delta (formerly CMARP), the pelagic organism decline (POD) investigation, and development of performance measures.

SESSION: From Concept to Utility: The Use of DRERIP Models in Ecosystem Restoration Planning, 10/24/2008, 9:20 AM, Room 314

Reed[1], D.J., A. DRERIP
University of New Orleans, Dept. Earth & Environmental Science, New Orleans, LA 70148
djreed@uno.edu

Using Conceptual Models in Ecosystem Restoration Planning

The adaptive management approach adopted by the CALFED Ecosystem Restoration Program uses conceptual models as a central component linking program goals and objectives with restoration actions. Many ecosystem restoration efforts see conceptual models as where scientific knowledge of system dynamics is stored and regularly updated. The vision is that DRERIP models are updated as more information becomes available. Moreover, they have been specifically formatted to interface with a procedure for scientific evaluation of candidate restoration actions, and can also assist with identifying appropriate restoration actions to reach specific goals. The DRERIP AMPT has developed a comprehensive method for scientific review of a restoration action. Each restoration action is articulated to clearly identify the action, the approach used and the expected outcome. The evaluation procedure uses the models, and any additional information available, to assess magnitude and certainty of ecosystem outcomes and to identify gaps in understanding or data. The procedure also estimates the degree of 'worth' and 'risk' associated with the action, and uses that together with potential reversibility and opportunity for learning to provide an implementation recommendation in the context of the adaptive management approach (e.g., full scale, pilot, research, set aside). Components of the scientific evaluation procedure can be used with the conceptual models to 'screen' proposed restoration actions and provide planners with a general assessment of the benefits that might result from implementation. In addition, where a restoration program has clearly identified goals and objectives the models can be used to identify the 'system drivers' which should be modified to achieve desired ecosystem outcomes. However, using the conceptual models to develop actions in this way requires an additional step to identify appropriate and feasible actions and approaches. The presentation will illustrate the use of models to evaluate, screen and develop actions for ecosystem restoration in the Delta.

CALFED Statement of Relevance
This talk describes a science-based work product for the Delta Regional Ecosystem Restoration Implementation Plan (DRERIP) being developed under the Adaptive Management Planning Team (AMPT) and coordinated by the CALFED Ecosystem Restoration Program (ERP) and the CALFED Science Program. DRERIP also provides a forum for collaboration for several planning efforts currently underway, including the Delta Vision process, the Bay-Delta Conservation Plan, a comprehensive framework for monitoring and assessment in the Bay-Delta (formerly CMARP), the pelagic organism decline (POD) investigation, and development of performance measures.

SESSION: From Concept to Utility: The Use of DRERIP Models in Ecosystem Restoration Planning, 10/24/2008, 9:40 AM, Room 314

Dobroski, N.A., Gehringer, D.B., C. Scianni, M. Falkner
California State Lands Commission, 100 Howe Ave Suite 100S, Sacramento, CA 95825
dobrosn@slc.ca.gov

Traffic Patterns for Vessels Arriving to the San Francisco Bay and Implications for Nonindigenous Species Introduction Pressures

The Marine Invasive Species Program (MISP) at the California State Lands Commission has aggressively pursued the prevention of nonindigenous species (NIS) release from commercial vessels into California waters. By receiving and processing ballast water management reports for every commercial call to California ports, MISP staff can monitor vessel traffic patterns and ballast water discharge activities to evaluate the risk of NIS release, and recommend actions to prevent further introductions. Data collected from the ballast water management reports submitted in 2007 indicate that 35% of the 11,238 arrivals to California occurred in the San Francisco Bay region (Bay), with arrivals to Oakland alone representing 18% of the state's vessel arrivals. The vessel types that arrived to the Bay were representative of the state overall: 50% and 44% of arrivals to the Bay and California, respectively, were container ships, and 21% and 19% of arrivals to the Bay and California, respectively, were oil tankers. Combined with information on the last port of call, statistics such as these will be useful in assessing potential NIS invasion pressures from vessel fouling and ballast water to California and sensitive ecosystems, such as the Bay. The information gathered by MISP is currently used in conjunction with research examining vessel fouling communities and the efficacy of ballast water treatment technologies to guide the development of regulations to reduce the introduction and establishment of NIS in California waters.

