STATE OF THE SAN FRANCISCO BAY-DELTA ESTUARY

2006

Science & Stewardship

SAN FRANCISCO ESTUARY PROJECT
&
CALFED
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STATE OF THE ESTUARY PROCEEDINGS

Opening Remarks

This Report describes the current state of the San Francisco Bay- Sacramento-San Joaquin Delta Estuary's environment — waters, wetlands, wildlife, and watersheds. It also highlights restoration activities, research needs, and pressing issues we need to address if we are going to protect water quality, supply, and habitat.

San Francisco Bay and the Delta combine to form the West Coast's largest estuary, where fresh water from the Sacramento and San Joaquin rivers and watersheds flows out through the Bay and into the Pacific Ocean. In the early 1800s, the Bay covered almost 700 square miles, and the Delta's rivers swirled through a vast Byzantine network of 80 atoll-like islands and hundreds of miles of braided channels and marshes. Back then, almost a million fish passed through the Estuary each year and 69 million acre-feet of water crashed down from mountain headwaters toward the sea. But in 1848 the Gold Rush began and hydraulic mining plugged the rivers and bays with more than one billion cubic yards of sediments. Over time, farmers and city builders filled up more than 750 square miles of tidal marsh, and engineers built dams to block and store the rush of water from the mountains into the Estuary and massive pumps and canals to convey this water to thirsty cities and farms throughout the state.

Today's Estuary encompasses roughly 1,600 square miles, drains more than 40% of the state (60,000 square miles and 47% of the state's total runoff), provides drinking water to 22 million Californians (two-thirds of the state's population), and irrigates 4.5 million acres of farmland. The Estuary also enables the nation's fifth largest metropolitan region to pursue diverse activities, including shipping, fishing, recreation, and commerce. Finally, the Estuary hosts a rich diversity of flora and fauna. Two-thirds of the state's salmon and at least half of the birds migrating along the Pacific Flyway pass through the Bay and Delta. Many government, business, environmental, and community interests now agree that beneficial use of the Estuary's resources cannot be sustained without large-scale environmental restoration. There is also a greater need than ever for increasing public awareness about the Estuary.

This 2006 State of the Estuary Report summarizes advocacy and stewardship efforts, and restoration and science recommendations drawn from the 44 presentations and 195 posters of the October 2005 State of the Estuary Conference and related research. The report also provides some vital statistics about changes in the Estuary's fish and wildlife populations, pollution levels, and flows over the past two years, since the last State of the Estuary report was published.

The report and conference are all part of the San Francisco Estuary Project's ongoing efforts to implement its Comprehensive Conservation and Management Plan (CCMP) for the Bay and Delta and to educate and involve the public in protecting and restoring the Estuary. The S.F. Estuary Project's CCMP is a consensus plan developed cooperatively by over 100 government, private and community interests over a five-year period and completed in 1993. The project is one of 28 such projects working to protect the water quality, natural resources and economic vitality of estuaries across the nation under the U.S. Environmental Protection Agency's National Estuary Program, which was established in 1987 through Section 320 of the amended Clean Water Act. Since its creation in 1987, the Project has held seven State of the Estuary Conferences and provided numerous publications and forums on topics concerning the Bay-Delta environment. In 2001, CALFED joined the Estuary Project as a major sponsor of the conference. CALFED is a cooperative state-federal effort, of which U.S. EPA is a part, to balance efforts to provide water supplies and restore the Bay-Delta watershed.

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Executive Summary

Reprint of a December 2005 ESTUARY Newsletter article.

Amid the metaphorical popping of champagne corks at this year's "Celebrating Science and Stewardship" State of the Estuary Conference in Oakland's Henry J. Kaiser Convention Center, scientists and policymakers sounded a series of SOS calls to an audience of more than 700. The loudest cries for attention were over the Delta and the ways it is changing physically, politically, and ecologically, and how the future of the Central Valley—as ag land or urban sprawl—will affect the Bay-Delta Estuary.

The S.F. Regional Board's Larry Kolb kicked things off by asking whether Californians are as "clueless" in managing our water systems—and the Delta—as those who channelized the Mississippi River, cutting it off from its floodplains and depriving the wetlands at its mouth of sediment, thereby contributing to the damage from Hurricane Katrina. In both places, said Kolb, we are mismanaging water and marshes, building on subsided marshy soils—on floodplains—and then, in a vicious cycle, building ever bigger levees and dams to protect the homes and infrastructure behind them.

> "We spend $100 million per year explaining why agriculture is important. But we spend less than 10 percent of that telling people why oceans and estuaries are valuable."
>
> Jerry Schubel, Aquarium of the Pacific

Other speakers following Kolb the first morning sounded more alarms—and called for action. Jerry Schubel, from the Long Beach Aquarium of the Pacific, told the crowd that while we've made huge strides with science, we need to make sure stewardship keeps pace. "Both scientists and citizens need to be keepers of the Estuary," said Schubel. Everyone—"all sizes, shapes, races, NGOs, scientists, and politicians"—needs to get involved in making decisions about the Bay-Delta Estuary, said Schubel. "If you're not at the table," he quipped, "you're on the menu."

Lack of scientific understanding isn't the problem at this point, said Schubel, who called for a "compelling vision" and new approaches for managing Bay-Delta resources, including better communication with the public. "We spend $100 million per year explaining why agriculture is important," he added. "But we spend less than 10 percent of that telling people why oceans and estuaries are valuable." Schubel also advised the crowd that we need to be flexible in managing water resources. But the bottom line, he said, is that we must build better collaborations among researchers, decisionmakers, and stewards.

> "To protect the Delta, we need a new Sylvia McLaughlin, Kaye Kerr, and Esther Gulick."
>
> Joe Bodovitz, former executive director, BCDC and California Coastal Commission

Stewards were also on the mind of Joe Bodovitz, the former—and first—executive director of both BCDC and the Coastal Commission, who began his talk by chronicling the sometimes-volatile political process that led to the creation of CALFED. Under former governor Pat Brown's reign—which Bodovitz termed the "golden era of California"—the State Water Project and lots of other infrastructure we benefit from today got built. But things are changing, he warned, stressing that as the state's population burgeons, the Central Valley will need more water and will play a more prominent role in water plumbing and politics. The most critical issue facing the Bay-Delta, said Bodovitz, is how much water Central Valley agriculture will keep or sell to urban areas.

