The 2003 CALFED Science Conference: A Summary of Key Points and Findings

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Introduction

The 2003 CALFED Science Conference, the 2nd biennial forum for presenting the latest findings and ideas regarding the Bay-Delta, its watershed, and the adjacent coastal ocean, was held January 14 through 16 at the Sacramento Convention Center.

Nearly 1200 scientists and managers registered for the conference to hear six plenary talks and about 180 technical presentations, and to view more than 100 posters. The attendees came from throughout California (585 from the Sacramento area, 385 from the Bay Area, and 145 from elsewhere in the state), from out of state (44 from 20 states and Washington, DC), and from other countries (one each from Canada, Japan, and the United Kingdom).

The wide geographic range represented by the attendees demonstrates that the quality and scope of the CALFED Bay-Delta Program is drawing attention from far beyond the local community. We expect that the strength of the science behind this huge environmental restoration/water management program, and the unique opportunities provided by these science conferences to learn about the key issues and latest findings, will continue to attract a broad range of scientists and managers to learn from our experiences.

Purpose of the Summary Report

Our purpose in preparing this summary report is threefold. Our primary purpose is to highlight for CALFED managers and scientists that information from the conference that we feel is most pertinent to carrying out the massive CALFED restoration and water management programs. We have attempted to summarize some important points from each of the 18 technical sessions using the abstracts submitted and notes prepared by the session chairs, by rapporteurs recruited by CALFED, and by Jim Eychaner of the US Geological Survey. We summarized the plenary session talks using detailed notes written by Eleanor Ely. We thank all of these individuals for their hard work in creating an important record of the conference. However, we take complete responsibility for the accuracy and emphasis of the final content of this report. The session summaries appear below, and the conference program is provided in Appendix A.

The other purposes of this summary report are to provide recommendations for future CALFED Science Conferences based on our experiences during this and the preceding conference, and to make general programmatic recommendations to CALFED. We also want to acknowledge the hard work and contributions of the many individuals who helped organize and manage the conference.

Recommendations for the Next CALFED Science Conference

The 2000 and 2003 CALFED Science Conferences have provided valuable forums for exchanging scientific information relevant to accomplishing the ambitious ecosystem restoration and water management goals described in the 2000 Record of Decision. We have the following recommendations for the next CALFED Science Conference, scheduled for October 4-6, 2004, in the Sacramento Convention Center.

- The name should be retained. The CALFED Science Conference has name recognition and a certain connotation.
- The format should be similar to the 2003 conference with a plenary session and no more than four concurrent sessions.
- The plenary session should have a mix of presentations from both local and outside speakers. The local speakers could focus on what we have learned from specific courses of action such as, for example, addressing the question, “Are native fishes benefiting from CALFED restoration actions?”
- Papers in the 2004 Science Conference should be balanced between invited (perhaps in special sessions) and those selected from contributed abstracts. Although it is difficult to determine the correct balance, planners for the 2003 Science Conference thought at least half of the papers should be contributed papers.
- CALFED should identify the conference chairs during the summer of 2003, and the conference chairs in turn should select program and poster chairs and planning committee members by early October 2003.
- Active planning for the 2004 Science Conference should begin shortly after the 2003 State of the Estuary Conference, to be held October 21-23, 2003.
- The Call for Abstracts for the 2004 Science Conference, to be issued in spring of 2004, should encourage speakers to identify in their abstracts the relevance of their projects to CALFED goals and objectives.
- The conference co-chairs should periodically (at least every two months and more frequently as the conference approaches) brief CALFED management on plans for the 2004 CALFED Science Conference.

General Program Recommendations

The CALFED Bay-Delta Program is making significant advances in building the scientific foundation needed to select and evaluate restoration actions. That being said, we do have a few general recommendations.

- CALFED should resolve questions about the use of adaptive management. The term is cited widely in reports, proposals, etc., but active adaptive management is little used in practice. Pointing out this dilemma is not meant to be a criticism of the concept or of CALFED's desire to apply it. Active adaptive management is a well-documented concept. But it has been difficult to apply the concept to real situations,

particularly in a heavily managed system that is constantly changing due to human interventions (e.g., water management) and natural events (e.g., climate change).

- The CALFED requirement to include monitoring as part of restoration projects must be augmented to include the requirement to analyze the resulting information, and to make the information and analyses publicly available so that it will be possible for other scientists and managers to assess how well the projects have done in achieving their goals and objectives.
- CALFED needs to develop and implement a baseline environmental monitoring program that will allow scientists and managers to track overall changes in the Bay-Delta watershed system. The monitoring program should include a suite of indicators or performance measures to help managers assess the effects of CALFED actions on species and ecological functions of interest. The baseline monitoring program must include a data management system that provides data storage/access capabilities. This seemingly daunting task is helped considerably by the existence of extensive and long-term monitoring programs that provide information regarding many of the components, constituents, and processes of interest.
- CALFED should continue to solicit and fund thoughtful hypothesis-driven research proposals, including those that emphasize the analysis of existing information.
- CALFED should continue to encourage researchers to make syntheses of their information available through publication in the open literature, perhaps in the new on-line publication series, San Francisco Estuary and Watershed Science.
- CALFED should continue to encourage the use of multidisciplinary approaches to resolving research and management issues, as is being successfully done in the study of the effects of the Delta Cross Channel gate operation on flows, water quality, and fish movement. As an example, there appears to be an opportunity for collaborative work on the sources, fate, and effects of two major environmental contaminants in the system—mercury and selenium.
- CALFED needs to continue to incorporate the results from climate change studies in long-term restoration and water management planning and decision making.

Acknowledgments

A huge effort is required to organize and run these conferences. As with all undertakings of this magnitude, conference organization and management only works successfully when an energetic and knowledgeable team makes it happen. We wish to give special thanks to the program co-chairs, Elise Holland and Larry Brown, and the poster session co-chairs, Anke Mueller-Solger, Bellory Fong, and Bruce Thompson, for their dedication and hard work in making the conference so successful. In addition we recognize and thank the other members of the Conference Planning Committee (see Appendix B for a list of the participants) who, over the one-year planning period, helped bring all the details together. Finally, we thank Joan Patton and Marcia Brockbank (and the staff of the Association of Bay Area Governments and the San Francisco Estuary Project) for the impeccable logistical support that made it such a smooth-running conference. We thank Eleanor Ely and Lauren Buffaloe for editing and formatting the report. Involvement of the

San Francisco Estuary Project is particularly important because its biennial State of the Estuary Conference and the biennial CALFED Science Conference are now closely linked.

Session Summaries

We have organized the session summaries in the same sequence as they appeared in the conference program (Appendix A). Each technical session summary contains a brief introduction to indicate its importance to the CALFED Bay-Delta Program and managers and scientists interested in protecting and restoring Central Valley biological and water resources.

Plenary Session

Sam Luoma (CALFED Lead Scientist and US Geological Survey), Session Chair

The Conference Planning Committee selected six plenary speakers to provide broad perspectives on a variety of topics related to the CALFED Bay-Delta Program. The following are very brief summaries of some important points made by each speaker.

Mary Nichols, Secretary Resources Agency
"The Role of Science in Resolving California Water Policy Conflicts:
CALFED versus Klamath"

No issue is as challenging and complex as the intersection of water resources management and ecosystem restoration. The role of science in managing our state's water resources continues to evolve. The contrasting CALFED and Klamath River projects provide insight into how to, and how not to, manage these huge programs to balance competing interests. The CALFED project is built on decades of work conducted by agency, university, and stakeholder scientists, allowing science to be used in decision making. Most important, great emphasis has been placed on creating a collaborative environment for agency, stakeholder, and academic scientists to work together. In the process, participants are beginning to agree on the questions that need to be addressed. Because managers trust the process, they are eager to make use of the results. In contrast, the science being done on the Klamath project is "interest based," i.e., being done by agencies or interest groups working independently, who then compete with one another in policy development.

Susan Bell, University of South Florida
"Seagrass Restoration Studies in Florida:
Lessons Learned about Site Selection and Monitoring Programs"

Seagrass restoration studies in Tampa Bay, Florida, provide five key lessons that can benefit restoration programs elsewhere. (1) One must be prepared for the unexpected in any restoration project; that is, the amount of effort expended does not guarantee a comparable degree of success in achieving restoration objectives. (2) Reference conditions can be extremely variable, and the selection of reference sites can influence the later

interpretation of restoration success. Multiple reference sites are necessary to provide a more accurate assessment of success. (3) One needs to consider the necessity of re-engineering habitats in order to achieve a successful large-scale restoration project. (4) Long-term monitoring is usually necessary for demonstrating the success and benefits of a restoration project, and this is probably best done by university staff that can make the necessary long-term commitment. (5) The evolution of collaboration among agency, stakeholder, and university scientists is key to a successful restoration program.

Kim Taylor, CALFED Bay-Delta Program
"Beyond California:
Observations on Science in Other Restoration/Water Management Programs"

The large Murray Darling River Basin in the southeast corner of Australia, with many of the same issues facing CALFED (rainy winters, dry summers, water diversion, environmental degradation, "environmental water," salinization, etc.) provides an instructional example of the way others manage such issues. The Murray Darling Basin Commission—an intergovernmental managing body analogous to CALFED—was set up in 1993 to resolve the key environmental and water management problems. The commission structure, with federal and state representatives at all levels and elected legislators from state and federal governments to make it easier to change legislation in response to management needs, has focused on three main policy issues: water diversion caps, salinity management strategy, and environmental flow set-asides. The Murray Darling Basin Program makes effective use of scenario tools, has a policy process structure that considers one issue at a time, and supports long-term scientific investigations in advance of discussing the issues. However, managers are not committed to building knowledge over time. In contrast, the CALFED Science Program has an ongoing investment in knowledge and in assessing the performance of our programs, and we have more effective methods for keeping science and policy separate. But CALFED's time frames are relatively too short for full scientific support of policy discussions, and CALFED has not been as successful as the Australian program in using big-picture scenarios to help guide decision making.

Dan Bottom, National Marine Fisheries Service
"Ocean Conditions, Estuaries, and the Bottleneck Theory of Salmon Management"

In 1875 the first US Commissioner of Fish and Fisheries predicted the demise of the Columbia River salmon runs because of excessive fishing, dams, and loss of habitat. The subsequent cornerstone of salmon management was getting more fish through the earliest life stages. By 1960 hatchery technology was perfected to the point where fish could be released as large smolts ready to go to the ocean. But in 1976 something changed and although more and more smolts were released, fewer and fewer adults returned. Eventually, climatologists identified the Pacific Decadal Oscillation (PDO)—shifts between warm and cool regimes. Under the warm regime salmon survival was greater off Alaska than further south; the reverse was true under the cooler regime. These new findings undermined the earlier production-based assumptions under which fish were managed. More recently there have been two lines of thinking in relation to the

Columbia River estuary: (1) The estuary is unimportant to salmon production because most salmon are hatchery-raised to a large size and do not stay long in the estuary, and (2) the estuary actually is a "bottleneck" making the fish susceptible to predators concentrated near the estuary mouth, requiring hatchery rearing and release strategies that minimize the time young salmon spend in the estuary.

A third, much older line of thinking is that salmon species are composed of isolated, self-perpetuating groups or populations from many different spawning and rearing areas upstream. Thus, to conserve salmon, managers should conserve a diversity of salmon-rearing behaviors in the face of a very uncertain environment; i.e., spread out risks and dampen the effect of variability in the environment. When stock diversity is lost, the ability to dampen out variability is compromised. This is the case in the Columbia River estuary where there are now only three different life-history types with a predominance of fish that have reared upriver rather than in the estuary. Many of these are hatchery fish. The decrease in diversity of the salmon community structure is most likely due to the following factors: (1) hatchery releases now largely drive the composition of juvenile Chinook in the estuary, (2) much estuarine salmon habitat, e.g., tidal marsh, has been lost, and (3) flow regulation at the dams and diking of the tidal river have eliminated overbank flows and the potential for smaller subyearling Chinook salmon to access productive shallow floodplain habitats. In short, the resilience of salmon in an unstable environment depends on a diversity of life-history types, and that diversity is directly linked to variation in habitat opportunities. Because hatchery releases and habitat losses may obscure the true rearing potential for salmon that exists in the estuary, present-day patterns of estuary use by salmon may not be useful in defining restoration goals. In other words, bottlenecks to production at one life stage are not easily separable from those at another, and managing for optimum production may impede resilience and recovery.

Brian Richter, The Nature Conservancy
"The Role of Science in Ecologically Sustainable Water Management"

Three principles are fundamental to ecosystem management: sustainability, ecological goal-setting and adaptive management. If these three things could be done well, and if governing structures could grow up around them and policy initiatives could foster their development, we could move into a new era of water management that would better serve the needs and values of the 21st century. A sustainable approach to water management recognizes that it is necessary to limit the overall alteration of natural patterns of flow in order to maintain flow conditions that are necessary to sustain river health and ecosystem services. In ecological goal-setting, society must decide what it wants a river to be. If the goal is to sustain or restore a high degree of ecological integrity, we may need to retain as much as 75-80% of the natural flow character of the river. If there is willingness to accept some degree of ecological degradation and loss of ecosystem functions, more human use or hydrologic alteration is allowable. The question of sustainability is central to this goal-setting process. The process of ecological goal-setting is a useful mechanism for discussing, debating, and clarifying societal values for river management, and fosters education and awareness in the larger society beyond the scientific community. Scientists have very important roles to play in ecologically sus-

tainable water management, including (1) defining the flow and other conditions needed to sustain desired ecological conditions and (2) serving as educators and communicators to explain to the community what could be gained from improving conditions, and what might be lost from further degradation.

James Cloern, US Geological Survey
"Science in Support of Ecosystem Restoration – A Tribute to Aretha Franklin"

The goals of CALFED's Ecosystem Restoration Program include the recovery of native species, the rehabilitation of ecosystem functions that support those species, and the restoration of habitat that generates those functions. However, we do not know the most effective steps to take because (a) we do not fully understand what factors limit recovery of these species; (b) we do not know which ecosystem functions are critical; (c) we do not know what habitat mixes are most appropriate; and (d) we do not know how multiple interacting stressors impede our ability to achieve the goals.