CALFED Statement of Relevance
This presentation will discuss vessel traffic statistics to assess degraded water quality issues pertaining to potential nonindigenous species invasion pressures from commercial shipping, and will summarize policy-based recommendations for reducing the introduction and establishment of nonindigenous species in California waters.

SESSION: Invasive Species, 10/24/2008, 10:20 AM, Room 314

Scianni, C.K., D.B. Gehringer, N.A. Dobroski, M.B. Falkner
California State Lands Commission, 100 Howe Ave., Suite 100 South, Sacramento, CA 95825
sciannc@slc.ca.gov

What the Hull is Going On: A Preliminary Look at the Fouling-Related Practices of Vessels in California

Fouling of aquatic organisms to the submerged areas of vessels is a major vector for the transfer of nonindigenous species (NIS) both locally and globally. In the San Francisco Bay-Delta, vessel fouling has been implicated in over 26% of all NIS introductions - more than any other single vector, including ballast water. Introduction of NIS through vessel fouling occurs as organisms spawn, fall off, or are physically removed from the underwater areas of vessels. Although vessel fouling can be a significant contributor to the transfer of NIS into the Bay-Delta, and California in general, it is difficult to assess the risk of NIS introduction through this vector because of limited information on the fouling-related practices of vessels operating in California. To fill this information gap, the California State Lands Commission (Commission) has developed a Hull Husbandry Reporting Form (HHRF) that vessel owners are required to submit annually. The form includes ten questions related to the hull husbandry practices and voyage characteristics, such as average speed or extended port stays, which may influence fouling accumulation. Preliminary data indicate that 98.8% of vessels operating in California have been removed from the water for hull cleaning and treatment with an antifouling coating within the past 5 years, and 80.1% of those vessels have used an antifouling coating containing at least one biocide. This information, along with the rest of the data gathered from the HHRF, will provide more detail about the specific practices of these vessels. When used in conjunction with the fouling-related research the Commission is currently funding, these data will guide the development of regulations governing the management of fouling on vessels operating in California. The implementation of these science-based management policies will greatly enhance the ability of the Commission to prevent the spread of NIS into the waters of California.

CALFED Statement of Relevance
This work provides useful data on commercial vessel practices related to vessel fouling. This information will help guide the development of regulations to reduce the spread of nonindigenous species into the Bay-Delta system, and California in general, as nonindigenous species may pose a threat to all four CALFED program objectives.

SESSION: Invasive Species, 10/24/2008, 10:40 AM, Room 314

Ruch[1], S.A., C. Aquatic Weed Unit[2]
[1]ReMetrix LLC, 2041 Bancroft Way, Berkeley, CA 94704
[2]California Department of Boating and Waterways, 2000 Evergreen St., Ste. 100, Sacramento, CA 95815
scott@remetrix.com

Battling Invasive Brazilian Waterweed (Egeria densa) in the Sacramento-San Joaquin Delta: Multi-Year Benchmark Adaptive Management in Frank's Tract