Echoing Schubel, Bodovitz said another critical issue is stewardship. To protect the Delta, he said, we need a new Sylvia McLaughlin, Kaye Kerr, and Esther Gulick, the three Berkeley women who kept the Bay from becoming a parking lot. Saving the Delta is a much trickier proposition, said Bodovitz. Recalling how the three women got people to send bags of sand to

their legislators, he said, "People could understand that if we filled the Bay, things would be greatly changed. People got it—it was either going to be water or dry land." But the Delta, he said, is "light-years more complex" and gets approached as a plumbing problem instead of as a landscape.

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> Joe Bodovitz

One of the morning's highlights—a preview of Ron Blatman's upcoming four-part television documentary, "Saving the Bay"—showed exactly what stewardship can do. With historical and current images of the Bay and interviews with then-legislators and key environmental activists, the film chronicles how by the 1960s, almost one-third of the Bay had been filled, and how a 1959 Army Corps of Engineers report predicted that by 2020, 70 percent of the Bay would be filled for development. But then the three women who founded Save the Bay stepped in and stopped the fill.

On the conference's second day, speakers focused on the disconnect between the Delta's geomorphology and the state's land use policies: As the Delta continues to subside, we continue to build more houses and other structures behind levees, partly in response to the Bay Area's expensive housing stock. "The Delta is the number-one most-subsided landscape in the world relative to its size," announced U.C. Davis' Jeff Mount. Mount predicted that as urbanization continues to encroach upon the Delta—30,000 homes were approved in flood-prone areas in Stockton and another 8,500 in Lathrop—some of the ecosystem services the Delta has provided in the past will have to give, particularly if we continue our practice of serial engineering and particularly if we continue sprawling. "Once you start putting homes in the Delta, all bets are off," declared Mount. Mount said we are mistakenly treating the Delta like a crime scene, where everything that is going to happen has already happened. "The pace of [physical] change is rapid, yet we've got four CALFED programs wrapped around a static Delta," said Mount. Today's engineering is based on 1980s hydrology, he warned, predicting that South Delta improvement projects will adapt poorly to changing conditions. The Delta is warming up, and its hydrology and ecosystems are changing, he said. "If you raise sea level by three feet, the Delta ecosystem is going to be more like a Chesapeake Bay. In 15 to 20 years, we'll have a whole different food web." Mount said we need to define future probable states and take the long view, recognizing that some ecosystem services cannot be sustained over the long term. In response to moderator Tim Ramirez asking which ecosystem service will "get voted off the island," Mount predicted that the loser will be farming.

The Department of Water Resource's Jerry Johns followed Mount, taking more of a crime-scene approach. We need to act now to protect the infrastructure—high-pressure gas lines, water lines, and roads, among others—that crisscrosses the Delta, said Johns. "We need to take a comprehensive view and make 'no-regrets' decisions that improve flexibility." But Johns also asked whether it is possible to "move forward" with pumping more water from the Delta when we don't understand the recent decline in pelagic organisms. "Do we put off decisions on [water project] operations until we have more data, a new ROD?"

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>
> Jeff Mount, UC Davis

Whatever we do, said the Central Delta Water Agency's Tom Zuckerman, the solution needs to be "Delta-centric" and come from the people who live in the Delta. Zuckerman added to Mount's concerns about the onslaught of urbanization. "We need to avoid making stupid, thoughtless decisions, such as putting people behind levees in tract houses," said Zuckerman. "But how do we get politicians—the state government and the federal government—to focus on

the Delta? It really is entitled to priority. It's an environmental and recreational treasure." Zuckerman told the audience that we have a once-in-a-lifetime opportunity to preserve the standard of living and way of life in the Delta—an opportunity that will soon be lost.

Former Rio Vista mayor Marci Coglianese reiterated Zuckerman's concerns and added to them. "The Delta is no longer a remotely populated area," she said. "It's no longer a backwater filled with fish and stubborn farmers." Since 1993, said Coglianese, more than 94,000 residential units have been built in the Delta's secondary zone. "Every day, the Delta is being influenced by a Tower of Babel of governmental agencies," said Coglianese. "But there is no shared vision or acknowledgment of impacts. The time is ripe for a broader examination of all state policies affecting the Delta; we need a serious discussion of how state and local growth policies are putting development behind levees and in floodplains."

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> Marci Coglianese, former mayor, Rio Vista

Although the Delta Protection Commission has made a laudable attempt to protect the inner core, said Coglianese, the legislature has not given it any real authority, and new conflicts are cropping up even there. Like Zuckerman, Coglianese thinks we have a "teachable moment" right now, after Katrina, in which we have the public's attention. Yet, she concluded, "The fundamental problem in the Delta is that the state government is not supplying the leadership needed to deal with hard problems. I urge the governor as he tries to refocus CALFED to bring together local governments, legislators, and interests who are talking to themselves right now." Solutions to the Delta's problems cannot be imposed on the Delta, said Coglianese. "But we need some unifying force to bring us together. Right now, we're a region without leadership. We need the state to help us out. Most of us don't even know where the floodplains are."

It takes scientists—not politicians—to delineate floodplains. Yet one conference speaker, MWD's Tim Quinn, said scientists should not be making policy. "Too often in California water, you have people sitting at the table crossing the line," said Quinn. "We also have scientists crossing the line. The *San Francisco Chronicle, Contra Costa Times,* and *Sacramento Bee* are not good places to publish your science." Quinn's comments aside, most conference speakers said there was an ever-increasing and more urgent need to communicate science to the public.

The science behind the recent decline in pelagic organisms in the Delta was a popular topic. Ted Sommer outlined the Interagency Ecological Program's efforts to identify all possible causes of the decline, from toxic algal blooms and new pesticides to the timing and amount of Delta pumping to impacts from exotic species. Posing another possible cause, Sommer cited problems with two species of zooplankton—*Pseudodiaptomus forbesi* and *Limnoithona tetraspina*. *Pseudodiaptomus,* which crashed in 2004, is a major food source for larval fish, said Sommer, while *Limnoithona*, which was relatively abundant in 2004, is a poor food source and possible predator of *Pseudodiaptomus*. The next day, S.F. State University's Wim Kimmerer explained that the *Pseudodiaptomus* population had a recruitment failure in recent years, which meant the loss of later life stages that would grow to adult organisms—and said there is no evidence that *Limnoithona* feeds on other copepods. He is trying to figure out why copepods crashed but not phytoplankton. Another culprit could be the invasive overbite clam, which may have decimated *Pseudodiaptomus* larval stages.