Three sets of recent discoveries by an interdisciplinary research team may help in the development of a strategic plan for achieving restoration goals. First, laboratory assays and field studies have shown that the most important energy supply fueling biological production in Delta food webs is photosynthesis by phytoplankton within the Delta, not riverine inputs of dissolved or particulate organic matter as earlier suspected. Moreover, analysis of long-term data suggests that the rate of primary production in the Delta has declined in the last couple of decades. Second, the team has found that the Delta is a spatially complex mosaic of interconnected habitats, such that operational actions at one geographic location can influence regional-scale patterns of water flow and water quality across the entire Delta; and regional-scale patterns of variability propagate to other spatial scales, such as within individual flooded islands. Numerical models are a useful tool in helping understand the combined variability in space and time. Third, *Corbicula fluminea*—an introduced species of freshwater clam—plays a large role in shaping ecosystem function of the Delta. Where it occurs in abundance it can remove phytoplankton faster than new biomass can be produced, thereby competing with other animals that are often perceived as more important to the Delta's food web.

All of these findings point to the need to explicitly consider how planned actions to modify the Delta system (e.g., operational actions, barriers, tide gates, and pumps) might affect the phytoplankton food-supply function. Finally, we need to recognize explicitly that the outcome of building new habitats is highly uncertain because we cannot predict whether those new habitats will be colonized by invasive species, the "wild cards" in Bay-Delta restoration. As Aretha Franklin sang in a popular old movie, we need to "think!" We need to think carefully and mechanistically, i.e., through process-based scientific discovery, about how to achieve CALFED's lofty goals.

Helen Ingram, UC Irvine
"The Conflicted Boundaries Between Science and Policy"

Science is important to policy making, but it is a troubled relationship. Good policy has to be justified by science, but policy that is run by science alone, particularly advocacy science, is viewed skeptically by the public. This is particularly the case in California because of the negative impacts that water projects have had on our rivers and because agency representatives tend to downplay the risks involved in proposed projects. The clash between science and policy making often arises because the proponents of each represent different cultures with different rules of behavior and ideas of success. Scientists place emphasis on clear criteria for mastery of the subject matter, precision, expertise, and credentials. By contrast, politicians and policy makers place more importance on procedure, negotiation, compromise, public support, and media attention.

But more than culture is involved. Social scientists refer to the “wicked problems”: those issues that have multiple definitions as to their nature, multiple and conflicting criteria for defining solutions, and no rules for determining when the problem can be declared solved. To resolve these differences, science relevant to water problems must be multidisciplinary and sensitive to different value orientations, i.e., involving a process of discovering and mediating tastes and preferences as well as of finding scientific truth. Three different models are commonly employed in instances of disagreement. The precautionary principle, widely adopted by the European Union, states that lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation. At the other end of the spectrum is a principle of making decisions based on government regulations. The third alternative, adaptive management—loosely defined as “learning by doing”—is an explicit directive to incorporate new and evolving science into natural resources decision making. Management needs are taken into account in setting the agenda for scientific research, and practices are modified in response to the findings of that research. Adaptive management embodying multidisciplinary studies is based on policy flexibility and change, incorporates public involvement, and respects the knowledge of local people. CALFED's Environmental Water Account (EWA) is an example.

Technical Sessions

As mentioned earlier, the sessions are arranged according to the order in which they appeared in the conference program and not in any sense of ecological order or importance. The sessions themselves were organized based on the abstracts submitted in response to the initial call for abstracts.

Function and Effects of Flooded Islands

Lisa Lucas (US Geological Survey), Session Chair

Several of the Sacramento-San Joaquin Delta islands that flooded in the past due to levee breaks have not been reclaimed. Vestigial levees interact with bathymetry, tides, wind, river flow, and diurnal heating and cooling to govern hydrodynamics in and around the islands. The resultant circulation and mixing are different from what would be found in a completely open water body in the Delta. These physical processes interact with biological and geochemical characteristics of the islands to provide a variety of habitats for native and introduced plants and animals.

Flooded islands are important to CALFED in that proposed habitat restoration projects involve filling existing flooded islands or breaching levees to create additional wetland and perennial aquatic habitat in the Delta. Since islands have flooded at different periods during the past century or so, an examination of their physical and biological processes—for example, by the BREACH 1, BREACH 2, and CASTT (Carbon and Selenium Transport & Transformation) studies funded by CALFED—can yield valuable information about the projected evolution of newly flooded islands. The physical configuration of other existing ecologically important open bays, such as Honker Bay, makes these areas behave somewhat like flooded islands in their water circulation and biological properties and provides further insight regarding the potential functioning of Delta flooded islands. Finally, the location and size of the breaches in flooded islands may affect local and Delta-scale water quality.

Key Points

- Delta islands will flood in the future. The existing Delta configuration is not sustainable in the face of continuing levee failures and sea level rise. Islands that remain flooded, including those whose levees are breached on purpose, will contain a mix of introduced and native species, but we are presently unable to predict the composition of the mix.
- Restoration of flooded islands in the Delta requires a detailed understanding of the effects of specific breaches on circulation, mixing, and biological responses. The geometry and location of the breaches are critical determinants of water transport and residence/response time. The physical environment, in turn, governs the eventual biological attributes of the system. We do not, as yet, have a strong predictive understanding of these processes.
- In addition to local breach configuration, physical forcings such as tides, wind, river flow, heating/cooling, and non-local operations (barriers, gates, and CVP and SWP pumping) determine the mix of source waters (and associated sediments, contaminants, nutrients, and biota) in and around a flooded island.
- Mathematical modeling, coupled with field data, is a key tool in helping design the number, size, and location of breaches being considered in restoration projects.
- McCormack-Williamson Tract is an example of shallow water areas that may not necessarily provide useful habitat for native species. Only about 2% of the fish in present flooded island habitats in this area are natives. Submerged aquatic vegetation (SAV) is one of the major determinants of fish population, and in the vicinity of McCormack-Williamson introduced centrarchids (e.g., black bass) dominate in the SAV. Edge and seasonally flooded habitat may be the most hospitable habitat for native fishes.
- In view of the prominent role of invasive species in the McCormack-Williamson Tract area, restoration should perhaps focus on one of two goals: (1) seasonal flooding that could benefit native species, or (2) development of habitat that would benefit birds or other desirable wildlife.

- Phytoplankton has recently been shown to represent the dominant, though limiting, source of organic carbon to the Delta planktonic food web. Studies of one flooded island, Mildred Island, demonstrated the complex nature of phytoplankton dynamics in such islands. Phytoplankton biomass varies considerably in time and space within the island. These findings emphasize the importance of a spatially and temporally comprehensive monitoring program that provides information on the variability of such key ecosystem components as phytoplankton. Typical infrequent and spatially limited sampling will probably be inadequate to understand the key biological processes occurring in these complex but very important habitats.
- Ingestion by an introduced clam, *Corbicula fluminea*, can substantially limit algal biomass and availability to the zooplankton (the fish food). Although this clam has been around for several decades and is abundant in many locations, we are still unable to say if Corbicula will invade a given restoration site. Keystone alien species may dominate ecological functionality in future flooded islands.
- Concentrations, transformation rates, and time scales of variability of nutrients and trace elements vary within flooded islands. The dissolved and particulate forms of selenium cycle quite rapidly in Mildred Island. Compared to other sites in the Delta, Mildred Island sediments are slightly enriched with selenium, and waterborne selenium concentrations are somewhat lower.
- Restoration of flooded islands to tidal marsh will take longer in the Delta than in the Bay because of limited sediment supply; moreover, mudflat consolidation and subsidence counteract accretion of sediments.
- To understand the internal functioning of flooded islands, we must consider their interactions with local adjacent channels and with operations in the greater Delta. Conversely, flooded islands can modify transport processes and distributions of particles and dissolved constituents on the Delta scale. Flooded islands, therefore, are not ecological “islands.”
- The physical, biological, and geochemical function of these islands is complex and site-specific; therefore, greater process understanding is needed.

Adaptive Assessment of Restoration Programs

Jeff Mount (UC Davis), Session Chair

Adaptive management and adaptive assessment, part of the general restoration program lexicon, are often touted as being integral CALFED program components. Active adaptive management is a formal process involving hypothesis formulation and testing (including research and monitoring) and information feedback among scientists and managers. This information is then used to adjust the course of action. Many projects embrace adaptive management but usually in the more passive mode and without the formal rigor required by active adaptive management. In reality there are few restoration projects in the world that successfully incorporate active adaptive management in their restoration strategy.

In this session, the speakers (a) proposed adaptive assessment/management approaches, (b) described information that might be used in such an approach, or (c) described how well CALFED and the Central Valley restoration community are using, or not using, adaptive management/assessment techniques. CALFED scientists and managers need an adaptive management process, or something similar, to help them allocate restoration funds, determine how well the funded projects are helping to achieve restoration goals, and adjust funding priorities (both for the projects themselves and for science needed to assess their benefits and test underlying hypotheses), as CALFED moves toward achieving overall program objectives.

Key Points

- The Cosumnes River Preserve study may provide a useful example/case study of the development of an adaptive assessment conceptual model. In the first phase, project participants used the watershed context, including pre-disturbance conditions, pre-project conditions, and reference conditions, to define restoration goals and project design. In the second phase, research hypothesis testing, data collection, and reference to post-project conditions were used to refine restoration goals.
- One presenter described a conceptual, GIS-based decision support system (IMPACT DSS) that may be used to evaluate a suite of restoration projects within a basin. Although one component of this spatial decision support modeling system includes developing community consensus, the DSS has not been used to date.
- One conclusion from an assessment approach to evaluating the effectiveness of fish restoration actions was that uncertainty regarding the effects of restoration was relatively high; consequently, management confidence in the outcomes was low. The assessment approach being proposed is intended to provide a consistent method of documenting assumptions and identifying the research needed to reduce uncertainty.
- A Bay-Delta Ecological Scorecard is being developed to track ecosystem health using indicators such as habitat extent, species abundance (fish and wildlife), flow, water quality, and human-related perturbations. The scorecard conceptual model needs to be thoroughly reviewed and tested by the scientific community before it can be applied by the broader community.
- CALFED has invested more than $300 million in ecosystem restoration. Program accomplishments include 58,000 acres proposed for protection, 39,000 acres proposed for restoration, 73 fish screens, 16 fish ladders, 10 dam removals, and 75 projects supporting local watershed stewardship and environmental education. A look back at the program indicated that nearly all projects needed better experimental design and project-related monitoring. There was essentially no use of formal adaptive management in the restoration projects.
- A more specific look at the large number of riverine habitat restoration projects on the Merced and Mokelumne rivers and Clear Creek demonstrated that any adaptive management was passive and lacked structure based on sound experimental design. The report from this forum-based approach concluded that the restoration projects

offered “world class” opportunities for scientific study and experimentation and recommended that a scientific liaison team be established to work with project implementation teams to take advantage of these opportunities.

Fish Passage Facilities and Operations

Joe Cech (UC Davis) and Marcin Whitman (California Department of Fish and Game), Session Co-Chairs

There are more than 2200 water diversions in the Sacramento-San Joaquin Delta, including the CVP and SWP intakes in the southern Delta. Most of the diversions are small and move water from Delta channels onto Delta islands to irrigate crops. Except for a few agricultural diversions that are screened as mitigation for SWP project impacts, Delta agricultural diversions are not screened to reduce the number of fish entrained in the diverted water. CALFED and the resources agencies are considering the need to screen many or all of these small diversions to protect listed fish such as winter Chinook salmon and delta smelt.

The CVP and SWP diversions are screened to reduce the numbers of fish entrained. However, the screens were built in the 1950s and 1960s and do not meet many of today's fish-screen criteria. These screens also have problems that may limit their effectiveness in minimizing the impacts of project diversions on fish. For example, the SWP screens are located behind Clifton Court Forebay, and many of the fish entrained into the SWP intake may be lost to predators in the Forebay before they encounter the screens. For these and other reasons, CALFED and the CVP and SWP operating agencies are considering major changes in the design and location of their screening systems—changes that could cost hundreds of millions of dollars.

For several years the Department of Water Resources (DWR) and the US Bureau of Reclamation (USBR) have constructed temporary rock barriers in south Delta channels to mitigate for impacts of pumping on south Delta water levels. In general project pumping can lower water levels during certain periods, and the reduced water levels can adversely affect the farmers' ability to draw irrigation water from Delta channels by siphons. The barriers cause water levels to rise sufficiently to allow the gravity diversions to work. However, the barriers also cause changes in water circulation patterns and may block or impede fish passage. DWR and the USBR are using a combination of field data collection and modeling to assess the effects of barrier installation and operation.

Key Points

- Fish-friendly pumps (Archimedes screw and Hydrostal) can efficiently move fish with minimal or no damage or post-test mortality. These pumps are being considered for use in new fish-salvage facilities at the CVP and SWP intakes.
- Existing louver screens at the CVP may be able to successfully screen adult and juvenile delta smelt, although high screening efficiencies may depend on debris-free screens—a condition that is difficult to achieve in an area subject to floating and submerged weeds. (In particular, the water hyacinth, *Eichornia crassipes*, and the com-

mon waterweed, *Egeria densa*—both introduced—cause major screen-cleaning problems.)