Introduced to the Sacramento-San Joaquin Delta (SSJD) 40 years ago and well-suited for life in this complex ecosystem, the invasive submerged aquatic macrophyte *Egeria densa* negatively impacts biological, commercial, and recreational resource the SSJD provides Californians. Adaptive management of invasive *Egeria densa* in the complex waterways of the SSJD presents many challenges. Rapid tidal fluxes, varying and often strong current patterns, sediment composition, changing water temperature, and turbidity can all influence the efficacy of treatment regimes. Understanding how and why cultures of *Egeria densa* react to management efforts throughout growing seasons in the SSJD is key to realizing best practice in regulating invasive growth. The semidiurnal tidal flux and significant turbidity of SSJD waters has historically rendered empirical measurements of *Egeria* coverage and biovolume unreliable. Hydroacoustic plant mapping technology, applied in Delta waters since 2003, has provided a breakthrough in solving this assessment problem. Combining hydroacoustic transects with underwater photographic surveillance and traditional point sampling techniques provides the most complete picture to date of submerged vegetation conditions in the unique shallow water habitats of the SSJD. Eighteen sites in the central Delta have been monitored since 2003 for submerged vegetation species, health, biocover, and biovolume. The goal of this ongoing monitoring approach is to better measure actual efficacy and the factors that influence efficacy on Brazilian waterweed. Efficacy is determined by comparing the aggregation of acoustic-based plant-coverage and biovolume models, photographs, and physical data at each treated site with control sites. Yearly summaries strongly contribute to adaptive management decision-making. Within the operational context of the goals of the California Department of Boating & Waterways *Egeria densa* Control Program, analysis results from Frank's Tract, a ~3,000-acre treatment site located in the central SSJD, will be utilized as an example of progress in managing volume and coverage of *Egeria*.

CALFED Statement of Relevance
This research is highly relevant to the CALFED Bay-Delta Program. The underwater landscape of shallow water habitat has been identified as critical to several endangered SSJD fish species and this dataset provides the most extensive and detailed submerged vegetation data to-date, extremely important to current and future ecological restoration efforts in the Delta.

SESSION: Invasive Species, 10/24/2008, 11:00 AM, Room 314

Andrew, M.E.*, S.L. Ustin
UC Davis, Department of Land, Air, & Water Resources, Davis, CA 95616
meandrew@ucdavis.edu

Ecological remote sensing of invasion by perennial pepperweed

Hyperspectral and LiDAR remote sensing data have the potential to address a wide variety of ecological research questions. We present results of three ecological applications of remote sensing data to study the invasion of the San Francisco Bay/Sacramento-San Joaquin River Delta by *Lepidium latifolium* (perennial pepperweed). *Lepidium* is a noxious Eurasian weed that is aggressively expanding in the western US; understanding the ecology and management options for this weed are CALFED priorities. Its spectral characteristics allow its successful discrimination in hyperspectral image data, and we have used these image data to map its distribution in several sites of the Bay/Delta region annually over 2004-2007. Annual distribution maps allow quantification of *Lepidium* spread and dispersal. For example, on Bouldin Island, the *Lepidium* infestation has increased by 50% (from 119,000m2 to 178,000m2) in just these three years and new patches were detected as far as 500m from preexisting ones. We have generated habitat distribution/susceptibility models for *Lepidium* at the Rush Ranch Open Space Preserve with data extracted from the hyperspectral distribution maps and environmental variables derived from both the hyperspectral and LiDAR datasets. This analysis found that *Lepidium* occurrence at this site is primarily a function of the distance from a channel and the distance from the upland-marshland margin. Finally, the hyperspectral datasets of Rush Ranch and Cosumnes River Preserve revealed substantial spatial and annual variation in *Lepidium* phenology. Environmental variables extracted from the hyperspectral and LiDAR datasets explained 33-56% of the spatial variation in phenology at these two sites and interannual phenologic differences at the Cosumnes River Preserve were closely related to hydrology. Our results highlight the importance of microtopography and water availability to *Lepidium* distribution and phenology, increasing our understanding of this invasive species and informing better management.

CALFED Statement of Relevance
Remotely sensed detailed, accurate, timely, and comprehensive maps of perennial pepperweed throughout the Delta and the ecological inferences they support improve management and understanding of this aggressive, exotic weed. This study addresses two goals of CalFED's Ecosystem Restoration Program: 1) protecting habitats and 2) reducing impacts of invaders.