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Many speakers suggested that poor water quality—particularly as a result of the huge increase in the use of pyrethroids by farmers—may have decimated pelagic organisms. If we are going to improve water quality

in the Delta, many folks think we can't do it without addressing water quality in the San Joaquin River. "It's not if, but when we restore the San Joaquin," proclaimed the Bay Institute's Gary Bobker. When Friant Dam was put in, the river was flat-lined, said Bobker, and the main stem cut off from the Delta. This has resulted in saltwater intrusion and poor water quality in the Delta, said Bobker.

Low flows in the San Joaquin have contributed to the problem of low dissolved oxygen in the water, particularly in the Stockton Ship Channel, the topic of U.C. Davis' Alan Jassby, who explained that other contributing factors include dredging of the channel, its geometry, and inputs of oxygen-devouring nutrients, such as nitrogen and phosphorus. Lawrence Berkeley Laboratory's Tryg Lundquist explained how real-time management of water quality in the San Joaquin could allow resource managers and farmers to take advantage of windows of opportunity for improving water quality by holding back polluted water and releasing it at times when there is less pollution in the river. USGS's Larry Brown described the river as the "most-invaded major river in the West," but said a surprising number of native fish species are surviving in it anyway.

U.C. Berkeley's John Dracup warned that global climate change could affect the river—and Northern California rivers overall—by putting more water in them earlier in the spring (which might tempt water purveyors to build more dams), and less later in the year when we need it more. The Friant Water Authority's Ron Jacobsma said that this year, more water was released from dams on the San Joaquin than "would have occurred in nature." Scott McBain, of McBain and Trush, delved into restoration challenges, describing the river's variable underlying geology and geomorphology. The river's slope and gravel pits are constraints, although not insurmountable ones, said McBain. His firm has restored other rivers that had been gravel-mined, he said, adding that some solutions—such as removing dikes and berms and allowing the river to re-establish a channel and floodplain in certain areas—would be simple.

The river's valley was the topic of the Great Valley Center's Carol Whiteside, who painted a picture of a rapidly disappearing landscape. The Central Valley's population is growing faster than California, the United States overall, and even Mexico, said Whiteside. "As housing in the Bay Area and coastal regions gets less affordable, people continue to pour into the Central Valley." Plus, said Whiteside, there is a high rate of immigration from other countries—and a high fertility rate among Central Valley residents. Whiteside wondered why farmers and environmentalists are not partnering to save open space and ag land in the valley. But when a developer offers a farmer a million dollars for an acre, she lamented, ag land disappears. "I urge you to help us," she implored the crowd. "We have a chance right now to develop a strategic long-term view of the valley."

A panel discussion on CALFED and its role in the Delta wound up the talks on Day Two, with moderator Steve Ritchie questioning whether the state and federal agencies that make up CALFED are capable of resolving the thorny issues looming ahead. CALFED's new interim director, Joe Grindstaff, said he thinks people have forgotten how important it is to work together as an institution. "If we didn't have [CALFED], we'd have to invent it again," said Grindstaff. The other panelists—the Department of Water Resources' Les Harder, Gary Bobker, and the State Water Contractors' Laura King Moon—agreed, although Bobker suggested that maybe CALFED's structure needs to evolve. "Any program is about achieving your ends," said Bobker. "If we don't have clear and measurable goals, we don't know where we are." Bobker argued for a more independent science program than we've had in the past under CALFED, while King Moon said the program might need to become more strategic in its focus. Harder pointed out that under the current science program, our level of scientific understanding has increased exponentially.

And the science at the conference was extensive, both big picture and detail-oriented. The first day's speakers discussed how science will guide restoration around the Bay. U.C. Berkeley's Maggi Kelly told the crowd that by taking a landscape ecology approach—and applying a variety of spatial scales—we can decide which functions we are interested in maintaining and restoring in Bay wetlands.

One of the largest such projects—the South Bay salt ponds—was the topic of San Jose State University's Lynne Trulio, who explained how science is helping define goals and pin down uncertainties. "How much tidal marsh should we restore?" asked Trulio. "Adaptive

management will tell us how far we can go along the way. We will learn as we go—it's not trial and error, but it's based on an understanding of the system." Science will also guide how we monitor projects, said Trulio.

Stuart Siegel, next on stage, set forth several needs related to monitoring, which is often seen as not that important. In monitoring, said Siegel, we need to look for change, try to detect the outcomes of our actions by analyzing data, and convert that analysis to knowledge. We need to make information widely available, develop "lessons learned" and reference conditions, and solve problems related to wetland restoration—like mercury methylation, contaminants, and sediment supply, to name just a few, said Siegel. We also need to come up with science-based strategies for regional and sub-regional monitoring efforts, he suggested.

Thirty years of monitoring of 45 tidal marsh restoration projects (2,800 acres) implemented around the Bay since the 1970s gives us sufficient information to restore the 20,000 acres now in planning and design stages, said Phyllis Faber. The lessons learned on those projects helped form the basis of the *Design Guidelines for Tidal Wetland Restoration in San Francisco Bay,* published by Phil Williams and Associates and the Bay Institute with funding from the Coastal Conservancy. Faber said one thing we know for sure is that if we get the elevations right, "it is wasteful and costly to plant. Natural processes have fared better than highly engineered projects. We need to be more patient, to measure time for restoration in decades, not years."

PWA's Michelle Orr spoke of lessons learned in South Bay restoration projects. We now know that we do have enough sediment in the South Bay for tidal marsh restoration, said Orr, but we do not yet understand the sediment demands of mudflats.

The University of San Francisco's John Callaway talked marsh and mudflat too, examining whether elevation is a good predictor of tidal salt marsh plant distribution and concluding that while elevation is important, so are inundation by the tides and creeks and competition from other plants.

Another area we don't completely understand is the extent to which restoring tidal wetlands will benefit Bay food webs. The interactions between tidal wetlands and pelagic areas are not well understood, said the University of Washington's Si Simenstad. We do know that the Delta is the "detritus mill" for the Bay, said Simenstad, with 30 percent to 40 percent of the organic matter it exports out of the system going to downstream food webs. Simenstad said we also know, from studying Suisun Marsh, that tidal marshes are highly productive, are critical rearing areas for fish and invertebrates, and provide refuge for native species.