- In laboratory tests, delta smelt encounters with the surface of fish screens, even at low approach velocities, were often injurious and potentially lethal. These results emphasize the difficulty of protecting this fish at diversions under the water velocity conditions tested.
- Comparisons of the results of laboratory and field fish-screen studies with juvenile Chinook salmon indicated that the fish responses were similar in both situations, leading to the conclusion that laboratory studies (under controlled conditions) provide useful information for fish-screen design and evaluation.
- Results using a test flume in Denver and an individual-based model (Fishsim) supported the use of a combined laboratory and modeling approach to evaluating fish behavior along the face of a fish screen. Adult Sacramento splittail and juvenile rainbow trout exhibited rheotaxis (i.e., swam against the flow along the screen face). The updated model may be able to help us understand the energetic requirements of fish exposed to various screen configurations.
- One of the results of an investigation in the vicinity of a physical barrier installed at the head of Old River (installed each spring to help protect juvenile salmon emigrating from the San Joaquin system) was the discovery of a strong recirculation zone immediately downstream of the barrier, located above a deep scour hole along the bank of the San Joaquin River. The speaker postulated that, due to the strong currents associated with the zone (demonstrated by a surface drifter being temporarily below the zone's surface), these areas may provide opportunities for increased predator effectiveness.
- Mathematical modeling results suggested that auxiliary pumping over a rock barrier that may be installed some years in Grant Line Canal can improve dissolved oxygen concentrations in the Stockton Deep Water Ship Channel (DWSC). Dissolved oxygen concentrations in the DWSC are often below standards designed to protect cold water fish.
- A study of entrainment in an agricultural diversion on Sherman Island, using paired screened and unscreened siphons, showed the following: entrainment is generally higher at night; entrainment is tidally affected; fish behavior and distribution have more effect than near-field hydrodynamics; screened diversions reduce entrainment to less than 1% of that seen in a comparable unscreened diversion; and laboratory studies and particle-tracking models probably overestimate the threat to resident fish posed by agricultural diversions in the Delta.

Effects of Non-Native Invasive Species

Kim Webb and Erin Williams (US Fish and Wildlife Service), Session Co-chairs

For more than 150 years the San Francisco Estuary and its watershed have been the recipients of numerous non-native plant and animal species, from the intentionally introduced East Coast oysters (including a host of other organisms attached to the oyster

shells) in the 1850s and the striped bass in the 1880s to the accidentally introduced Asian clam, *Potamocorbula amurensis*, in the 1980s. These invasions have been so numerous and successful that the San Francisco Estuary has been characterized as one of the most invaded estuaries in the world.

Many of these invasive organisms have dramatically changed Bay-Delta trophic (energy exchange) relationships. For example the introduced striped bass has long been the top-level carnivore in the northern estuary. The Asian clam, by consuming phytoplankton and small zooplankton, has altered the food web in the San Pablo and Suisun Bay complex. Others, such as the water hyacinth and the common waterweed, may affect the ability to divert water by clogging fish screens and pumps and impeding movement of boats in Delta channels.

In recent years, state, federal and local agencies have recognized the threat posed by non-native invasive species and have taken actions to limit the invasions and control established invaders. In spite of these actions, old and new invaders continue to affect the ecosystem, and it is likely this threat will persist for the foreseeable future.

Key Points

- The typical characteristics of successful invaders include flexibility, high tolerance for variable physical conditions, opportunism, broad dietary requirements, high fecundity, and early maturation. Our system will likely continue to support the establishment of invasive species and will incur significant impacts from them.
- An important native marsh grass, *Spartina foliosa*, is being destroyed by the exotic species of the same genus, *S. alterniflora*, *S. anglica*, and *S. patens*, partly by hybridizing and partly by crowding out the native grass. (The primary impacts thus far have been attributed to *S. alterniflora*.) The impacts of the invasive grasses (all of which were purposefully planted as part of early restoration projects) put all new restoration projects at risk. In one case, a California species of special concern—the Alameda song sparrow, *Melospiza melodia pusillula*—was not found in habitat colonized by invasive Spartina but was found in habitats where native Spartina occurred. In addition, S. alterniflora alters habitat structure and composition to the extent that the highly competitive and predatory marsh wren has become attracted to the historical habitat of the song sparrow.
- An introduced and now well-established carnivorous copepod, *Tortanus dextrilobatus*, appears to have an extremely high predation rate on native copepods. Modeling the rate of predation indicates that the potential predation impact may be significantly changing food web dynamics.
- Although there is general agreement that the introduced Asian clam has dramatically altered the food webs in San Pablo and Suisun bays, there is as yet no definitive evidence that the altered food webs have adversely affected fish abundance. However, we do not know if the change from a plankton-based to a benthos-based food web reflects a permanent change to lower system productivity.

- The diet of the introduced Chinese mitten crab (*Eriocheir sinensis*) overlaps with the non-native, but long established, freshwater crayfish (the introduced *Procambarus clarkia*) in Coyote Creek, Santa Clara County. The mitten crab occupies a much higher trophic level and is able to successfully use a wide variety of food resources in freshwater and tidal habitats.
- In the Cosumnes River watershed and other foothill streams an introduced fish, the redeye bass, dominates the middle reaches of the river. The bass affects native trout populations by competing for food resources, preying on juvenile trout, and inducing behavior changes in adult trout.
- In a somewhat counterintuitive finding, early results from a two-year field study indicated that continuous seasonal (October-June) cattle grazing in vernal pool grasslands reduced the cover of exotic (non-native) plant species compared to ungrazed treatment plots and thus promoted native species richness and cover in vernal pools and the adjacent grasslands. In vernal pool grasslands where cattle have grazed historically, cessation of cattle grazing may have detrimental effects on the cover and richness of native species in the vernal pools and grasslands.

Riparian Restoration

Greg Golet (The Nature Conservancy), Session Chair

Before the Gold Rush, most Central Valley streams had an extensive riparian canopy along stream margins. Leaf and insect fall from this canopy provided a significant food contribution to the streams, the shade ameliorated water temperatures, the riparian forests provided important habitat for a variety of native species, and the trees and their root structure helped minimize erosion.

As befell riverine floodplains, flood control and other human-related factors have reduced riparian forests and affected ecosystem function. Many CALFED environmental protection actions are designed to maintain or enhance the remnant riparian forests. These activities must balance environmental concerns with human safety and welfare concerns. As in all restoration projects, pre- and post-project monitoring is essential in assessing the stability (or progression) of newly created riparian habitat and its ecosystem benefits.

Key Points

- There is evidence (from historical data and extrapolations) that Native Americans may have actively managed the riparian corridors. This management (pruning and tending certain plants such as white root to provide a reliable supply of material for basket making) may have yielded a more open understory than would have existed naturally.
- Soil carbon and soil density show promise as measures to gauge restoration success.

- In a managed system such as the Tuolumne River, seed germination of pioneer riparian tree species and the flood pulses needed to help ensure germination are no longer in synchrony. These species were adapted to germinate during the peak period of snowmelt, not in response to releases from reservoirs.
- A 1997 flood caused the breach of levees and yielded new stands of seedling black willows and Fremont cottonwood at the San Joaquin National Wildlife Refuge (near where the Tuolumne River empties into the San Joaquin River). Recent dry years and bark stripping by native and introduced rodents have caused many of the seedlings to die.
- The results of Valley Oak restoration on the Cosumnes River Preserve show that planners must consider two types of habitat, upland and riparian, when considering restoration projects. In some of the drier areas, irrigation should be considered to get the seedlings off to a good start.
- Analyzing 60 years of aerial photography proved to be a useful way to chronicle the meandering ways of the Sacramento River and could guide future restoration efforts.
- Floodplain modeling also can provide a useful means of considering riparian restoration projects. One model result, which was expected from intuition, is that the best predictor of riparian conversion is the length and magnitude of the spring flood. Using bird count data, it appears that riparian restoration will benefit some, but not all, targeted avian species.

From Mining to Microbes: Unraveling the Mercury Cycle in the San Francisco Bay Watershed

Mark Marvin-DiPasquale (US Geological Survey), Session Chair

Mercury mines have operated in many watersheds of the Coast Range, such as Cache Creek, for more than a century. During the Gold Rush, much of the mercury (from cinnabar, HgS) from these mines was used in the Sierra Nevada for extracting gold from the ore. A considerable quantity of the mercury used in gold extraction was lost to mountain and foothill streams and a lot of it eventually found its way to the estuary. Some of the mercury from those mines continues to enter the Delta and estuary from natural sources and from mine runoff into mountain streams and is found in Delta and Bay sediments.

Mercury is often transported in the less toxic inorganic phase, but can be converted by microorganisms to methyl mercury, a toxic compound that has become distributed in the estuarine and terrestrial food webs. As a result many of the game fish in the Delta contain sufficient mercury to be a public health concern. One concern is that CALFED restoration activities, including dredging and sediment movement, may increase the methylation rate and concentrations of mercury in the fish and birds.

The session focused on quantitative estimates of mercury and methyl mercury concentrations and transport loads at representative sites and biota throughout the Bay-Delta watershed. These estimates contribute to the understanding of mercury movement

through the aquatic and biological systems, with the eventual goal of quantifying the total flux of this element.

Key Points

- Mercury bioaccumulation is generally lower in the Central Delta and higher both upstream in freshwater and downstream in the lower estuary. This regional pattern is consistent across several ecosystem components and biota. However, sediment concentrations of mercury were often higher in Central Delta sites.
- At each scale of study, including Sierra reservoirs, Cache Creek, and wetlands in the Delta, mercury transport is not conservative, probably due to deposition and settling of mercury-rich sediments. We will need better understanding of the transport processes before we can predict the effects of restoration and propose remediation measures.
- Much of the mercury-budget data was collected during two relatively dry years and may not be representative of other water conditions.
- Methyl mercury production was highest in the top 0-4 cm of submerged sediments with variable degradation of methyl mercury at depths in the sediments. Methyl mercury production seems to be tied to sulfur and carbon biogeochemistry, with net methyl mercury production highest in moderate sulfur-reducing environments.
- 60% to 90% of the sportfish (largemouth bass, channel catfish, white catfish, and striped bass) from the Central Delta contained more than 0.3 ppm Hg, the human health screening level. Fish collected around the periphery of the Delta were more contaminated than those from the Central Delta.
- An increase in methyl mercury (as percent of total mercury) was observed moving up the food chain from herbivores to top predators. There was also a strong positive relationship between water column mercury and body burdens of mercury in invertebrates and small fish.
- Several avian species across the estuarine system exhibited high mercury levels in their eggs. In one instance, the failure of endangered clapper rail eggs to hatch may be linked to high mercury concentrations.

Recent Research on California Salmonids

Ken Lentz (US Bureau of Reclamation), Session Chair

Four races of Chinook salmon and steelhead rainbow trout (collectively called salmonids) inhabit Central Valley streams and use the Delta and San Francisco Bay as rearing and/or migratory habitat. All five fish are anadromous in that they spawn in freshwater and the young move to the ocean where they grow to adults before returning to their natal streams to spawn. All Chinook salmon die after spawning but some steelhead survive to repeat the cycle one or more times. The four salmon races—winter, spring, fall, and late-fall—have different life-history patterns and, as a result, adults and juveniles may be passing through, or residing in, the Delta almost every month of the year. (The

exceptions are July and August when few salmonids are found in the Delta.) All races have significant hatchery programs designed either to produce fish for the ocean and freshwater fisheries (spring, fall, and late-fall Chinook) or to supplement natural production in an attempt to restore the run (winter Chinook).

Winter Chinook is listed as endangered and spring Chinook as threatened pursuant to the state and federal endangered species acts, and the fall and late-fall races are candidate species under the federal Endangered Species Act. Steelhead is listed as threatened under the federal ESA. The 1992 Central Valley Project Improvement Act (CVPIA) has provisions to double the naturally spawning populations of these salmonids compared to levels in a specified base period.

Through CALFED's Ecosystem Restoration Program (ERP), the Science Program, the Interagency Ecological Program (IEP), and other organizations are funding and supporting studies to better understand the life histories of these organisms and to identify bottlenecks to their restoration. Through the ERP, CALFED is working to use multiple funding sources (including CVPIA funds through its Anadromous Fish Restoration Program and DWR and USBR mitigation funds) to restore salmonid habitat and understand salmonid life histories.

Key Points

- Steelhead in the Feather River spawn near the barrier dam but the young disperse downstream somewhat during rearing. High densities occur in side channels with thick riparian cover.
- The Livingstone National Fish Hatchery's winter Chinook program has apparently resulted in a net increase in the numbers of returning adults, although more adult hatchery fish than wild population fish are returning after two years. Genetic analysis of tissue samples collected from spawning surveys indicates that the effective number of breeders is now in excess of the critical minimum number needed to maintain genetic variability.
- Gravel permeability appears to be related to egg survival and should be considered as a measurement variable when evaluating the benefits of stream gravel restoration projects.
- Over the past several years, escapement of spring Chinook to Butte Creek has been far higher than to other streams. Recent tagging, screw trap, and escapement studies have indicated that ocean commercial and recreational harvest is relatively high; that the majority of the juvenile spring Chinook leave upper Butte Creek in January through March and rear in downstream areas such as Butte Sink and Sutter bypass; and that snorkel surveys seem to underestimate the numbers of spawners as compared to carcass surveys.
- Screw trapping at the Red Bluff Diversion Dam over a 5-year period allows for making estimates of the numbers of juvenile winter Chinook exiting the spawning grounds and for better understanding their movement into rearing areas in the lower river.

- Radio-tagging studies of juvenile salmon released at various sites in and around the Delta are increasing our understanding of movement patterns. These studies indicate that flow conditions at flow splits influence salmon movement and that there appear to be predation “hot spots” in the Delta.
- DNA analyses suggest that Central Valley hatchery fish are mixing with local stocks in the Santa Clara watershed but not with Russian River stocks.

Wetlands: Past, Present and Future

Peter Green (UC Davis), Session Chair

Historically the Bay-Delta system was surrounded by wetlands ranging from seasonal to tidal. These diverse habitats represented a complex ecosystem that supported a wide variety of plants and animals. The extensive wetlands also acted as sediment traps, and runoff containing the decomposition products of organic material growing in the wetlands contributed to overall system food webs.