SESSION: Invasive Species, 10/24/2008, 11:20 AM, Room 314

Whitcraft[1], C.R., B. Grewell[2], B. Wallace[3], D. Talley[1]
[1]San Francisco Bay National Estuarine Research Reserve, 3152 Paradise Dr, Tiburon, CA 94920
[2]USDA - ARS, UC Davis, Dept. of Plant Sciences, Mail Stop 4, Davis CA 95616
[3]Solano Land Trust, 1001 Texas Street, Suite C, Fairfield, CA 94533
cwhitcra@gmail.com

The Adaptive Management of Perennial Pepperweed Invasion Along an Inundation Gradient

Perennial pepperweed (*Lepidium latifolium*) is an aggressive, non-native weed that has invaded wetland and riparian areas throughout California. At Rush Ranch, a brackish marsh in the San Francisco Bay National Estuarine Research Reserve, we applied a two-pronged approach to understanding and managing pepperweed: (1) mensurative experiment documenting impacts of perennial pepperweed on the sediment community and food web (2) eradication experiments evaluating efficacy and non-target impacts of herbicide control in a seasonal wetland. Within a wetland isolated from tidal creeks, the presence of pepperweed significantly increased soil humidity and altered the diversity and composition of the surrounding plant and insect communities. In mid and low elevations, the effects of perennial pepperweed are reduced due to constant inundation and soil saturation. Herbicide treatments (Imazypyr, 2,4 D) were applied at flower bud stage in May 2007 and monitored at 1 month, 6 months, and 1 year following application. A single year of 2,4D was not effective in controlling pepperweed (< 1% pepperweed control) but had minimal non-target impacts on the native plant community. Imazypyr reduced pepperweed cover by more than 90% compared to untreated controls although non-target impacts on the native plant community were severe and persistent. No single year treatment offered complete weed control without collateral damage to the native plants. We have applied 2,4 D for a second time and will monitor all plots for a second year. In addition, we are conducting a pilot experiment with glyphosate and 2,4D in the tidal marsh. Our data provide important information about the consequences of perennial pepperweed invasion and about pairing science with eradication efforts. In addition, our results will be used to develop an integrated and adaptive management strategy for pepperweed control at this marsh reserve.

CALFED Statement of Relevance
Our research contributes to the CALFED mission by providing data about the impacts of and eradication strategies for *Lepidium latifolium*, a problematic invasive species throughout the Suisun estuary. Integrated approaches combining science and management strategy are crucial to improving the ecological health of the San Francisco Bay/Sacramento-San Joaquin River Delta.

SESSION: Invasive Species, 10/24/2008, 11:40 AM, Room 314

Phillips, J.
US Bureau of Reclamation, 2800 Cottage Way, Sacramento, CA 95825
jphillips@mp.usbr.gov

The San Joaquin River Restoration Program

After the San Joaquin River Settlement Agreement was Reached, the responsibility for action shifted from the settling parties to the implementing agencies. The Department of the Interior was established as the primary party for implementing the Settlement, with the State of California as a partner. A five-agency Program Management Team was established to guide implementation of the Settlement Agreement. Significant progress has been made to date, including the formation of a Program Management Plan, scopes of work for environmental compliance and related studies, as well as numerous technical memoranda. The agencies also are initiating preliminary investigations to establish a foundation for successful restoration, including geologic surveys, topographic mapping and installation of monitoring stations along the river.

CALFED Statement of Relevance
Many scientific and management tools and concepts developed by the CALFED Bay-Delta Program are utilized in this large-scale restoration program.