Tidal marsh restoration is also important for non-aquatic species. PRBO researchers are studying how birds like song sparrows and common yellowthroats are responding to marsh restoration—and how landscape-level factors, vegetation, and hydrological and geomorphic processes limit their numbers and reproductive success. We also know that birds—songbirds in particular—respond rapidly to riparian habitat restoration. PRBO's Geoff Guepel showed a graphic illustrating the immediate and steady upward climb of bird density on the Sacramento River after restoration, and described how this year, the endangered least Bell's vireo and the locally extirpated yellow warbler returned to a newly restored site on the San Joaquin River. "Revegetation is working," said Guepel, who added that planting a habitat mosaic and a diverse understory is critical to restoring bird diversity. But he cautioned that without restoring floodplain dynamics and taking other conservation actions, nest success—especially in remnant forests—may remain low.

> "The ecological value in intermediate-stage restoration sites is very high."
>
> Nadav Nur, PRBO Conservation Science

For some species, like chinook salmon and steelhead in the Central Valley, restoration measures will need to be more drastic. NOAA's Steve Lindley described how his agency is developing viability goals for populations and evolutionarily significant units (ESUs) for each species. But he cautioned that without access to their prime spawning habitat—much of which is behind impassable dams—these fish will remain at risk of extinction.

Restoring habitat by removing dams is politically tricky but pretty straightforward from a fish's perspective—suddenly you have access to habitat that

you didn't before. But for other types of restoration projects, said PRBO's Nadav Nur, we need to develop success criteria that focus on evaluating young restoration sites, so we can enhance the values of those sites for the critters we are targeting for recovery and so we can take corrective steps if necessary. We do know that a site doesn't have to be mature to be valuable as habitat, said Nur. "The ecological value in intermediate-stage restoration sites is very high."

It is also important to evaluate restoration from the perspective of the most dominant species, cautioned the South Bay Salt Pond Restoration Project's Steve Ritchie. "We can't let endangered species run the show. We need to use every opportunity to educate folks and to monitor changes in community values and interests as well. We need to make sure restoration works for humans, as well as animals."

The S.F. Bay Joint Venture, by pulling in as many human stakeholders as possible, is trying to make sure that happens. The Joint Venture's Beth Huning gave an overview of wetland and riparian acquisition, restoration, and enhancement projects around the Bay, describing how building partnerships among businesses, private individuals, and nonprofits has been critical to the projects that have taken place so far. Huning emphasized the importance of acquisition. "Before we can restore, we need to protect," she said.

And to acquire more land for restoration, we need to convince the public of the value of restoration. Science alone isn't enough, said the S.F. Regional Board's Bruce Wolfe, echoing earlier speakers. We must also be able to report on our actions to the public in ways they can understand, said Wolfe. "Decisionmakers and the public want to know how we're doing, they want to know what we've done, and they want to hear the message in easy-to-understand terms. "'Restoring creeks' resonates better than 'minimizing the hydrogeomorphic impacts to riverine functions,'" said Wolfe, who added that his agency is committed to working with Bay nonprofits and scientists to identify what enhancement and restoration the Estuary needs, the performance standards needed to do that, and how best to track our progress as we move forward.

The Bay Institute's Anitra Pawley described her agency's attempts to track progress with its just-released second Ecological Scorecard. "Society is obsessed with performance measures," said Pawley. With a simple conceptual framework, the scorecard asks, in general, if we can fish from, swim in, and drink Bay-Delta water, explained Pawley. While there is an incremental upward trend in these criteria for the Central and South bays, said Pawley, the upper parts of the Bay—San Pablo and Suisun bays—are in serious trouble, with fish and other organisms declining and invasive species increasing. "We've done a lot of damage to the Bay, and it will take a while to reverse," she predicted.

What's really needed in monitoring the health of the Estuary is an approach linking ecology and toxicology, said Susan Anderson of U.C. Davis' Bodega Marine Laboratory. She described how she has measured the exposure of mudsuckers, a sediment-dwelling fish, to contaminated sediments in Stege Marsh. "They're not sexy, but they live in salt marsh mud and are directly exposed to the sediments being regulated. We can measure a lot of things in an efficient and humane way—we use every part of the fish." Anderson pointed out that just because we don't always measure the effects of contaminants on fish and invertebrates, that doesn't mean impacts aren't there. "Our contention is that it's not enough to go out and see marsh birds—we need to know their health."

"Our challenge is to put the Bay, Baylands, and watersheds back together again"

Josh Collins, San Francisco Estuary Institute

The health of the food web also affects humans, of course, particularly those who eat fish from the Bay and Delta. Cal EPA-OEHHA's Bob Brodberg chronicled the history of fish consumption advisories for the Bay-Delta and said that as new chemicals are found, they will be monitored extensively. Consumption advisories not only provide the public with information and choices, said Brodberg, but could also be used in setting cleanup and restoration goals. The current advisory for the Bay-Delta Estuary, said Brodberg, is that adults should eat no more than two meals per month of Bay sport fish, including sturgeon and striped bass caught in the Delta. Adults should not eat any striped bass over 36 inches, said Brodberg, and women who are pregnant, may become pregnant, or are nursing should not

eat more than one meal of fish per month—nor should children under the age of six.

Another restoration and monitoring link we need to make is that of watersheds to wetlands, said SFEI's Josh Collins "We have to embrace the idea that the Baylands really are the edge of the Bay," he said, adding that those places where streams and rivers meet the Bay have become a sort of no-man's land, falling somewhere between watershed science and Bay science. "Our challenge is to put the Bay, Baylands, and watersheds back together again," said Collins. "We need to reconnect with our watersheds." Yet this year's conference had little focus on the streams that flow to the Bay or their watersheds. Collins' take-home point was that we need to set riparian habitat goals—"force ourselves to just do it!"—as we have already done for wetlands.