Over the past 150 years, wetlands around the Bay/Delta have been reduced by 90%, and this loss has affected the structure and function of the Bay-Delta ecosystem. Through many of its programs, CALFED is seeking to protect relict wetlands, to restore other areas to wetland habitat, and to understand the importance of wetland habitat and the effects of restorative actions. Wetland protection and restoration are complicated by such factors as the presence of non-native invasive species and the effects of urbanization and farm practices, including encroaching urban development.

Key Points

- Sediment yield to the estuary decreased by about half during the period 1957-2001. Because the major forces that govern sediment supply, i.e., retention behind dams and erosion resulting from increased urbanization, are competing, it will be difficult to predict whether the observed trend will continue. However, because of the critical importance of sediment supply to wetland maintenance and restoration, it will be essential to incorporate a good understanding of sediment dynamics into long-term restoration planning.
- A 5-year study of marsh elevation changes at 13 sites located in the north, central, and western Delta showed that trend lines are variable—from positive at Prospect West (north) to negative at a Sherman Island restoration site (west). Compaction can play an important role in elevation changes and its impacts must be considered by restoration planners. Also, mineral soils should be used in most restoration projects. In another talk the presenter observed that landscape position can strongly influence sediment supply and monthly higher spring tides can account for much of the local sediment loading. Finally one speaker used studies of two sites (one in Suisun Marsh and the other along the Napa River) to show that plant biomass productivity (both above ground and in the root system) can maintain marsh elevation in the absence of sufficient sediment supply and concluded that the relationship between biologic and geomorphic processes is not accounted for in current conceptual models.

- A comparison of fish and invertebrate populations in pristine (along the coast) and restored (McNaby Marsh near Martinez) marsh sites indicated that restored marshes (with ponds and open access to the channels) can support a complex and robust assemblage of organisms.
- In a study of effects of boat wakes on levee erosion, erosion was two times greater at chronic erosion sites than at sites in stagnant water (control sites with little or no boat traffic). It appears there is a small but measurable bank-stripping rate due to individual boat wakes. Overall the analyses demonstrated that there is considerable variability in erosion rates from site to site and numerous processes contribute to erosion.
- Preliminary results from a study of the effect of flooding on carbon storage on Twitchell Island indicate that shallow water treatments might provide significantly greater carbon storage (and less subsidence) than deeper water treatments. Extrapolating these results to the entire Delta indicates that about one-third of the Delta islands would have to be flooded to compensate for existing carbon losses (through decomposition of organic soils) to the atmosphere. It must be cautioned that additional work is needed to show conclusively that wetland restoration on Delta islands will halt or slow subsidence.
- A comparison of the vigor of three *Scirpus* species planted at a site in Georgiana Slough indicated that *Scirpus californicus* did best and was the most tolerant. Overall the study indicated that *Scirpus* species provide good habitat, wave attenuation, and levee protection and can improve water quality. Another study of *Scirpus*-dominated marshes indicated that, for restoration, a mix of species over an area of heterogeneous topography is beneficial; the success of vegetation reestablishment is dependent on initial plant selection; and restoration planners need access to information on the biology, ecology, and management of potential species to be planted.

River Channel Restoration

G. Mathias Kondolf (UC Berkeley), Session Chair

Projects to restore river channels have been under way since before the establishment of CALFED. Below large dams, depletion of sediment supply from upstream has led to coarsening of bed to cobble often too coarse for spawning. In some streams floods have been so reduced that fine sediment has accumulated in the gravel, thus reducing interstitial water flow. Gravel mining has further degraded salmonid habitat by removing spawning beds and creating habitat for exotic fish species—warm water fish that prey on young salmonids. These changes have often degraded the gravel and the river channels themselves to the point that successful salmonid spawning, egg and alevin survival, and the quality of rearing habitat were compromised.

Projects to restore salmon-spawning habitat in the Central Valley have included injecting gravel directly into the channel, constructing riffles, and rebuilding the banks to isolate the channel from adjacent gravel pits. Some recent river channel restoration projects were funded through DWR's 1986 program to mitigate for the installation of four additional pumps at its Delta pumping plant (the 4-pumps mitigation agreement). Other

projects were funded through the CVPIA's Anadromous Fish Restoration Program, sometimes in combination with the 4-pumps agreement funds. The US Bureau of Reclamation's Delta pumps mitigation program also entered into the funding mix. Since formation of CALFED, it has been the major funder and coordinator of such projects.

Although many projects are simple in concept, evaluating their long-term usefulness is less simple. For example, gravels used to reconstruct an important salmon-spawning riffle may be washed out in subsequent high flows. This session was organized to examine some river channel restoration projects to help determine their benefits to salmonid recovery and ecosystem restoration.

Key Points

- Examination of 68 gravel-augmentation projects completed during the period 1978–2001 revealed that such projects need better documentation, post-project evaluation, and monitoring and evaluations that are based on biological and physical features of the new habitat. Available evidence suggests that gravel injection is cheaper and more effective than riffle construction but requires high flows to distribute the gravel. Riffle construction can yield habitat in the short term but may require costly rebuilding every 5 to 10 years.
- The results of computer modeling of the Sacramento River mainstem, used to evaluate the impact of gravel-augmentation projects on sediment flux, suggested that the costs of such projects could be reduced by using larger gravel and by adding the gravel in sections of the river with active transport.
- One interdisciplinary approach to rehabilitating salmon-spawning habitat is a "spawning gravel integrated approach" involving four modes interactively applied: conceptualization, scientific exploration, data collection, and modeling. Using this approach the participants showed that gravel entrainment and good spawning habitat do not necessarily overlap and that geomorphological information is important in project design.
- Other important riverine habitat includes floodplain water bodies, such as oxbow lakes, which may have high species diversity. Research indicated that sedimentation in oxbow lakes in the mainstem Sacramento River was higher than in similar lakes reported in the literature. Restoration of dynamic channel migration and meander cutoffs, and development of new bends (through high flows and removal of riprap), are needed to maintain the physical form of these important habitats, and treatment or diversion of agriculture runoff may be needed to maintain or improve water quality in these areas.

Effects of Natural and Anthropogenic Processes on Water Quality

Brian Bergamaschi (US Geological Survey), Session Chair

Although specific water quality issues may differ, disparate investigations are frequently linked by common natural and anthropogenic causes of water quality degradation. Thus,

it is useful to examine regional water quality issues together and to explore linkages between them, as was done in this session.

One water quality issue addressed was the dissolved oxygen (DO) depletion in the Stockton Deep Water Ship Channel (DWSC), which impedes the passage of migratory fish. It is commonly thought that natural and anthropogenic oxygen-consuming materials are added into the San Joaquin River at upstream locations, and then transported by river flow into the DWSC.

Key Points Regarding DO Depletions in the DWSC

- According to model results, low DO conditions are caused by the interplay of low flow, elevated temperature, bathymetry, and import of algal materials, but might be ameliorated by restoration of San Joaquin River flow to 1000 cfs during critical periods, and reduction of algal loads by 10% to 25%.
- Chemical and biological evidence suggest that most DO consumption results from nitrification of ammonia as opposed to the re-mineralization of organic material, as has been previously reported.
- Isotopic evidence indicates that the nitrate in the San Joaquin River and DWSC that supports algal production has an animal-waste or sewage source, in contrast to the findings from some previous investigations that suggested it was derived from fertilizer sources.
- Additional collaborative work is necessary to establish the causes of DO consumption during critical periods, and to identify potential remedial measures.

A separate water quality issue addressed in this session was the release into Delta waters of dissolved organic carbon (DOC), commonly thought to be introduced with peat island drainage and often problematic because DOC forms carcinogenic compounds when water is chlorinated for potable use. As wetland restorations are contemplated on Delta peat islands, it is important to understand how the siting and operation of the restorations will affect DOC concentrations in Delta waters.

Key Points Regarding Release of DOC into Delta Channels

- Both modeling and chemical evidence suggest that the majority of DOC found in Delta waters under current conditions is derived in the rivers upstream of the Delta, in agreement with a previous mass-balance study.
- Also according to model and chemical evidence, the amount of DOC added in the Delta under current conditions varies seasonally, the greatest amount being added in the winter.
- Chemical evidence suggests half or more of the DOC added in the Delta under current conditions is derived from wetlands.

- Siting, historic soil conditions, and water management practices of restored wetland systems will have a large impact on DOC release from restored wetlands.
- Although the issue is not completely resolved, it appears that converting large areas in the Delta from agricultural to wetland use could result in an overall increase in organic carbon reaching the export pumps.

Trophic Ecology of the Bay-Delta and Its Watershed

Larry Brown (US Geological Survey), Session Chair

This diverse session encompassed reports on a range of studies regarding energy transfer from one portion of the food web to another. A simplistic example of a food web is as follows: microscopic plants growing in the water column (phytoplankton) are eaten by small barely visible animals swimming in the open water (zooplankton), which are in turn eaten by small fishes, which are in turn eaten by larger fishes (piscivores). Although humans are normally interested mainly in the top-level predators such as striped bass and largemouth bass, restoration ecologists must consider the complex food web when evaluating restoration options and assessing the benefits of restoration activities.

Given the magnitude and cost of the restoration actions being considered by CALFED, the seemingly esoteric topic of trophic ecology is of vital interest. A telling example involves the effects of the Asian clam, *Potamocorbula amurensis*, apparently accidentally introduced into the Bay-Delta system from China about 1986. This bottom-dwelling organism feeds by filtering phytoplankton and zooplankton from the overlying water column. There are now so many of these clams in portions of Suisun Bay, for example, that this organism may have changed the trophic ecology of this ecologically important area from one in which young fish feed mainly on planktonic (free-floating) organisms to one in which most of the food is concentrated on the bottom. Actions to restore fish that feed in the open water thus may be thwarted by changes in food availability. In addition the bottom-dwelling clams are more likely to concentrate contaminants and, when eaten by fish and birds, pass these contaminants up the food web.

Key Points

- The session served as a reminder of the complexity of food web interrelationships in the San Francisco Estuary and its watershed, and how little we know about them. In spite of the inherent complexity and poor understanding, restoration ecologists must consider trophic relationships when recommending, implementing, and evaluating restoration measures. The session also demonstrated the variety of field and laboratory techniques needed to study ecological relationships at spatial scales ranging from individual zooplankters feeding on planktonic algae to the abundance, species composition, and distribution of phytoplankton over the estuary.
- Periodically, phytoplankton production in the estuary may be reduced as a result of high ammonium (the dissolved form of ammonia) concentrations, presumably derived from sewage treatment plant effluent and agricultural runoff, because of the inhibitory effect of ammonium on phytoplankton uptake of the essential nutrient nitrate. This

finding is particularly important in view of recent findings that the estuarine food web is based largely on phytoplankton growing in the estuary, not on the breakdown of organic materials entering the estuary from upstream as previously assumed.

- Studies of the trophic ecology of the Cosumnes River and streams in the Santa Clara Valley watershed showed that the stream invertebrate populations (mostly aquatic insects) were most closely associated with landscape-level features such as elevation. Although these aquatic invertebrates are important food for fish during a part of their life cycle, consumption by fish apparently had little effect on stream invertebrate populations in the Cosumnes River watershed.
- Using stable isotopes, one investigator found that the several microhabitats within a single marsh supported distinctly different food webs. Thus, the ecological benefits of marsh restoration may need to be evaluated in terms of the relative amounts of each microhabitat created.
- Analysis of about three decades of seabird productivity and food habit data from the southeast Farallon Islands indicated that these data may help shed light on the effects of changing ocean conditions, that in turn affect food availability, on such fish as Chinook salmon and Pacific herring.

Floodplain Restoration

Anke Mueller-Solger (California Department of Water Resources), Session Chair

Central Valley streams have lost many of the seasonal floodplains that existed prior to the Gold Rush. Many of these streams are now confined to relatively narrow channels with flood bypasses to bleed off the larger flows. Dams on most of the major streams also modulate flows and reduce flood frequency.

The loss of floodplain habitat has adversely affected many of California's native fish species, in particular those that use flooded vegetation in the spring for spawning. The bypasses themselves (Yolo and Sutter) do replace some of the lost habitat. The Cosumnes River, which is not dammed, provides some idea of what things might have been like before the arrival of European settlers.

Key Points

- Recreated floodplain habitat is good for native fishes because it provides a diversity of resources. Research results to date suggest that manipulation of the period of flooding (for example, flooding between late February and April and draining by mid-May) can benefit native species and limit use by alien species.
- Results from the Cosumnes River floodplain show that while there are more food resources for fish within the forested portions of the floodplain, fish hardly use these resources. To maximize benefit to fish, restoration projects in the floodplain should enhance forest-floodplain connectivity.

- The growth potential for zooplankton is higher in floodplains than in adjacent rivers, and higher in natural floodplains (for example the Cosumnes floodplain) than in constructed floodplains (for example the Yolo Bypass), most likely because natural floodplains provide more sources of nutritious organic matter that support zooplankton growth.
- Even modest improvements in floodplain habitat connectivity (higher residence times, increased surface area, shallower water, lower water velocities) can enhance the value of the floodplain habitat for salmon.
- A comparison of engineered perennial ponds (broad, flat, shallow) versus natural ponds (smaller, deeper, and surrounded by levees with trees) in the Yolo Bypass showed that fish abundance and diversity were highest in the engineered ponds. All ponds contained 95% to 97% alien species. The results suggest that restoration should focus on seasonal flooding—not on creating ponds.
- Hydrodynamic models of floodplain flows can help integrate flood management and environmental enhancement.
- Evaluation of historical information (maps and photos) can be a useful tool in watershed management by providing a template for restoring natural form and function to watersheds.

Delta Cross Channel

Bruce Herbold (US Environmental Protection Agency), Session Chair

The US Bureau of Reclamation constructed the gated Delta Cross Channel in the early 1950s to help move water from the Sacramento River near Walnut Grove to the interior Delta and Central Valley Project pumps in the southern Delta. Until required by the 1992 winter-run Chinook salmon biological opinion, the manually operated gates were kept open during most of the year if flows in the Sacramento River were below about 25,000 cfs. The gates were closed during higher flows to reduce the risk of flooding to interior Delta islands.