SESSION: San Joaquin River Restoration Program: Integrating Science and Management (I), 10/24/2008, 1:00 PM, Room 314

Schmitt[1], M., J. Ron[2]
[1]Natural Resource Defense Council, 111 Sutter St., San Francisco, CA 94104
[2]Friant Water Users Authority, 854 North Harvard Avenue, Lindsay, CA 93247
mschmitt@nrdc.org

San Joaquin River Background and Settlement

The recent San Joaquin River Settlement Agreement marks the end of 18 years of litigation and the beginning of an ambitious effort to restore 150 miles of the second largest river in California. Nearly sixty years after the river was dewatered and the last salmon runs were extirpated from the system, the Settlement requires re-establishing naturally reproducing and self-sustaining populations of spring and fall run Chinook salmon. Extensive scientific analyses provided the basis for establishing the flow releases and the restoration actions necessary to meet salmon life history requirements. The Settlement also calls for the creation of a water management program to help minimize impacts to local water supplies as well as the establishment of timelines, funding mechanisms, provisions for on-going management, and participation by other parties not involved in the litigation, including the State of California. Many thought the San Joaquin River could never be restored, but this Settlement demonstrates the potential to restore major rivers while balancing the needs of aquatic ecosystems with the water supply.

CALFED Statement of Relevance
The San Joaquin River Restoration Program Settlement contributes to CALFED Program objectives including ecosystem restoration, the return of flows to a dry river, and improvements in levee stability.

SESSION: San Joaquin River Restoration Program: Integrating Science and Management (I), 10/24/2008, 1:20 PM, Room 314

Deister, A.
Brown and Caldwell, 10540 White Rock Road, Rancho Cordova, CA 95670
adeister@brwncald.com

So What is the Technical Advisory Committee?

The San Joaquin River Settlement establishes a Technical Advisory Committee. The voting members include two representatives from both the Plaintiffs and the Friant Defendants and two designees mutually-agreed upon. Representatives from Department of Water Resources and Department of Fish and Game participate as ex officio non-voting members and staff from U.S. Bureau of Reclamation, U.S. Fish and Wildlife Service, and National Marine Fisheries Service act as liaisons. The Technical Advisory Committee is led by the Restoration Administrator and consists of members that have relevant technical or scientific background or expertise in fields related to river restoration or fishery restoration. Responsibilities of the Technical Advisory Committee and the Restoration Administrator are identified in the Settlement. The Technical Advisory Committee via the Restoration Administrator plays a key role in providing relevant scientific review of the Program to the Secretary of the Interior.

CALFED Statement of Relevance
The San Joaquin River Restoration Program Settlement contributes to CALFED Program objectives including ecosystem restoration, the return of flows to a dry river, and improvements in levee stability.

SESSION: San Joaquin River Restoration Program: Integrating Science and Management (I), 10/24/2008, 1:40 PM, Room 314

Moyle, P.B.
UC Davis, 1 Shields Ave, Davis, CA 95616
pbmoyle@ucdavis.edu

Bringing Back Salmon AND Native Fish to the San Joaquin River

The fisheries goal of the San Joaquin River Restoration Program is to re-establish a self-sustaining population of Central Valley spring-run and fall-run Chinook salmon and other native fish in the upper San Joaquin River below Friant Dam to the confluence of the Merced River. Establishing population targets, goals, and milestones is essential for planning purposes as well as to monitor the progress towards restoring self-sustaining populations. The Technical Advisory Committee developed targets, goals, and milestones for re-establishment of spring-run and fall-run Chinook salmon. In order to achieve the goal, reintroducing a natural population of spring-run Chinook salmon that is specifically adapted for conditions in the upper San Joaquin River is needed, as well as a genetically and demographically diverse population. Reintroduction of fall-run and late fall-run Chinook salmon are important but junior priorities compared to spring-run Chinook salmon. A combination of data reflecting 1) minimum genetic viability, 2) minimum population viability, 3) 1942-1948 spring-run escapement on the San Joaquin River, 4) historic and present habitat carrying capacity, 5) trends in other recovering Central Valley Chinook salmon populations, and 6) historic escapement trends on the Tuolumne, Merced, and Stanislaus rivers, were used to develop population goals and milestones. In addition, while the Settlement Agreement specifically provides flows and restoration actions for reintroducing spring-run Chinook salmon, the more 'natural' flow regime provided by the Settlement Agreement should also improve habitat availability for a wide array of native and non-native fishes. Historically, the lower San Joaquin River supported at least 14 species of native fish, of which only seven have been noted in recent surveys, all with limited abundance and distribution. In particular, there should be a long reach of stream dominated by a fairly complete assemblage of native fishes, as has happened in Putah Creek, Solano-Yolo Counties. The assemblage could contain as many as 10 species of native fish. Most will recruit from existing local populations as demonstrated by DFG's sampling program, but some, such as hardhead and tule perch, may have to be reintroduced. Maintaining native fishes will require active management of the river and riparian areas, beyond just the flow regime.