The only other discussion of streams and watersheds occurred in a panel presentation about stewardship around the Bay—a first for the State of the Estuary Conference. Four people working and volunteering to improve habitat and water quality in and around the Bay described just how essential volunteers have become to maintaining and restoring wetlands, uplands, and streams. The Golden Gate National Parks Conservancy's Mike Lee calculated that more than 16,000 volunteers contribute 382,000 hours of support each year to his agency, dealing with visitors, working in native plant nurseries, maintaining trails, counting and banding birds, and handling other tasks. Mondy Lariz, with the Stevens and Permanente Creeks Watershed Council, said his organization has at least 80 full-time volunteers engaged in watershed stewardship, including water quality monitoring. And recently, 1,460 volunteers helped clean up 46 miles of creeks in Santa Clara County, said Lariz, removing 40,000 pounds of trash. U.S. Fish & Wildlife's Mendel Stewart said volunteers at the S.F. Bay National Wildlife Refuge complex are the equivalent of 19 full-time staff people, at a dollar value of $470,000. And Save the Bay's Marilyn Latta concluded that nearly 30,000 volunteers have contributed 150,000 hours to work on habitat restoration with her organization over the past five years. "Without public education and community support, we will never be able to truly save the Bay," she said. "Stewardship is one piece of the solution." Volunteers cannot replace "large-scale construction" efforts in restoration, she added, but they can supplement and enhance it.

With help from volunteers—and from federal and state agencies, nonprofits, and local governments and businesses—we're making progress. The largest restoration projects ever undertaken on the Bay are underway. The Coastal Conservancy's Amy Hutzel gave a progress report on two large tidal marsh restoration projects in the North Bay—the Napa salt ponds, which began in Fall 2005, and the Hamilton Airfield. Napa is less subsided than Hamilton, said Hutzel, and will be restored primarily by breaching and lowering existing levees. Hamilton, which has subsided by about 10 feet, presents more of a challenge and will need seven million cubic yards of dredge material deposited on it to achieve a restorable elevation.

The South Bay is also gearing up, said Cal Fish & Game's Carl Wilcox, with restoration projects at Bair Island (1,700 acres of diked Baylands to tidal marsh), Eden Landing (650 acres of former crystallizers and salt ponds to tidal marsh, plus enhancing another 200 acres of managed ponds and restoring some sloughs), and the former salt ponds (15,100 acres acquired from Cargill in 2003), which are being managed under an initial stewardship plan.

> "We have groundwater overdraft of one to two million acre-feet statewide. We cannot keep doing that kind of deficit spending."
>
> Kamyar Guivetchi, Department of Water Resources

Progress is being made not only on the ground but also at the policy level. The Department of Water Resources' Kamyar Guivetchi unveiled the California Water Plan 2005, which, for the first time, includes an implementation plan for using water efficiently, protecting water quality, and supporting environmental stewardship. "We have to wring every drop of water out of our water supply system," said Guivetchi. "We have groundwater overdraft of one to two million acre-feet statewide. We cannot keep doing that kind of deficit spending." Guivetchi proclaimed that in the future, we must have a better link between land use planning and water management, and that planning should be more inclusive of tribal and disadvantaged

communities. Another sea change for this plan, he told the crowd, is that key decisions about water are going to have to be made at the regional level—although not as islands unto themselves.

Amid the progress, new and old challenges lurk. Maurya Falkner with the State Lands Commission reported on the 2003 reauthorization of a statewide mandatory ballast water management law designed to reduce or prevent invasive aquatic species from entering the state's waters. Falkner said vessels have exceeded compliance requirements by 90 percent, but fouled ship hulls are still introducing invasives. SFEI's Andrew Cohen said that while the reports about compliance are reassuring, if you read the fine print, many ships are exempted and there is no good method of testing ships' ballast water at the end of a voyage. Cohen estimates that even when ballast water exchange does occur—more than 200 miles from shore as required—only 70 percent to 85 percent of the organisms are removed. Cohen agreed that fouled hulls are one of the biggest problems and added aquaculture to the list: "It's good at moving diseases and parasites and pests."

Another pest—of the vegetative kind—was the topic of the S.F. Estuary Invasive Spartina Project's Erik Grijalva, who reported on the most recent effort to control invasive spartina species. Between 2001 and 2003, said Grijalva, there was a 260 percent increase in non-native spartina hybrids with diverse genotypes that can start new colonies anywhere. "The greatest threats are to mudflats and restored tidal marshes," said Grijalva. "If we do something right now, we have a chance to control it." This year's treatment, after the marshes were surveyed for the presence of clapper rails, tackled 70 percent to 80 percent of the infestation, said Grijalva.

But the biggest challenges for the Estuary—and for restoration projects—will likely be meeting the economic and environmental challenges of the state's increasing population, said the Public Policy Institute of California's Ellen Hanak. The state's reliance on bonds to pay for public investments in infrastructure, land acquisition, park lands, restoration—and a host of other public benefits—is not sustainable, said Hanak, since the ratio of general fund debt to revenue may limit our capacity for new bonds in the near future. That bodes ill for restoration—state bonds have been its main funding source for several years. Funding will also be an obstacle for nonpoint source pollution control efforts, said Hanak. Yet despite the woeful state of the state's piggybank, most Californians are quite concerned about coastal pollution, toxics in soil and water, and polluted runoff in our rivers and lakes, according to an Institute survey. And most people surveyed agreed that even with the large state budget deficit, we should continue to fund environmental programs at the current level.

Adding to the doom side, the Coastal Conservancy's Nadine Hitchcock warned that although the Conservancy and the Wildlife Conservation Board have acquired more than 100,000 acres around the Bay, there is almost no money left for new projects. Politicians frequently see funding for ecosystem restoration as competing with funding for traditional engineering projects, said Hitchcock. Despite these setbacks, Hitchcock said, we need to do more restoration projects in disadvantaged communities, like the Conservancy-funded restoration of Yosemite Slough in San Francisco's Hunter's Point. "We have many more competing needs with limited funds," concluded Hitchcock. "We need to develop a regional vision for the landscape and pursue local and regional funding. There's a horse race between people acquiring land for preservation and people acquiring it for development."

"We need to develop a regional vision for the landscape and pursue local and regional funding. There's a horse race between people acquiring land for preservation and people acquiring it for development."

Nadine Hitchcock, California Coastal Conservancy

The Department of Water Resources and the Coastal Conservancy recently acquired the former Dutch Slough dairy farm in eastern Contra Costa County—at the center of the "horse race." That site will be restored to tidal marsh instead of being covered with 4,500 houses. "All of our restoration efforts will be relatively futile if we are unable to stem the tide of urbanization in the Delta," said the Natural Heritage

Institute's John Cain, one of the project's managers, sounding again the warnings from earlier in the conference. The most important thing we can do now, said Cain, is to acquire land. "Restoration can wait, but the time for acquisition and preservation is now," said Cain, who thinks we should expand the Delta Protection Commission to protect the secondary zone in the Delta.