Juvenile salmon survival studies, initiated in the Delta by the Interagency Ecological Program in the 1970s, indicated that the Cross Channel posed a threat to Chinook salmon emigrating from the Sacramento River. Juvenile salmon entering the Cross Channel had a lower survival to Chipps Island (downstream of the Delta) than those fish that remained in the Sacramento River. The results of these studies led to the present gate-operating criteria; i.e., the gates are closed each year from the first of February to the end of May and can be closed for up to an additional 45 days at the discretion of the resource agencies, from October 1 through the end of January. The fall/early winter closures are to protect spring-run yearling Chinook and other emigrating salmonids.

Gate closures during periods of low Sacramento River flow, combined with moderate to high CVP and SWP exports from the southern Delta, can degrade water quality in the interior Delta. This situation creates the possibility that environmental protection measures (closing the gates to protect salmonids) can create water quality problems at the

CVP, SWP, and Contra Costa Water District intakes. In 1999 gate closures to protect salmon and high pumping rates resulted in violation of Delta water quality standards. However, water project engineers were not able to define the exact water quality effects of various periods of gate closure and project pumping levels.

In 1999 an interagency, interdisciplinary team was created by the IEP to use modern flow-measurement and salmon-monitoring techniques to examine questions surrounding the movement of water and fish in the vicinity of the Delta Cross Channel and associated effects on water quality elsewhere. As the studies expanded over the next few years they began to look at the effects of gate operation on flows and fish movement in other channels including Georgiana, Sutter, and Steamboat sloughs.

Key Points

- With the gates open and at river flows below about 20,000 cfs, tidal dynamics produce dramatic changes in the direction of flows near and into the Cross Channel, with almost no water entering the channel during the ebb.
- Because of the momentum and configuration of the river and sloughs near the Cross Channel, much of the sediment suspended in Sacramento River water moves past the Cross Channel intake into Georgiana Slough.
- The use of hydroacoustic monitoring (basically bouncing sound waves off fish and recording the strength of the return signal) has demonstrated that movement of fish emigrating past the Cross Channel intake reflects a complex interaction among tides, flows, and fish behavior. For example, at night the young salmon are high in the water column and near the center of the channel and move more like sediment. However, during the day the fish are closer to the bottom and the sides of the channel and not as subject to hydrodynamic influences.
- A combination of trawling and hydroacoustics led to the conclusions that the young salmon move mainly at night, generally orient with the highest net flow velocities (which may take them into the Cross Channel), and exhibit somewhat random movement during tidal changes.
- Radio tagging (fitting juvenile salmon with small internal or external transmitters and antennae and tracking the fish movement by boat- or shore-mounted receivers) indicated that fish behavior (diel changes in location in the water column and movement) may cause fish to move much differently than would be indicated by three-dimensional models of the flow field.
- With the gates closed, large numbers of emigrating salmon can be entrained into Georgiana Slough. Taking this route through the interior Delta to the western edge of the Delta (as compared to remaining in the mainstem Sacramento) increases juvenile salmon mortality.
- Operation of the Cross Channel gates affects flows into Sutter and Steamboat Sloughs, and potentially juvenile salmon movement and survival as well.

- Studies of the effects of gate operation on water quality (mainly salinity) in the interior Delta indicated that gate operation is a third-order factor influencing water quality. First- and second-order factors include antecedent flows and the spring-neap tidal cycle. Other factors include pumping, wind, and barometric pressure.
- Sonic-tagging studies (similar to radio tagging) with adult Chinook salmon indicated that the Cross Channel can be an important pathway for adults moving toward the spawning grounds. Migratory pathways are complex and the fish may take from a few days to several weeks to move through the Delta. Gate operation (open all the time or half the time) appeared to have no effect on the pathway adults took to traverse the Delta.
- In light of the regional impacts that operation of the DCC gates appears to have on flows, the Cross Channel Team plans a more far-ranging effort in 2003. In particular, the team hopes to be able to use radio-tagged salmon and hydroacoustics to determine the relative proportions of fish going through Sutter and Steamboat Sloughs, into the Cross Channel or Georgiana Slough, and those remaining in the mainstem Sacramento. They would like to examine these splits under different flows and Cross Channel gate operations.

Selenium and Salinity in the San Joaquin River and Delta

Mary Menconi (Central Valley Regional Water Quality Control Board), Session Chair

Selenium. Previous studies have shown that most of the selenium in the estuary is derived directly from agricultural runoff from the west side of the San Joaquin Valley (via the San Joaquin River) and from oil refinery wastes discharged near the Carquinez Strait. At low levels selenium is an essential element, but it can be toxic at higher levels, and tissue concentrations can magnify in different trophic levels in the food web. As a result of concerns about selenium toxicity, actions have been taken in the San Joaquin Valley and at Bay refineries to reduce the amount of selenium being discharged to the estuary. The session presenters mainly discussed the fate and environmental impact of selenium in the estuary.

Key Points Regarding Selenium

- Modeling results indicate that increased selenium loads from the San Joaquin River would increase the level of particulate selenium in San Francisco Bay to concentrations that could be problematic for higher trophic levels. Although not specifically included in the model, there appears to be significant selenium removal within the Delta.
- Selenium levels in Delta food webs are lower than those observed in Suisun Bay and do not exceed toxicity thresholds. In the Delta the selenium levels in some invertebrates (clams, for example) were similar to those found in Suisun Bay; the lower selenium concentrations found at higher trophic levels were attributed to different foraging strategies. In the Delta, striped bass had the highest levels, but isotopic signatures suggested that the selenium was taken up when the bass fed in Suisun Bay. Sele-

nium can substitute for sulfur in sulfur-rich tissues (bird beaks and spinal cords, for example), a condition that can result in deformities. Sacramento splittail collected from Suisun Bay have exhibited evidence of selenium-induced spinal deformities.

- Selenium concentrations in the biota of the Delta are lower than might be expected from concentrations in the water. Uptake by phytoplankton seems to be the largest and most variable step in concentrating selenium through the food web. Lag time is an important component of understanding this uptake. For example, it may be biologically meaningful to collect and analyze water samples 12 to 280 days before collecting tissues for analysis. The lag times will vary with species. For example, a lag time of 30 to 50 days worked best for crayfish, but for sunfish it was 80 to 290 days.

Salinity. Salt concentrations at various sites in the estuary are mainly a function of tides and river inflow. At moderate to high winter inflows, the higher-salinity water is typically west of the Delta. During the summer, the water projects release sufficient water from upstream to keep most of the salt water out of the Delta. A combination of high pumping, low flows, tides, and winds can draw ocean salts into the Delta and degrade water quality for agricultural and municipal users. The west side of the San Joaquin Valley can also be a significant source of salt to the estuary. Salt concentrated from applied irrigation water is drained from the upper levels of farm fields and flows to the estuary via the San Joaquin River. Since selenium is derived from these same drainage waters, measures to modify salt loading (for example, land retirement) could also affect the amount of selenium reaching the estuary

Key Points Regarding Salinity

- Delta hydrodynamics are so complex that it is difficult to use the inflow from major streams to forecast the mixture of Sacramento and San Joaquin waters being pumped from the south Delta by the CVP and SWP pumps. Existing models require additional variables to improve forecasts of salinity for operational and environmental purposes.
- Models of salinity leaving the Grasslands Water District can be used to predict salinity at San Joaquin River compliance points, thus helping manage salinity loading from the west side of the San Joaquin Valley.

Biology of Special Concern Species

Christina Swanson (The Bay Institute and UC Davis), Session Chair

Throughout the Sacramento-San Joaquin watershed, plant and animal species have been impacted by habitat loss, alterations in hydrologic regimes, invasions of non-native species, and contaminants. Most of the public, media, and management attention has focused on charismatic species such as winter-run Chinook salmon (first listed under the Endangered Species Act in 1989). However, during the past three decades hundreds of species have been identified by the state and federal governments as endangered, threatened, or species of special concern. Recovery of these at-risk species and protection and restoration of the diverse ecosystems upon which they rely are key goals of the

CALFED Bay-Delta Program and its Ecosystem Restoration and Multi-Species Conservation plans.

Designing, implementing, and evaluating the protection and restoration programs needed to fulfill CALFED's goals requires understanding of the ecology, behavior, and physiology of target species. This session was organized to highlight the results of recent research on some of these sensitive species and explore applications for species recovery and ecosystem restoration.

Key Points

- Studies of soft bird's beak, an annual figwort that grows in a narrow band at higher marsh elevations, demonstrated the complexity of maintaining or restoring many native plants. The species has disappeared from much of its historic range due to habitat alteration and the impacts of non-native species. This semi-parasitic plant cannot be transplanted and requires native pollinators; therefore protection of relict habitats, in addition to restoration of degraded habitats and reintroduction (as seeds), will be important for restoration of this species.
- Several investigations of tidal marsh birds, including song sparrows, yellow throat, black rails, and marsh wrens, involved examination of the local and landscape-level habitat factors that affect distribution, abundance, and reproductive success. Species exhibited different habitat preferences; for example, yellow throat and marsh wrens favored tall plant species for cover while black rails were found in dense, low-growing vegetation near the water's edge. Song sparrows appeared to benefit from marsh channel complexity, foraging in pickleweed on the marsh plain but defending territory along marsh channels. However, access to suitable habitat may be inadequate for species recovery if, on a local scale, the habitat does not provide the elements necessary for reproductive success. For example, compared to song sparrows found in Cosumnes River marshes, Suisun Marsh song sparrows exhibited poor reproductive success, i.e., below the level needed to maintain stable populations. These results emphasize the need for understanding population demographics and for multidisciplinary approaches to studying birds—needs that have general application to all species.
- Studies of delta smelt population dynamics and feeding ecology suggested that multiple factors affect the abundance of this species from year to year. Results from histological and DNA-damage studies indicated that contaminants may not be a significant factor affecting the annual population index. Rather, at least in recent years, food supply may be critical. Native zooplankters that constitute the first food for the larval smelt have been replaced by exotics, a food web alteration that may or may not have long-term implications for smelt nutrition. Long-term population analyses indicated that, in some years, entrainment losses of large numbers of adult and juvenile delta smelt at state and federal water projects in the Delta contributed to the population decline of this species. More detailed analyses of the influence of water project pumping on the success of individual cohorts (spawns) illustrated the complex interactions between delta smelt spawning timing, duration, and location, and food avail-

ability, water project export operations, and annual variations in climate. Understanding these interactions may provide a useful tool for improved protection and management for the species.

- Adult green sturgeon, which can live several decades, undertake extensive migrations along the coast and, like Pacific salmonids, migrate up large rivers to spawn. Genetic analyses indicated that green sturgeon from San Pablo Bay were more similar to those from the Columbia River basin than those from the geographically closer Klamath Basin. These results indicate that green sturgeon may be using some cue to return to their natal streams and that the San Pablo Bay and Columbia River populations are distinct from those in the Klamath River. Physiological studies showed that green sturgeon subjected to chronic stress (simulated by daily chasing, confinement, or dewatering in the laboratory-based experiments) had elevated maintenance metabolic rates and reduced metabolic scope for activity—factors that, if exhibited in wild stocks, could have long-term consequences for the species.
- A multi-decade educational sampling program by the Marine Ecological Institute offered a previously unanalyzed cache of data on the annual and seasonal abundance of fishes in the South San Francisco Bay. During the sampling period, a number of fish species exhibited very high seasonal and annual variability. For example, the California halibut, which was rare in the 1980s, became more abundant in the 1990s, probably in response to warmer ocean conditions during the latter period. These data also may prove useful for baseline studies to evaluate the large-scale habitat restoration projects planned for the South Bay, including restoration of the Cargill salt ponds to tidal marsh. This sampling program, conducted almost daily with the help of schoolchildren (and outside the typical CALFED and agency funding cycle), showed that such local, “volunteer” sampling programs, while largely qualitative, can provide very useful information.
- A study evaluating the restoration of Tolay Creek to improve tidal flow and provide enhanced pickleweed habitat for the salt marsh harvest mouse illustrated the need for improved understanding of the relationships between habitat quality and species abundance and distribution. The restored tidal habitat supported pickleweed in areas previously poorly or not vegetated with the ecologically important plant. However, correlations between pickleweed percent cover, density, and height and harvest mouse abundance and distribution were weak or not apparent. This suggests that additional monitoring of other aspects of habitat quality may be needed to better understand pickleweed-harvest mouse dynamics.

Fate and Effects of Organic Contaminants in Surface Waters

Kathy Kuivila (US Geological Survey), Session Chair

Organic contaminants enter our streams from a variety of sources including direct discharge from waste treatment plants, agricultural and urban runoff, and atmospheric deposition. Managers, biologists, and the public have been particularly concerned about the effects of organic compounds on biota ever since Rachel Carson's Silent Spring demonstrated the relation between hatch rate in certain birds and chlorinated hydrocarbons.

Although many chlorinated hydrocarbon pesticides are now banned from use in the United States and many parts of the world, their stable nature ensures that they are still being found in some soils and biota. Other compounds, polycyclic aromatic hydrocarbons (PAHs), polychlorobiphenyls (PCBs, banned for most applications in 1980), and new pesticides are still of environmental concern.

San Francisco Bay has some of the highest concentrations of PAHs yet measured along the West Coast of the United States. Although PCBs have been banned for more than two decades, PCB concentrations at many Bay sites are an order of magnitude higher than water quality criteria require. Central Valley farmers and homeowners use a variety of organic compounds to control weeds, insects, and other pests. Material from car tires, fireplaces, and sprays can enter the atmosphere and be deposited in the water during precipitation. Organic carbon coming from all these sources can adversely affect all levels of the food web and potentially negate the benefits of CALFED restoration efforts.