CALFED Statement of Relevance
The restoration of flows to the San Joaquin River required by the San Joaquin River Settlement contributes to the restoration of multiple fish species assemblages, contributing to CALFED Bay-Delta Program's Ecosystem Restoration Program goals.

SESSION: San Joaquin River Restoration Program: Integrating Science and Management (I), 10/24/2008, 2:00 PM, Room 314

Hanson, C.
Hanson Environmental, 132 Cottage Lane, Walnut Creek, CA 94595
chansonenv@aol.com

The Technical Advisory Committee Reintroduction Strategy

The fisheries goal of the San Joaquin River Restoration Program is to re-establish a self-sustaining population of Central Valley spring-run and fall-run Chinook salmon and other native fish in the upper San Joaquin River below Friant Dam to the confluence of the Merced River. The Technical Advisory Committee developed specific reintroduction strategies for Central Valley spring-run and fall-run Chinook salmon. A number of recommended objectives and criteria are recommended including criteria regarding the origin of the stock, genetics of the stock, the source population condition, and existing conditions of salmon stocks in the San Joaquin basin. The reintroduction strategy includes a three-phased approach, including an experimental phase, an early introduction phase, and an establishment phase, all of which focus on a reduction in the level of human intervention to achieve the restoration goal of restoring naturally producing salmon. The Technical Advisory Committee also recommended the pursuit of additional information needs to revise the reintroduction strategy, such as the development of a genetic management plan, additional literature review regarding lessons learned from past reintroduction strategies, further evaluation on the stock selection, and the evaluation of alternative adaptive management strategies. The data used in developing the objectives and principles of the reintroduction strategy stem from published and empirical scientific information. Reintroduction of fall-run and late fall-run Chinook salmon are important but junior priorities compared to spring-run Chinook salmon.

CALFED Statement of Relevance
The restoration of flows to the San Joaquin River required by the San Joaquin River Settlement contributes to the restoration of multiple fish species assemblages, contributing to CALFED Bay-Delta Program's Ecosystem Restoration Program goals.

SESSION: San Joaquin River Restoration Program: Integrating Science and Management (I), 10/24/2008, 2:20 PM, Room 314

Webb, K., J.S. McLain
US Fish and Wildlife Service, 4001 N. Wilson Way, Stockton, CA 95205
Kim_Webb@fws.gov

Fisheries Management Planning Approach

As part of the San Joaquin River Restoration Program, a Fisheries Management Workgroup was established composed of implementing agencies and consultant representatives. A key task is the development of a Fishery Management Plan coupled with conceptual and qualitative models, monitoring objectives, and an adaptive management plan. Conceptual models will be used to explain in conceptual and qualitative terms how environmental factors are expected to influence the abundance of salmon in the San Joaquin River between Friant Dam and the Merced River confluence. It is the intention that these conceptual models would be used to identify and prioritize limiting factors and restoration actions in a general sense; whereas quantitative models are needed to develop testable hypotheses that would form the basis of an adaptive management strategy for the restoration program. Quantitative models could also help develop and refine quantitative population goals for salmon, assist with the assessment of restoration alternatives, and guide restoration flow and management actions. The conceptual and quantitative models would provide a critical framework for understanding the observed responses of Chinook salmon in the San Joaquin River and provide a means of assessing the relative effects of in river restoration and management actions versus the effects of downstream, Delta, Bay, and ocean conditions.