> "Restoration can wait, but the time for acquisition and preservation is now"
>
> John Cain, Natural Heritage Institute

There is a lot of work to be done, especially around land use issues—the ghost in the cellar we've never quite faced. Yet it is not too late for the Bay Area to lead the way to a more sustainable future, said Rainforest Action Network founder Randy Hayes, now with the City of Oakland. "San Francisco, Berkeley, and Oakland were named as among the top 10 'green cities' in the country," he told the audience. "But we're at best light green. We can work toward medium and deep green. We need to work toward an ecological U-turn, to start a paradigm shift that sets the tone for the entire country."

> "We need to better explain, in economic terms, why protecting the natural environment is important to solving other problems."
>
> Will Travis, BCDC

Not only did there seem to be a general consensus among conference speakers that we need better land use policies and communication with the public, but there was also a consensus that we cannot rest on past accomplishments. We need to keep on saving the Bay, as Save the Bay founder Sylvia McLaughlin said in a recent interview in the *San Francisco Chronicle*. In his rousing conference wrap-up, BCDC's Will Travis described how McLaughlin told him that sometimes there can be too much science—that she saved the Bay because she had "never seen anything so beautiful." We need to remember those reasons, said Travis, when communicating with the public.

Dismayed at the lack of discussion of the environment and the Bay at a recent Bay Area Council dinner he attended, Travis told the Estuary conference crowd, "We need to make the case for the Bay in the language most people understand—that of economics." If we sit around speaking science among ourselves, he warned, we will fail to play the role we need to play in political decisions about where the predicted one million new California residents will live and work, how to develop affordable housing for those residents, and how they can avoid spending most of their lives in traffic jams. "We need to better explain, in economic terms, why protecting the natural environment is important to solving these other problems," said Travis.

According to the Joint Venture Silicon Valley's Russell Hancock, the Silicon Valley is starting to think about how the environment benefits its economy, which, he said, is slowly improving in a more sustainable way, without another flash-in-the-pan dot-com boom and bust. "The best way to compete [with other regions] is to provide a fabulous place to live," said Hancock. As Travis put it, with the Bay, we have the "equivalent of a national park in our front yards," where we can swim, fish, sail, and enjoy wildlife. "The decision to save the Bay in 1965 is responsible for our economic prosperity today," Travis reminded the crowd. "[The Bay] is probably the best fringe benefit any Bay Area employer can offer. We need to keep reminding them of how much it's worth."

> "With the Bay, we have the equivalent of a national park in our front yards, where we can swim, fish, sail, and enjoy wildlife."
>
> Will Travis, BCDC

Vital Statistics

Photo courtesy of David Hart and John Sanger

Flows

Recent Inflows

Normal or above normal rainfall has meant improved Delta inflows in recent years. Inflows to the Delta and Estuary were 21.6 million acre-feet (MAF) in water-year 2004 (October 1, 2003–September 30, 2004) and 21.8 million acre-feet (MAF) in water-year 2005 (October 1, 2004–September 30, 2005). Delta outflows were 15 MAF in 2004 and 15 MAF in 2005. (Interagency Ecological Program, 2005)

Diversions for Beneficial Use

Water is diverted both within the Delta and upstream in the Estuary's watersheds to irrigate farmland and supply cities. In-Delta exports have largely remained within the range of 4 to 6 MAF per year since 1974, but the percentage of Delta inflow diverted can vary widely from year to year. In water-year 2004, 6.1 MAF was diverted, and in 2005, 6.4 MAF. The average percentages of total Delta inflow diverted were 36.9 in 2004 and 36.7 in 2005. (Interagency Ecological Program, 2005)

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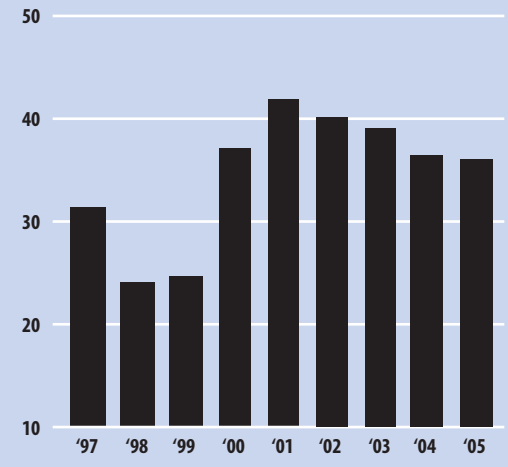
PERCENT OF INFLOW DIVERTED



Source: DWR, Exports TOT

Water Use Efficiency

Water use efficiency, conservation, and recycling projects within the Bay-Delta region aim to provide a "drought-proof" source of water to help meet the needs of cities, industries, and agriculture. As of 2004, CALFED's water use efficiency program had provided $43 million in water recycling grants, with additional funding provided by propositions 13 and 50. CALFED expects that these projects will make a significant contribution toward meeting its water use efficiency goals.

At the local level, the Bay Area Water Recycling Program's (BARWRP) Master Plan, now complete, calls for recycling 125,000 acre-feet/year in the Bay Area by 2010, and about 240,000 af/year by 2025. Many Bay Area agencies are forging ahead with the design, construction and operation of water recycling projects. For example, the Dublin San Ramon Services District (DSRSD) recycling facility's current treatment capacity is 3 million gallons per day (mgd), with 10 miles of distribution installed. Planned capacity for this facility is 9.6 mgd. DSRSD and the East Bay Municipal Utility District (EBMUD) are jointly developing the San Ramon Valley Recycled Water Program (SRVRWP), which will serve areas of Blackhawk, Danville, Dublin, and San Ramon. When complete, this multi-phased 6.7-mgd project is expected to deliver 3.3 mgd to DSRSD's service area and 2.4 mgd to EBMUD's service area with 1 mgd available to either. DSRSD has been delivering recycled water since November 2005. EBMUD customers including the City of San Ramon, the San Ramon Valley Unified School District, and Chevron's world headquarters began receiving recycled irrigation water in February 2006. Meanwhile, EBMUD currently produces almost 6 mgd of recycled water. In addition to its joint project with DSRSD, EBMUD's multi-phased East Bayshore Recycled Water Project (EBRWP) is currently under construction and is expected to begin delivery to Oakland customers in the late summer or fall of 2006, expanding to Albany, Berkeley, and Emeryville in 2007. The EBRWP will ultimately include nearly 30 miles of pipeline through parts of Alameda, Albany, Berkeley, Emeryville, and Oakland and will save 2.5 mgd (2,800 acre-feet/year) once all recycled-water customers are hooked up to the system. The first phase will supply up to 0.7 mgd. Eventually, EBWRP water may be used in wetlands restoration.