Key Points

- PAH concentrations in Bay sediments have remained relatively stable for the past decade while concentrations in bivalve tissue have been variable. Automobiles are a major source of PAHs. Therefore, increasing urbanization (and automobile use) exacerbates the problem.
- Monitoring of PAH concentrations has demonstrated the need to consider both hydrodynamic and chemical characteristics, with PAH concentrations varying on daily, seasonal, and annual time scales. Atmospheric contribution of PAHs is significant. PAH concentrations are generally much higher after the first rains (and urban runoff) of the season.
- Contribution of PCBs from point source discharges has decreased since 1979 but is only a small portion of the current loads. The majority of the current PCB load is from non-point sources such as riverine input, urban runoff, and sediment disturbance.
- Mercury and PCB levels in eggs of Caspian and Forster’s terns vary across San Francisco Bay. Significantly lower reproductive success in Forster's terns (salt pond foragers) in North and Central Bays corresponds with higher levels of PCBs in eggs. In contrast, Caspian terns (bay foragers) have a slightly lower reproductive success in South Bay which corresponds with the highest levels of mercury in eggs. These findings demonstrate the need to know the populations and food sources before reaching general conclusions.
- Sediment-associated pyrethroid insecticides are bioavailable. Sediment concentrations of pyrethroids were variable, but in tail water ponds from lettuce fields the levels were high enough to be toxic to bioassay organisms.
- The combined toxicities of several binary combinations of pesticides were highly variable. In some cases they were additive (56%), in others less than additive (21%), and in still others, greater than additive (21%). For example, mixtures of an organophos-

phate insecticide and triazine herbicides were synergistic while an organophosphate insecticide combined with esfenvalerate (a pyrethroid) were less than additive.

- The highest frequency and magnitude of algal toxicity was found in urban creeks and agricultural drains. Modified toxicity identification evaluation procedures found that diuron was the sole source of toxicity to algae in samples collected from Central Valley water bodies.
- It appears that farmers can reduce the movement of organophosphate pesticides from orchards by several means: orchard-floor vegetation, early treatment, and combining organophosphates with copper-based fungicides. Similarly, it appears that cover crops and sediment traps can reduce surface and sediment runoff from agricultural lands.

Climate Change

Mike Dettinger and Dan Cayan (US Geological Survey), Session Co-Chairs

California's climate and precipitation vary widely from place to place and from year to year. This variability, coupled with an ever-increasing population, has resulted in an extensive water management infrastructure. Dams, pumping plants, wells, and water distribution systems are designed with the consideration of getting us through a series of dry years such as occurred in the 1930s. From a strictly water supply standpoint, the system has worked reasonably well for the past 50 or so years, although back-to-back years of extreme drought, such as occurred in the 1976 and 1977 water years, have severely tested the system. On the other hand, the system has not been able to maintain ecosystem integrity and, as shown earlier, many species have been listed as threatened, endangered, or species of special concern.

The opportunity now exists to develop a more robust water management system—a system incorporating both human and ecological considerations. At this moment, however, we are confronted with the challenge of making the system flexible enough to accommodate a stressed ecosystem, increased urban water demands, and the strong likelihood that we will see climate changes and variations of (historically) unprecedented scales during the 21st century.

The uncertainties of global climate change, superimposed on California's water management system, present many challenges. Sea level rise, changes in the snow-rain mix of precipitation in the Sierra Nevada, and rises in stream temperature are now part of the mix of climate changes that are of increasing concern in the CALFED water-management planning process. This session was organized to help better understand modern climate the historic temperature and precipitation records and model predictions for California's climate in the upcoming decades.

Key Points

- Modern climate models and emissions scenarios project relatively narrow ranges of plausible increases in temperature and sea level for the 21st century; however, the range of precipitation projections remains broad.
- Paleoclimate records indicate that the past 150 years have been unusually wet, and climatic variation has been relatively limited. Many droughts in past centuries have been much more prolonged and severe than we have experienced since Europeans first settled in California.
- Nearly all climate scenarios (based on climate-trend modeling, tree ring and other paleoclimatic analyses, and observed stream flow changes) point to warming, reduced snow pack in the Sierra Nevada, wetter winters with more flooding, and drier summers.
- Water management plans must evolve to accommodate an uncertain suite of possible climates during the 21st century, and must at least be flexible enough to accommodate changes on the order of current projections.
- Some of the talks demonstrated how to use a climate scenario to project hydrologic and water resource changes, but results from scenario building efforts should not be taken as the solution to water management problems, given that future climates will remain uncertain until they become past climates. Flexibility and margins for error are key components of an effective water management system in an uncertain climatic future.
- Because the continuing impact of humans on the San Francisco Estuary and its watershed is superimposed on other sources of variability such as climate change and sea level rise, predicting both longer-term ecosystem change and the benefits of ecosystem restoration remains elusive. A better understanding of the complex interactions among animals and their environment will help develop better predictive capability, but we do not yet have that level of understanding.
- Policy responses to the implications of climate change have been slow in developing, in part because policy making generally follows media attention rather than scientific understanding. We need to find a means of getting scientists more involved in the policy making process.

Water Demand Reduction and Alternative Supply Possibilities

Mark Roberson (CALFED), Session Chair

California's population increased by about 40% between 1980 and 1998 and is now estimated to be over 35 million. Water to meet the increasing urban, agricultural, and industrial demands can come from several sources including increased efficiency, increased storage, and reallocation among agricultural and urban users (through land retirement and water marketing and transfers); or, most likely, a combination of these. The need to consider seriously these alternatives was made even more pressing by recent federal

actions on the lower Colorado River that decrease the amount of water to California from this source.

Evaluation of the efficacy and feasibility of demand reduction and alternative supply possibilities is a key feature of the CALFED Record of Decision. Urban water demand reduction can range from replacing water-inefficient hardware and appliances (for example, water heaters, toilets, shower heads, and dishwashers) to changes in landscaping practices. Over the past two decades implementation of these and other practices has resulted in an increase in the residential water demand by only about 14% while the population was increasing by 40%. Alternative supply possibilities being considered include desalting seawater, new storage reservoirs, and more efficient mixture of groundwater and surface use (conjunctive use).

Evaluation of water demand reduction and alternate supply possibilities is also a key component of assessing the impacts of water management on environmental resources. For example, new offstream storage reservoirs along the Sacramento River will affect the magnitude and timing of mainstem flows. Proposed in-Delta storage will affect the amount of dissolved organic carbon (DOC) in water discharged from the flooded islands that, in turn, can affect not only the quality of water for drinking but also the Delta foodweb.

Key Points

- California has made great strides in improving water use efficiency and thus reducing unit demand. Substantial improvements can still be made economically and quickly. We need to allocate sufficient effort to water use to make sure these improvements are realized.
- One of the conclusions from a comparison of water use efficiency in Marin County and Chula Vista (located in the desert of southern California) is that, whereas Marin County's aggressive water use efficiency program has about reached its limit, Chula Vista (a coastal city in San Diego County) has many options to increase water use efficiency. In Marin County, seawater desalting seemed to be most cost-effective measure to adopt.
- Although it is still in its very preliminary stages, an agricultural water efficiency program based on a regional, incentive-driven, objective-oriented approach may help achieve the goal of increased water use efficiency.
- An estimated 65% of average rainfall is consumed by evapotranspiration from trees and other plants—the largest single water use in California. Despite the importance of evapotranspiration, we do not have reliable methods of evaluating these losses in time periods shorter than one year.
- Membrane technology (through reverse osmosis) can remove 99% of the salts from seawater. At desalination plants producing 10 million gallons per day of product, the cost is about $600 to $700 per acre-foot, not including brine disposal. At these prices,

membrane technology can be included in the water supply options, especially as a source of backup supplies.

- The results of a statewide economic engineering-optimization model indicated there are promising opportunities for conjunctive use of surface and groundwater at the local and regional scales, particularly in the Sacramento Valley. Optimization at the statewide level did not increase the economic benefits of conjunctive use.
- A computer model is available to help managers of the Environmental Water Account make economically optimal decisions about how much and what kind of water to purchase. The model results indicate EWA managers may be able to acquire the water needed with the available funds ($42 million in 2002), but only if cost is based on a "net program cost" that includes water-acquisition costs, power costs, and the sale of any surplus water.
- Modeled evaluations of the concentrations of DOC from two Delta islands (Bacon Island and Webb Tract) demonstrated the importance of assumptions in model results and the need for more information. Using high-end predictions of DOC production, the water discharged from the islands violated the water quality standard in almost every instance, whereas using the low-end production value resulted in calculated values that violated the standard much less often, and hardly ever at Rock Slough and Los Vaqueros intakes.

Appendix A: Conference Program

CALFED Science Conference 2003

JANUARY 14, 2003

Plenary Session—Exhibit Hall D

7:00 AM
Registration

8:30 AM
Welcome
Samuel N. Luoma, CALFED Bay Delta Program & U.S. Geological Survey

8:35 AM
The Role of Science in Resolving California Water Policy Conflicts: CALFED vs. Klamath
Mary Nichols, Secretary, Resources Agency

8:50 AM
Seagrass Restoration Studies in Florida:
Lessons Learned about Site Selection and Monitoring Programs
Susan Bell, University of South Florida, Tampa, FL

9:20 AM
Beyond California—
Observations on Science in Other Restoration/Water Management Programs
Kim Taylor, CALFED Bay-Delta Program

9:50 AM
Ocean Conditions, Estuaries, and the Bottleneck Theory of Salmon Management
Dan Bottom, National Marine Fisheries Service, Newport, OR

10:20 AM

BREAK

10:40 AM
The Role of Science in Ecologically Sustainable Water Management
Brian Richter, The Nature Conservancy

11:10 AM
Science in Support of Ecosystem Restoration: A Tribute to Aretha Franklin
James Cloern, U.S. Geological Survey

11:40 AM
The Conflicted Boundaries Between Science and Policy
Helen Ingram, University of California, Irvine

12:10 PM
Closing Remarks
Samuel N. Luoma, CALFED and USGS

12:20 PM

LUNCH

JANUARY 14, 2003 – Afternoon Sessions

	Concurrent Session—Room 204	Concurrent Session—Exhibit Hall D	Concurrent Session—Room 203	Concurrent Session—Room 202
	Function and Effects of Flooded Islands *Session Chair: Lisa Lucas, USGS*	**Adaptive Assessment of Restoration Programs** *Session Chair: Jeff Mount, UC Davis*	**Fish Passage Facilities and Operation** *Session Chairs: Joseph Cech, Jr., UC Davis, and Marcin Whitman, NMFS*	**Effects of Nonnative Invasive Species** *Session Chairs: Kim Webb, FWS, and Erin Williams, FWS*
JAN. 14 1:00 PM	**Effects of the Tides, Geometry, Meteorology, and Project Operations on Circulation and Mixing in a Flooded Island Environment: Lessons from Mildred Island** *Jon Burau, USGS*	**A Whole System Approach to Geomorphic Monitoring and Adaptive Management, Cosumnes River, CA** *Jeff Mount, UC Davis*	**Technical Advances and Results of Fish Passage Research on Internal Screw-Type Lifts and Pumps in California** *Charles Liston, USBR*	**What Distinguishes A High-Impact Invader?** *Heather Peterson*, Romberg Tiburon Center, SFSU*
1:20 PM	**Circulation and Mixing within Delta Flooded Island Habitats: Implications for Ecosystem Restoration** *Nancy Monsen, USGS*	**River Restoration Decision Support System-Application in the Salmon River Sub-Basin, Idaho** *J. Carter Borden*, Romberg Tiburon Center, SFSU*	**Average Channel Velocity and Delta Smelt Louver Efficiency at the Tracy Fish Collection Facility: Improving Facility Operations and Delta Smelt Salvage** *Mark Bowen, USBR*	**Spread of Exotic Cordgrasses and Hybrids (*Spartina* sp) in the Tidal Marshes of San Francisco Bay** *Debra Ayres, DWR*
1:40 PM	**Spatial and Seasonal Variability in the Hydrodynamics of Shallow Water Habitats in the Delta** *Mark Stacey, UC Berkeley*	**Assessment of Species Response to Restoration and Water Management** *Warren Shaul, Jones & Stokes*	**Close Encounters with a Fish Screen: Anatomy of an Impingement** *David White, NOAA Fisheries*	**The Impact of Invasive *Spartina* on San Francisco Bay Song Sparrow Populations: Direct and Indirect Influences** *J. Cully Nordby, UC Berkeley*
2:00 PM	**Sherman Lake: A Case Study in Circulation and Mixing in a Shallow Estuarine Environment** *Catherine Ruhl, USGS*	**Measuring Bay-Delta Health: The Bay Region Ecological Scorecard** *Anitra Pawley, The Bay Institute*	**Close Encounters with a Fish Screen: Linking Laboratory and Field Studies on Juvenile Chinook Salmon** *Christina Swanson, UC Davis*	**Feeding Ecology and Potential Predatory Impact of *Tortanus dextrilobatus,* an Invasive Carnivorous Copepod in the San Francisco Estuary** *Rian Hooff*, Romberg Tiburon Center, SFSU*
2:20 PM	BREAK			
2:40 PM	**Circulation in Honker Bay, A Natural Shallow Water Habitat** *Jessica Lacy, USGS*	**Examples of Adaptive Management in Action: Linking Monitoring to Project Objectives and Implementation** *Daniel Efseaff, Sacramento River Partners*	**Validation of an Individual-Based Movement Model for Fish Extraction Facilities** *Bertrand Lemasson*, Utah State Univ.*	**Recent Investigations of Introduced Species in the Foodweb of the San Francisco Estuary** *Wim Kimmerer, Romberg Tiburon Center, SFSU*
3:00 PM	**Bay-Delta Geometry: The Shape of Things and Their Impact on Salinity Mixing** *Christopher Enright, DWR*	**CALFED ERP Projects Review—A Look Back** *Vance Russell, Kleinschmidt Associates*	**Hydrodynamic Field Investigation on the San Joaquin River Near the Head of Old River Barrier** *Jay Cuetara, USGS*	**Carbon, Crustacea and Carnivory: Using Stable Isotopes to Discern the Trophic Ecology of the Chinese Mitten Crab in its New Home in San Francisco Bay** *Deborah Rudnick*, UC Berkeley*
3:20 PM	**Prediciting Restored Habitats: The Physical Evolution of Tidal Wetlands in Breached Sites** *Michele Orr, Philip Williams & Associates*	**The Adaptive Management Forum for Large-Scale Channel and Riverine Habitat Restoration Projects: A Collaborative Peer Review Process** *Rhonda Reed, CALFED Bay-Delta Program*	**Effects of Auxiliary Flows (Pumped Across Grant Line Canal Barrier) on the San Joaquin River Dissolved Oxygen Levels** *Hari Rajbhandari, DWR*	**Ontonogenetic Feeding Shifts in Native and Alien Fish in the Cosumnes River Watershed** *Beth Chasnoff*, UC Davis*
3:40 PM	**Changes in Carbon Dynamics Over Time in a Restored Wetland in the Delta** *Robin Miller, USGS*	**Using the Ecosystem Management Decision Support System Together with a Comprehensive Watershed Data Management Tool to Target Restoration Opportunities and to Support AM in Battle Creek** *Michael Ward, Terraqua, Inc.*	**Evaluating Entrainment Vulnerability to Agricultural Irrigation Diversions: A Comparison Among Open Water Fishes** *Matt Nobriga, DWR*	**Cattle Grazing in Vernal Pool Grasslands: Can We Increase the Diversity of Native Plant Species by Reducing the Abundance of Exotics?** *Jaymee Marty, TNC*
				** Denotes student presenter*
4–7:00 PM	POSTER SESSION/RECEPTION—EXHIBIT HALL E			