CALFED Statement of Relevance
The restoration of flows to the San Joaquin River required by the San Joaquin River Settlement contribute to the restoration of multiple fish species assemblages, contributing to CALFED Bay-Delta Program's Ecosystem Restoration Program goals.

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Sun, Y.
MWH Americas, 3321 Power Inn Road, Sacramento, CA 95826
Yung-Hsin.sun@us.mwhglobal.com

Water Management Goal and Real-time Operation Considerations for Implementing Restoration Flow

The Settlement includes two goals: (1) Restoration Goal – To restore and maintain fish populations in good condition in the mainstem San Joaquin River below Friant Dam to the confluence of the Merced River, including naturally reproducing and self-sustaining populations of salmon and other fish, and (2) Water Management Goal – To reduce or avoid adverse water supply impacts to all of the Friant Division long-term contractors that may result from the Interim Flows and Restoration Flows provided for in the Settlement. The operation of the Friant Dam and associated water management plan would contribute to both goals because it is anticipated that the releases would meet the intended biological objectives and fishery management strategy, and at the same time, facilitate water a management strategy to reduce the water supply impacts to the Friant Water Users. The negotiation of the Settlement and the anticipated accomplishments for both restoration and water management goals were based on a 83-year historical hydrology without forecast uncertainties. However, the timing of availability and associated quality of hydrologic forecast would have a significant effect on the strategy for real-time implementation. Exhibit B of the Settlement identifies a set of six hydrographs that vary in shape and volume according to the annual unimpaired runoff of the San Joaquin River at Friant Dam for a water year (October 1 through September 30). The six year types are “critical-low,” “critical high,” “dry,” “normal-dry,” “normal-wet,” and “wet.” According to the year type specification, a prescribed flow schedule would be provided to the river. The remaining water budget is then allocated to contractors based on existing guidelines and additional criteria developed through the restoration program. The challenge of real time operation stems from the availability and quality of hydrologic conditions and resulting adaptation practices for the fishery management and agricultural practice (based on potential contract allocation). Starting from February, DWR published hydrologic forecast information based on snow survey data, and they published monthly updates until May. DWR uses a composite approach to produce 10-, 50- and 90-percent forecasts. The real-time operation could be further complicated by the complex interaction between fishery and environmental factors such as seasonality, river temperature, and other factors. This real-time monitoring information would also trigger an additional adaptive management strategy and thus, part of the factors considered in real-time operation. A methodical and rational approach to real-time operation would be a key element for the success of restoration program as a whole.

CALFED Statement of Relevance
The San Joaquin River Restoration Program Settlement contributes to CALFED Program objectives including ecosystem restoration, the return of flows to a dry river, and improvements in levee stability.

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Mooney, D.
US Bureau of Reclamation, 2800 Cottage Way, Sacramento, CA 95825
dmooney@mp.usbr.gov

Integrated Modeling Strategy

Regular flows to the river will result in changes to the physical and biological characteristics. A modeling strategy provides a platform to evaluate the outcome of different management decisions on resources. The start of the integrated analysis plan identifies the major goals, constraints, physical processes, and relationships between processes. In addition to the Fish Restoration and Water Management Goals, constraints on flood capacity, invasive species, and 3rd party impacts constrain potential decisions. Grouping of analysis tasks resulted in areas of water management, hydraulics, temperature, sediment transport, morphology, groundwater, and fisheries. Each analysis group identified existing information and documented the process of selecting the most appropriate tools and techniques for environmental documents, implementation, and adaptive management. Linkages occur through a combination of coupled models and defined data transfers between groups. The plan does not attempt to capture all possible linkages, but only those considered most important to success. The structure of the analysis plan provides consistency in assumptions, transparency in sources and consumers of information, and flexibility in the ability to incorporate new information and new tools.