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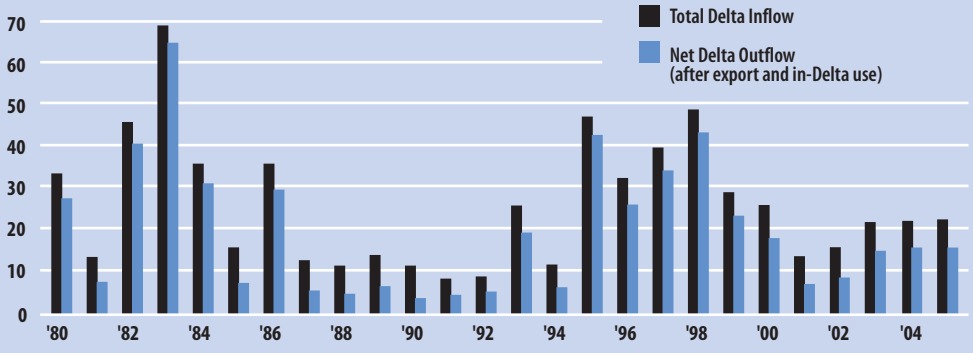
FRESHWATER FLOWS TO THE SAN FRANCISCO ESTUARY, 1980-2005
IN MILLIONS OF ACRE FEET



Source: DWR, Dayflow QTOT

Steelhead

Chinook Salmon

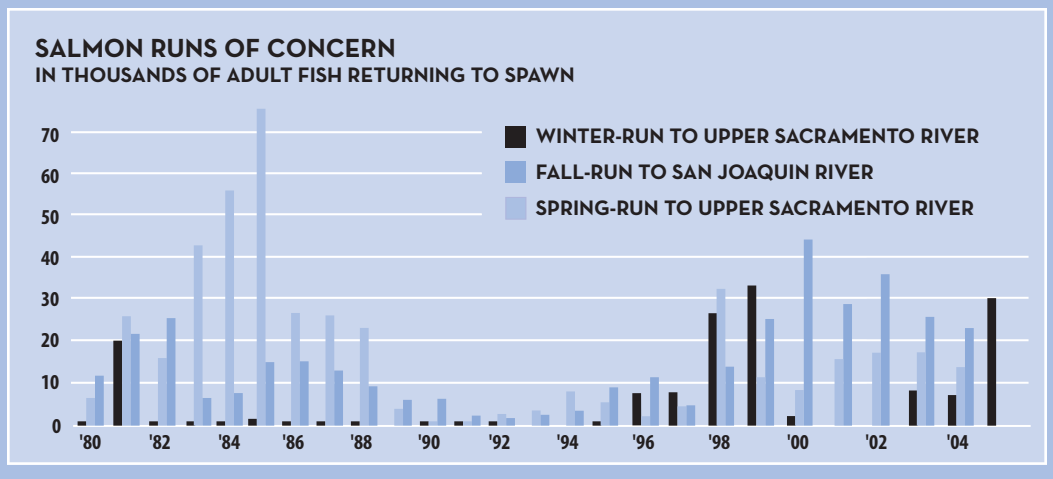
Illustrations: Bill Crary

Fish

Central Valley Salmon

Most populations of Central Valley chinook salmon seem to be holding relatively steady. Central Valley chinook salmon occur in four discrete runs—winter-run, spring-run, fall-run, and late fall-run (run refers to the season in which adults return to their native streams to spawn). The winter-run chinook salmon, with the lowest population, has been listed as both a state and federal endangered species since 1994. As a result of more regular interagency scrutiny of operations, a new counting method for chinook winter-run salmon critical to assessing "incidental take limits" is now in place. Federal incidental take limits for winter-run allow up to two percent of "juvenile production" to be lost at the pumps. The formula for setting take limits combines the number of offspring produced ("juvenile production") with the number of adult fish returning to spawn each year ("adult escapement"). The latter number—based on how many fish passed through the Red Bluff Dam fish ladders—became questionable in recent years as the dam gates remained open for longer periods and fewer fish had to use the ladders. An alternative method, counts of spawned female carcasses upstream, backed up by earlier surveys, revealed a variation of up to a factor of five in the total estimates of spawning adults. The new higher estimates of adult escapement translated into a higher estimate of juvenile production and meant that the take limit was never reached in 2001, for example, changing the need to reduce pumping and use EWA resources to protect fish. The winter-run population was 8,218 in 2003 and 7,785 in 2004. The 2005 winter run was estimated by the Department of Fish and Game as 15,000, of which 18 percent were hatchery fish—higher than the usual 5 to 10 percent. (*Sacramento Bee*, November 21, 2005)

The next most sensitive stock, the spring-run, was state listed as threatened in 1998 and federally listed in 1999. The spring-run population was 17,564 in 2003 and 13,907 in 2004. Sacramento fall-run are the most



abundant chinook stock. Their population fluctuated from 569,976 returning in 2001 to 839,956 in 2002 (the estimated population for Battle Creek was the highest on record), dropping to 579,293 in 2003 and 346,277 in 2004. Returns of the San Joaquin fall-run in 2003, at 25,348, and in 2004, at 22,654, were both above the 1967–1999 average annual return of 20,470. The late fall-run (distinct from fall-run) population was 8,322 in 2003, increasing to 13,922 in 2004.

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Striped Bass

Native to eastern North America, the striped bass (*Morone saxatilis*) was introduced to California in 1879, when fish from New Jersey's Navasink River were released in the San Francisco Estuary. The species did well in its new environment, supporting a commercial fishery from 1888–1935, and is still the basis for an important sport fishery. However, the population began to decline in the 1930s, prompting tighter regulation of sport fishing and intensive research.

Abundance indices of striped bass in their first year of life (young-of-the-year or YOY) remain at very low levels. Where the peak Midsummer Townet Survey (TNS) index was 117 in 1965, the 2005 index was 0.9. The TNS index of 0.8 in 2004 was the lowest in the 45-year history of the survey. Where the peak Fall Midwater Trawl Survey (FMWT) index was 20,038 in 1967, the 2005 index was 121, up from 53 in 2004.