JANUARY 15, 2003 – Morning Sessions

	Concurrent Session—Room 204	Concurrent Session—Room 202	Concurrent Session—Room 105	Concurrent Session—Room 203
	Function and Effects of Flooded Islands *(continued)* *Session Chair: Lisa Lucas, USGS*	**Riparian Restoration** *Session Chair: Greg Golet, The Nature Conservancy*	**From Mining to Microbes: Unraveling the Mercury Cycle in the San Francisco Bay Watershed** *Session Chair: Mark Marvin-DiPasquale, USGS*	**Recent Research on California Salmonids** *Session Chair: Ken Lentz, USBR*
JAN. 15 8:30 AM	**Strong Diel Patterns of Phytoplankton Biomass in a Tidal Flooded Island: High Frequency and "Fast Biology"** *Tara Schraga, USGS*	**Traditional Resource Management and Ecological Restoration of Riparian and Wetland Areas** *Michelle Stevens, DWR*	**Assessment of Hg Contributions from Historic Mercury and Gold Mine Sites in the Sulphur Cr Mining District to the Cache Cr Watershed, Comparisons with Other Mercury Sources and Implications for Remediation Activities** *Ronald Churchill, CGS*	**Demography, Distribution, and Habitat Use of Juvenile Steelhead in a Large, Regulated River** *Ryon Kurth, DWR*
8:50 AM	**Spatial Variability of Phytoplankton Dynamics in a Tidal Flooded Island** *Cary Lopez, USGS*	**Using Ecosystem Function to Measure the Success of Riparian Forest Restoration: A Case Study from the Sacramento River** *David Wood, CSU Chico*	**Mercury Loading From the Upper Cache Creek Mining Districts** *Tom Suchanek, FWS*	**Sediment and Salmon: Use of Gravel Permeability to Assess Survival-to-Emergence in Artificial Redds** *Frank Ligon, Stillwater Sciences*
9:10 AM	**The Distribution and Temporal Trends in *Corbicula fluminea* Biomass and What They Tell Us About the Function of Habitats** *Janet Thompson, USGS*	**Reproductive Phenology and Groundwater Requirements for Seedlings of Three Pioneer Riparian Species on the Lower Tuolumne River** *John Stella*, Stillwater Science*	**Mercury and Methylmercury Concentrations and Loads in the Cache Creek Watershed, CA, January 2000 through May 2001** *Joseph Domagalski, USGS*	**New Otolith Carbon Isotope Method to Distinguish Tributary and Delta Use in Juvenile Chinook Salmon in the Sacramento-San Joaquin River System** *Peter Weber, UC Berkeley*
9:30 AM	**Insights Gained from Top-Down Food Web Investigations in the Delta** *Lenny Grimaldo*, DWR and SFSU*	**The Interaction of Biological and Physical Processes and the Long-Term Survival of Riparian Forests at the San Joaquin River National Wildlife Refuge** *F. Thomas Griggs, Sacramento River Partners*	**Preliminary Results of Mercury and Methylmercury Transport Studies in the Bear River and Yuba River Watersheds, 1999-2002** *Charles Alpers, USGS*	**Emigration Timing, Abundance and Life History of Juvenile Winter Chinook Salmon Passing the Red Bluff Diversion Dam, 1995-1999** *Phillip Gaines, FWS*
9:50 AM	**Should We Create More Permanent Shallow Water Habitat in the Delta? Example: McCormack Williamson Tract** *Patrick Crain, UC Davis*	**Landscape Scale Analysis of Valley Oak Restoration at the Cosumnes River Preserve** *Kaylene Keller*, UC Davis*	**Spatial and Temporal Trends of Solid Phase Methyl and Total Mercury in the Delta** *Wesley Heim, Moss Landing Marine Laboratories*	**The Sacramento River Winter Chinook Carcass Survey and its Use in Evaluating the Supplementation Program at the Livingston Stone National Fish Hatchery** *Kevin Niemela, FWS*
10:10 AM	BREAK			
10:30 AM	**Biogeochemical Cycling of Nutrients and Trace Elements in Flooded Island Habitats** *Martina Doblin, Old Dominion Univ., VA*	**Chronosequence Analysis of Cottonwood Recruitment and Riparian Patch Dynamics on the Middle Sacramento River** *Alexander Fremier*, UC Davis*	**Microbial Mercury Cycling in Sediments of the Delta** *Mark Marvin-DiPasquale, USGS*	**Migration Patterns of Chinook Salmon Smolts in the North, Central, and South Delta Using Radio Telemetry: Results of Research Performed in 2000-2002** *David Vogel, Natural Resource Scientists, Inc.*
10:50 AM	**Dissolved and Particulate Selenium Dynamics in Mildred's Island: Biotic Controls on a Trace Element Cycle** *Gregory Cutter, Old Dominion Univ., VA*	**Progress on Development of Spatial Modeling Tools for Riparian Landscape Restoration and Impact Assessment on the Sacramento River** *Steven Greco, UC Davis*	**Investigation of Potential Mercury "Translators" Between Aqueous Mercury Fractions, Low Trophic Level Bioindicators, and Large Fish in the Cache Cr. Watershed** *Darell Slotton, UC Davis*	**Population Genetic Structure of Fall-Run Chinook in the Santa Clara Valley Watershed** *Kevin Williamson*, UC Davis*
11:10 AM	**The Future of Flooded Islands in the Delta: A Commentary** *Peter Moyle, UC Davis*	**Linking Hydrological and Biological Dynamics in Riparian Landscapes: Empirical Models, Predictions and Uncertainty** *Elizabeth Crone, Univ. of Montana*	**Mercury in Sport Fish from the Delta Region** *Jay Davis, SFEI*	**Provenance Analysis of Chinook Salmon in the Santa Clara Valley Watershed** *Dino Garcia-Rossi, UC Davis*
11:30 AM	**An Overview of CALFED Ecosystem Restoration Program Plans for Restoring Delta Flooded Islands** *Lauren Hastings, CALFED Bay-Delta Program*	**Lessons Learned from Restoring the Tuolumne River: At the End of the Day Project Success is when Design and Construction Come Together** *Tony Barela, HDR, Inc.*	**Field Assessment of Mercury Exposure of Aquatic Birds in the Delta Ecosystem Using the Avian Egg** *Steven Schwarzbach, USGS*	**Temporal Variation in Microsatellite Allele Frequencies Indicates Increasing Effective Number of Breeders in an Endangered Salmon Population** *Dmitri Churikov, UC Davis*
11:50 AM	LUNCH			

JANUARY 15, 2003 – Afternoon Sessions

	Concurrent Session—Room 204	Concurrent Session—202	Concurrent Session—Room 105	Concurrent Session—Room 203
	Wetlands: Past, Present, and Future *Session Chair: Peter Green, UC Davis*	**River Channel Restoration** *Session Chair: G. Mathias Kondolf, UC Berkeley*	**Effects of Natural and Anthropogenic Processes on Water Quality** *Session Chair: Brian Bergamaschi, USGS*	**Trophic Ecology in the Bay-Delta Watershed** *Session Chair: Larry Brown, USGS*
JAN. 15 1:00 PM	**Trends in the Sediment Yield of the Sacramento River, 1957-2001** *Scott Wright*, USGS*	**Lessons Learned from Gravel Augmentation Programs in Central Valley Rivers** *Erin Lutrick and G. Mathias Kondolf, UC Berkeley*	**Sources of Oxygen Demand in the San Joaquin River** *Peggy Lehman, DWR*	**Effects of Anthropogenic Ammonium Input and Flow on Primary Production in San Francisco Bay** *Richard Dugdale, Romberg Tiburon Center, SFSU*
1:20 PM	**A Multi-Year Record of Sedimentary Processes and Marsh Surface Elevation Change in Restored and Ancient Tidal Marshes of the Delta** *Denise Reed, Univ. of New Orleans*	**A Sediment Flux Model for Assessing the Long-Term Impacts of Proposed Rehabilitation Strategies in Large Rivers** *Michael Singer*, UC Berkeley*	**Dissolved Oxygen TMDL of San Joaquin River** *Carl Chen, Systech Engineering, Inc.*	**The Effect of Spatial and Temporal Variability in Food Concentration on the Behavior, Feeding Physiology and Egg Production of the Estuarine Copepod *Acartia* sp.** *Alexander Bochdansky, Romberg Tiburon Center, SFSU*
1:40 PM	**Initial Ecological Comparisons of Restored and Historical Marshes of San Francisco Estuary, and More Pristine Brackish Marshes Along the Central CA Coast** *Christopher Kitting, CSU Hayward*	**Oxbow Lakes of the Sacramento River: Physical Processes and Conservation Strategies** *Ingrid Morken, UC Berkeley*	**Tracing Nitrate Sources, Transformation, and Sinks from the Central Valley, Through the Delta, and Within the Bay Using Stable Isotope Techniques** *Carol Kendall, USGS*	***Acartia* spp. Copepods as Protozoan-Metazoan Food Web Links in San Francisco Bay: Microplankton Prey Communities and Copepod Feeding Dynamics 1997-2000** *Gretchen Rollwagen-Bollens*, UC Berkeley*
2:00 PM	**Processes of Geomorphic Evolution in a San Pablo Bay Restored Tidal Marsh** *Stuart Siegal, Wetlands and Water Resources*	**Watershed Environmental Hydrology Model for Upper Cosumnes River Watersheds** *ZhiQiang Chen, UC Davis*	**Evaluation of Unknown Organic Contaminants in the San Francisco Estuary** *Daniel Oros, SFEI*	**The Tidal Marsh Food Web: Species-Level Interactions and Trophic Flows Between Marsh Habitats** *J. Letitia Grenier*, UC Berkeley*
2:20 PM	BREAK			
2:40 PM	**Delta Levee Erosion: Long-Term Monitoring and Short-Term Processes** *Bernard Bauer, USC*	**New Methods for Diagnosing and Managing Upslope Sediment Sources at the Watershed Scale, Napa River Basin, Napa County** *Eileen Weppner, Pacific Watershed Associates*	**Potential Effects of Wetland Restoration on Subsided Peat Soils: Release of Dissolved Organic Carbon and Disinfection Byproduct Precursors** *Roger Fujii, USGS*	**Landscape Level Influences on Aquatic Insects and Food Web Structure in the Cosumnes Watershed** *Edwin Grosholz, UC Davis*
3:00 PM	**Carbon Storage and Sediment Accretion in Restored Wetlands on Twitchell Island** *Judy Drexler, USGS*	**Interdisciplinary Approach to Rehabilitating Salmon Spawning Habitat and Fluvial Geomorphic Processes in the Central Valley** *Gregory Pasternack, UC Davis*	**Assessment of Processes Affecting Dissolved Organic Carbon Loads in Drainage Water on Twitchell Island** *Steven Deverel, HydroFocus, Inc.*	**Affects of Land Use and Dams on Stream Food Web Ecology** *Kateri Harrison,* San Francisco State University*
3:20 PM	**Transitional Habitats in Tidal Marsh Restoration: Avian Response to Mud Flat Formation on Tolay Creek, San Pablo Bay** *Isa Woo, Humboldt State Univ. Foundation*	**Geomorphic Processes and Salmonid Habitat in Sulphur and Carneros Creeks, Napa River Watershed** *Sarah Pearce, SFEI*	**Estimating Dissolved Organic Carbon (DOC) Concentrations in the Delta with Limited Data** *Jamie Anderson, DWR*	**Documenting Physical/Biological Patch Structures During 2000 and 2001 USGS San Francisco Bay Hydrographic Surveys Using Alongtrack Data: Toward Characterizing Three Decades of Hydrographic Data** *Karen Fisher, Romberg Tiburon Center, SFSU*
3:40 PM	**The Effect of Channel Order on Fish Abundance, Community Composition, and Diet in a Tidal Marsh** *Tammie Visintainer*, Romberg Tiburon Center, SFSU*	**Assessing In-Stream Fish Habitat in the Context of Watershed Stewardship and a Broad Based Approach to Restoration and Conservation** *Jonathan Koehler, Napa County. RCD*	**The Contribution of Natural and Restored Wetlands to Changes in Dissolved Organic Material in the Delta and Estuary** *Brian Bergamaschi, USGS*	**Traveling in Uncharted Waters: Seabird Indicators of Climate and Oceanic Conditions Complement Traditional Information for Managing Bay Delta Fish** *Kyra Mills, PRBO*
4–7:00 PM	POSTER SESSION/RECEPTION—EXHIBIT HALL E			