CALFED Statement of Relevance
Models developed for the San Joaquin River Restoration Program will be a critical component in the decision-making process and are an example of many of the tools and techniques developed by the CALFED Science Program.

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Israel, J.A., M.R. Stephens, M.R. Baerwald, B. May
UC Davis, 1 Shields Ave, Davis, CA 95616
jaisrael@ucdavis.edu

Genetic Issues for the Reintroduction of Native Fishes on the San Joaquin River

The processes of translocation, natural recolonization, and hatchery reintroduction can each influence the genetic composition in the repatriation of a restoration-targeted population. As part of the San Joaquin River Restoration Program (SJRRP), a decades-long iterative framework will be necessary to provide management feedback on restoration strategies for native salmonids. This will enable a biologically relevant shift from manager-assisted hatchery supplementation to river-facilitated natural reproduction and increase the potential for long-term viability of salmonid populations resulting from the SJRRP. A baseline genetic study of possible source and recolonizing populations of salmonid species of interest will be completed to compare the genetic signatures, diversity, and effective population size of adult stocks possibly influencing reconstitution of San Joaquin salmonid populations. Pre-action consideration of the genetic diversity of suggested source stocks is essential for evaluating recovery scenarios and being able to assess future results in light of likely changes in genetic composition caused by adaptation, inbreeding, hybridization, reduced effective population size or other demographic processes in both source and restored populations. Methods will be developed to determine if recolonizing fish present in the San Joaquin are derived from naturalized (or translocated), hatchery, or admixed broodstocks and easily track genetic changes occurring in these populations. Hatchery Genetic Management Plans and Hatchery Operational Plans will be developed to provide the foundation of information and process by which future genetic research can be incorporated into evaluating long-term viability and success of salmonid population recovery in the San Joaquin. Genetic Monitoring Plans will also become an element of the fisheries management framework in the SJRRP. A monitoring program for all life stages will determine if genetic diversity is maintained when selecting the out-of-basin source broodstock, releasing juvenile cohorts, and finally when spawning returning adults.

CALFED Statement of Relevance
Spring run Chinook salmon and Central Valley steelhead are threatened ESA-listed species and it has been demonstrated that hatchery programs can have negative consequences on wild and hatcheries populations. Genetic research is fundamental to effective monitoring and reducing the uncertainty in adaptive management strategies.

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Leon Cardona, A.
Department of Water Resources, 3374 E. Shields Ave., Fresno, CA 93726
aleoncar@water.ca.gov

Toxicological Considerations in the Restoration of San Joaquin River Salmonids

Salmonid restoration efforts in the San Joaquin River (SJR) will likely be affected by water contamination from diverse sources. Contaminants of concern include aquatic and terrestrial herbicides, urban and agricultural pesticides, trace elements from agricultural activities and other contaminants of natural or anthropogenic origin in the San Joaquin Basin. Poor water quality in the lower reaches of the SJR due to point and non-point sources of pollution will likely affect juvenile salmonids. These contaminant sources can have potential acute, sub-lethal or indirect effects on reintroduced populations of Central Valley salmonids. The Fisheries Management Work Group of the San Joaquin River Restoration Program acknowledges the importance of avoiding adverse effects of contaminants on reintroduced spring-run and fall-run Chinook salmon. Information regarding the exposure of introduced salmonids to toxics are unknown, and the Fisheries Management Work Group is utilizing the best available science in an effort to prioritize the various limiting factors that will impact introduced salmon.

CALFED Statement of Relevance
Efforts to identify and mitigate for contamination of salmonids and other native fishes as a result of the restoration of flows to the San Joaquin River required by the San Joaquin River Settlement contribute to CALFED Bay-Delta Program's Water Quality Program goals.

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