JANUARY 16, 2003 – Morning Sessions

	Concurrent Session—Room 204	Concurrent Session—202	Concurrent Session—Room 205	Concurrent Session—Room 203
	Wetlands: Past, Present, and Future *(continued)* *Session Chair: Peter Green, UC Davis*	**Flood Plain Restoration** *Session Chair: Anke Mueller-Solger, DWR*	**Delta Cross Channel** *Session Chair: Bruce Herbold, US EPA*	**Selenium and Salinity in the San Joaquin River and Delta** *Session Chair: Mary Menconi, CVRWQCB*
JAN. 16 8:30 AM	**Marsh Plain Sedimentation Processes within the San Francisco Estuary** *Steven Culberson, DWR*	**Use of a Re-Created Floodplain by Native and Alien Fishes** *Peter Moyle, UC Davis*	**Hydrodynamics of the Delta Cross Channel Region** *Jon Burau, USGS*	**Modeling the Biogeochemical Cycle of Selenium in the San Francisco Bay** *Greg Cutter, Old Dominion Univ., VA*
8:50 AM	**Interspecific Differences in Growth of *Scirpus* Species Across a Depth Gradient** *Jeff Hart, H.A.R.T., Inc.*	**Processes Influencing Secondary Production in a Seasonal Floodplain of the Cosumnes River** *Edwin Grosholz, UC Davis*	**Delta Salinity Response to Experiments of Delta Cross Channel Gates Position** *Samantha Salvia, CC Water District*	**Understanding Selenium Bioaccumulation in Shallow-Water Habitats of the Delta: Importance of Trophic Pathways, Biogeochemistry, and Hydrodynamics** *Robin Stewart, USGS*
9:10 AM	**Species Composition and Structure of *Scirpus* Dominated Marshes** *John Hunter, Jones & Stokes Associates*	**Food Quality and Quantity for Zooplankton in Two Contrasting Central California Floodplains** *Anke Mueller-Solger, DWR*	**Repeated Surveys by Acoustic Doppler Current Profiler for Flow and Sediment Dynamics at Delta Cross Channel** *Randal Dinehart, USGS*	**Ratios of Selenite and C Uptake in Suspended Phytoplankton: Implications for Prediction of SE Incorporation into Food Webs** *Stephen Baines, Stony Brook Univ., NY*
9:30 AM	**Waterside Stability of Delta Levees** *Edwin Hultgren, Hultgren-Tillis Engineers*	**Effects of Landscape Level Hydrologic Variation on the Biota of the Sacramento River and Yolo Bypass Floodplain** *Ted Sommer, DWR*	**Delta Cross Channel Hydrodynamics and the Potential for Entrainment of Outmigrating Juvenile Salmon** *Michael Horn, USBR*	**From Water to Wildlife: Lag Time in Selenium Bioaccumulation in a Temporally Viable Flowing System** *William Beckon, FWS*
9:50 AM	**Tidal Marsh and Floodplain Habitat Enhancement on the McCormack Williamson Tract: An Evaluation of Potential Scenarios with a Hydraulic Model and GIS** *Christopher Hammersmark*, UC Davis*	**Fish Communities and Habitat Characteristics of Perennial Floodplain Ponds of the Sacramento River with Implications for the Conservation of Native Fish** *Frederick Feyrer, DWR*	**Responses of Coded-Wire Tagged Outmigrant Salmon to Delta Cross Channel Hydrodynamics** *Bruce Herbold, US EPA*	**Economic Modeling of Drainage Water Reuse and Treatment** *Ray Hoagland, DWR*
10:10 AM	BREAK			
10:30 AM	**Building a Habitat Conversion Model for San Francisco Bay Wetlands: A Multi-Species Approach for Integrating GIS and Field Data** *Diana Stralberg, PRBO*	**Fish Assemblages in Newly-Restored Tidal and Floodplain Habitats in the Napa Creek Flood Control Project** *Mike Dietl, USACE*	**Migratory Behavior of Radio-Tagged Juvenile Salmon in the Vicinity of the Delta Cross Channel in Response to Local Hydrodynamic Conditions** *David Vogel, Natural Resource Scientists, Inc.*	**Real-Time Wetland Salinity Management in the San Joaquin Valley (part I)** *Mark Hanna*, UCLA*
10:50 AM	**Restoration and Enhancement of Salt Ponds in San Pablo Bay and San Francisco Bay** *Nadine Hitchcock, CCC*	**Modeling Floodplain Flow on Lower Deer Creek** *Michael MacWilliams*, Stanford Univ.*	**The Movements of Adult Chinook Salmon, Outfitted with Ultrasonic Transmitters and External Spaghetti Tags, in the Delta and Delta Cross Channel** *Derek Stein, DFG*	**Effects of Project Operations on Salinity in South Delta Exports** *Barry Montoya, DWR*
11:10 AM	**Reversing Effects of Subsidence in the Delta** *Steven Deverel, HydroFocus, Inc.*	**Morphologic Modeling for Restoration - From the Thalweg to the Floodplain** *Christopher Bowles, Philip Williams & Associates*	**On the Future of the Delta Cross Channel Studies** *Jon Burau, USGS*	**Recalibration and Refinement of a Salinity-Outflow Model for the Delta (G-Model)** *Richard Denton, CC Water District*
11:30 AM	**Projecting Future Habitat Mixes: The Influence of Sediment Dynamics on Habitat Restoration Strategies** *Jeremy Lowe, Philip Williams & Associates*	**Landscape Change in the Napa River Watershed, 1800-2002: Implications for the Restoration of In-Stream, Floodplain, and Valley Floor Habitat** *Robin Grossinger, SFEI*		
11:50 AM	LUNCH			

JANUARY 16, 2003 – Afternoon Sessions

	Concurrent Session—Room 204	Concurrent Session—Room 202	Concurrent Session—Room 205	Concurrent Session—Room 203
	Biology of Special Concern Species *Session Chair: Christina Swanson, The Bay Institute and UC Davis*	**Fate and Effects of Organic Contaminants in Surface Waters** *Session Chair: Kathy Kuivila, USGS*	**Climate Change** *Session Chairs: Mike Dettinger, USGS and Dan Cayan, USGS*	**Water Demand Reduction and Alternative Supply Possibilities** *Session Chair: Mark Roberson, CALFED-Water Use Efficiency Program*
JAN. 16 1:00 PM	**Reintroduction of Endangered Soft Bird's Beak to Restored Habitat in Suisun Marsh** *Brenda Grewell, UC Davis*	**A Mass Balance Model for the Fate of PAHs in the San Francisco Estuary** *Ben Greenfield, SFEI*	**Climate Science Issues and Needs of the CALFED Bay-Delta Program** *Michael Dettinger, USGS*	**Managing Demand in California's Commercial, Industrial, and Institutional Sectors** *Peter Gleick, Pacific Institute*
1:20 PM	**Multiple-Scale Predictors of Tidal Marsh Breeding Bird Distribution and Abundance in the San Francisco Estuary** *Hildie Spautz, PRBO*	**Inputs of PCBs to the San Francisco Estuary Via Point Source Discharges** *Donald Yee, SFEI*	**The Record of Natural Climate Variability Over the Central Valley Watershed** *Malcolm Hughes, Univ. of Arizona*	**Managing Demand in California's Residential Sector** *Dana Haasz, Pacific Institute*
1:40 PM	**Habitat Needs of the San Pablo Song Sparrow Across the Salt Marsh Tidal-Influence Gradient** *J. Letitia Grenier*, UC Berkeley*	**Dynamics of Dissolved and Particle-Bound Organic Contaminants in Northern San Pablo Bay** *Thomas Young, UC Davis*	**Paleoclimate Changes in San Francisco Estuary and its Watershed** *Frances Malamud-Roam, UC Berkeley*	**Comparing and Contrasting Benefits and Costs of Water Use Efficiency Measures in Marin County and in Chula Vista** *Bahman Sheikh*
2:00 PM	**Temporal Trends and Spatial Heterogeneity in Reproductive Success of Song Sparrows in San Francisco Bay and the Central Valley: Assessing the Role of Local Versus Global Influences** *Nadav Nur, PRBO*	**Sediment-Associated Pesticides in the Bay-Delta Watershed and Their Toxicological Effects** *Donald Weston, UC Berkeley*	**Geomorphic Record of Climate Variability in Lowland Rivers in the Bay-Delta Watershed** *Joan Florsheim, UC Davis*	**Development of Water Use Efficiency Quantifiable Objectives to Address CALFED Goals** *Mark Roberson, CALFED*
2:20 PM	**Integrated Monitoring to Understand the Health, Survival, and Population Dynamics of Delta Smelt** *William Bennett, UC Davis*	**Mixtures of Pesticides… Additive? More or Less** *Kimberly Parks*, Southern Illinois Univ*	**Climate Variability - A Regional Stress on California's Water and Power Systems** *Daniel Cayan, UC San Diego*	**Reference Evapotranspiration Equations for California** *Bekele Temesgen, DWR*
2:40 PM	BREAK			
3:00 PM	**Inter-Specific Differences in the Feeding Ecology Osmerids in the Low Salinity Zone of the San Francisco Bay-Delta Estuary** *James Hobbs*, UC Davis*	**Investigating Causes of Toxicity to Algae in Central Valley Waterways: Modified Study Design & Method Development** *Karen Larsen, CVRWQCB*	**Potential Effects of Climate Change on the Sacramento/San Joaquin Watershed and the San Francisco Estuary** *Noah Knowles, UC San Diego*	**Membrane Technology: A Key Element in Expanding the Use of Nonconventional Water Sources in California** *Fethi BenJemaa, DWR*
3:20 PM	**Application of Genetic Markers for Species Identification and Population Structure Analysis of Green Sturgeon *(Acipenser medirostris)*** *Joshua Israel*, UC Davis*	**Habitat Condition and Benthic Community Assemblages in Agriculture-Dominated and Effluent-Dominated Waterbodies of Sacramento River Watershed** *Robert Holmes, CVRWQCB*	**Distributed Climate Change Hydrologies for Modeling Water Management in California** *Tingju Zhu*, UC Davis*	**Linkage of CALSIM II CVP/SWP Planning Simulation Model with the Daily Time-Step Delta Operations Model for In-Delta Storage Investigations** *Daniel J. Easton, DWR*
3:40 PM	**Investigations into the Effects of Chronic Stress on Swimming Performance, Standard Metabolic Rate and Metabolic Scope for Activity in Green Sturgeon, *Acipenser medirostris*** *Scott Lankford*, UC Davis*	**Contamination Levels in Piscivorous Birds in the South San Francisco Bay** *Cheryl Strong, SFBBO*	**Yogi Berra Was Right: Predicting the Effects of Climate Change on the San Francisco Estuary** *Wim Kimmerer, Romberg Tiburon Center, SFSU*	**Conjunctive Use Opportunities for California: An Integrated Economic and Operations Perspective** *Marion Jenkins, UC Davis*
4:00 PM	**An Analysis of Changes in Fish Populations in South San Francisco Bay Over a Thirty Year Period** *Katherine Schafer, Marine Science Institute*	**Water Quality Effects of Pesticides Used in Orchard Agriculture: Evaluating Management Alternatives and Off-Site Movement** *Frank Zalom, UC Davis*	**Effects of Climate Change on Fish Populations of the San Francisco Estuary** *William Bennett, UC Davis*	**Got Water? Developing an Optimal Water Acquisition Strategy for the CALFED Environmental Water Account** *Adam Diamant, EPRIsolutions, Inc.*
4:20 PM	**Effect of Tidal Marsh Restoration on Salt Marsh Harvest Mice: The Need for Indices of Habitat Quality** *Michael Bias, Ecosystem Restoration Sciences, Inc.*	**Managing and Analyzing Quality of Year-Round Runoff from Annual Cropping Systems in California** *Paul Robins, Yolo County RCD*	**Climate Change and the Science-Policy Interface—A Case Study of California Water Policy** *Michael Kiparsky*, UC Berkeley*	**Evaluation of DOC Concentration From In-Delta Storage Project Islands Releases** *Michael Mierzwa, DWR*
4:40 PM	ADJOURN			

Appendix B: Planning Committee Members

Planning Committee Members

Anke Mueller-Solger . . . . . Department of Water Resources
Barbara McDonnell . . . . . Department of Water Resources
Bellory Fong. . . . . CALFED Bay-Delta Program
Bruce Thompson . . . . . San Francisco Estuary Institute
Diana Jacobs . . . . . Department of Fish and Game
Elise Holland . . . . . The Trust for Public Land
Ellie Cohen. . . . . Point Reyes Bird Observatory
Fred Nichols. . . . . US Geological Survey (Retired)
Greg Golet . . . . . The Nature Conservancy
Gregg Elliott . . . . . Point Reyes Bird Observatory
Joan Patton . . . . . San Francisco Estuary Project
Joe Cech . . . . . UC Davis
Kim Taylor . . . . . CALFED Bay-Delta Program
Ken Lentz. . . . . US Bureau of Reclamation
Kim Webb . . . . . US Fish and Wildlife Service
Larry Smith. . . . . US Geological Survey
Larry Brown . . . . . US Geological Survey
Marcia Brockbank . . . . . San Francisco Estuary Institute
Stephen Monismith . . . . . Stanford University
Richard Morat . . . . . US Fish and Wildlife Service
Randy Brown . . . . . Department of Water Resources (Retired)
Sam Luoma . . . . . CALFED Bay-Delta Program
Tim Ramirez. . . . . Resources Agency

Web Support

Karl Jacobs . . . . . Department of Water Resources
Jim Hagy . . . . . Estuarine Research Federation

Publication Support

Eleanor Ely. . . . . Consultant
Lauren Buffaloe . . . . . CALFED Bay-Delta Program