Calculations of recent adult striped bass numbers have not been completed, but catch-per-unit-effort and length-frequencies during 2005 spring tagging for the adult population study show recruitment has been substantial even though indices of young-of-the-year abundance were very low the years these fish were spawned. This relationship is the subject of on-going investigation.

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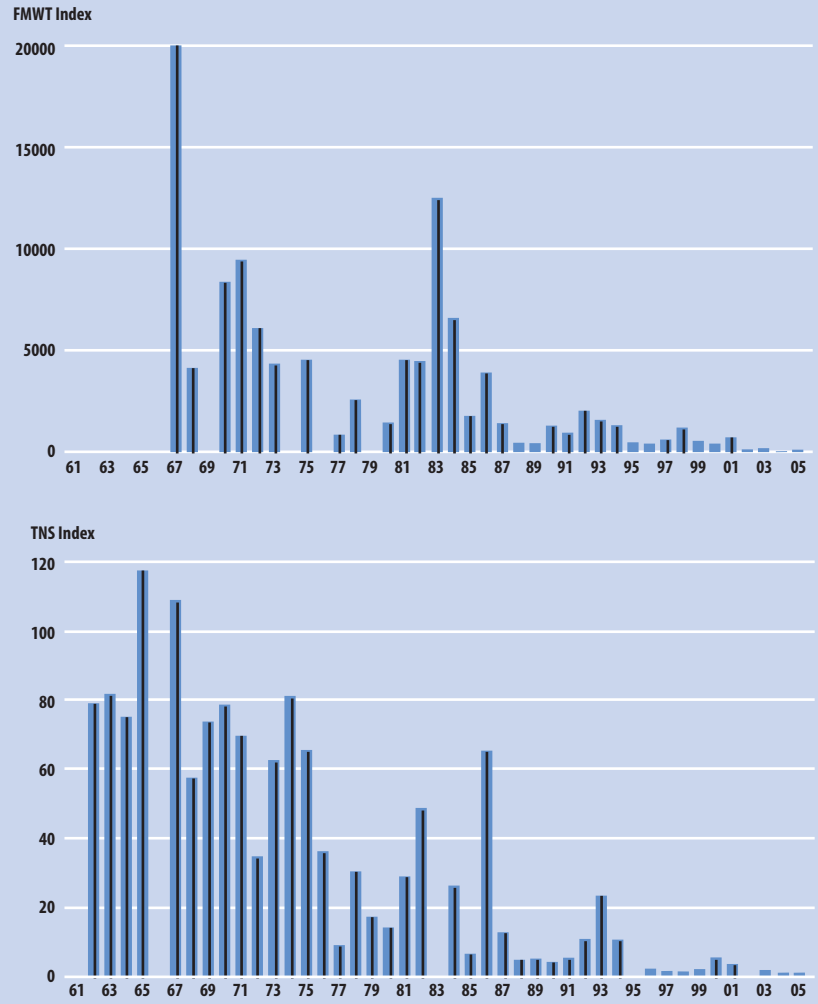
Delta Smelt

The Delta smelt (*Hypomesus transpacificus*), a 55–70 mm long osmerid, is endemic to the upper San Francisco Estuary. It was once quite common, but a dramatic decline in the 1980s led to the federal and state listing of this fish as a threatened species in 1993. It is the annual life cycle, limited diet, low fecundity, and restricted distribution within the Estuary that make Delta smelt environmentally sensitive. Possible reasons for the decline of Delta smelt include reductions in Delta outflow, extreme high flows (which displace them away from suitable rearing habitat), entrainment losses at major water diversions and power plants, prey item changes, competition, toxicants, disease, changes in salinity, and predation.

Delta smelt abundance generally increased during the 1990s, which may have been due to above-normal outflow conditions and reduced pumping exports, aiding in the transport of larval/juvenile fish from the Delta to their rearing grounds in the Suisun Bay area. To reduce the impact of Delta pumping operations on smelt, CAL-

STRIPED BASS INDEX
1961-2005



FED developed the Environmental Water Account (2000), which helps to reduce Delta smelt take by shifting the timing of pumping. It is still difficult to determine whether or not this effort is benefiting Delta smelt on a population level.

More recently, as of 2001, Delta smelt abundance indices have reached all-time lows for two of California Department of Fish and Game's (DFG) long-term monitoring surveys, Summer Townet Survey (TNS, since 1959) and the Fall Midwater Trawl (MWT, since 1967), despite respectable water years. For example, TNS indices from 2003–2005 are 1.6, 2.9, and 0.3 respectively (compared to the 2002 TNS of 4.7), while MWT indices for the same years are 210, 74, and 26 (compared to the MWT 36-year average of 556). Such abrupt decreases in Delta smelt and other pelagic fishes have prompted a special task force to address this Pelagic Organism Decline (POD).

Just recently (2005) a new monitoring survey called the Delta Smelt Larval Survey (DSLS) began, which targets larval Delta smelt. Information from the DSLS along with the 20 mm survey may aid in water management decisions in order to maintain a balance between preserving Delta smelt and providing California's water.

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Longfin Smelt

Longfin smelt (*Spirinchus thaleichthys*) in the Estuary represent the southernmost spawning population in North America, and their abundance continues to be positively correlated with Delta outflow during their December-May larval period (Baxter 1999). Since the extremely wet winter of 1998, Delta outflow for the December-May period has generally declined through 2005, and so has the abundance of longfin smelt, as measured by Cal Fish & Game's Fall Midwater Trawl Survey. Since 2003, the abundance index for longfin smelt has been below 200, and in 2005 it dropped to 129. These indices are close to the record low indices recorded at the end of the 1987–1992 drought (http://www.Delta.dfg.ca.gov/data/mwt/), and probably reflect poor early survival conditions resulting from recent low winter outflow years and changes in food web dynamics brought about by the introduced Asian clam, *Corbula amurensis* (Kimmerer 2002). On a positive note, for several years Cal Fish & Game has continued to collect 115–40 mm spawners (about three years old) in trawl sampling. These age-three females can produce over twice as many eggs as age-two females, and such spawners can help buffer against poor year-classes. (Baxter, Pers. Comm., 2006)

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Splittail

Abundance of young Sacramento splittail (*Pogonichthys macrolepidotus*) has been low from 2002 to 2005 based upon results from the Cal Fish and Game Fall Midwater Trawl (http://www.Delta.dfg.ca.gov/data/mwt/). For most of these years low abundance resulted from low river flow and lack of floodplain inundation during the splittail spawning period in late February–May. However, spring flows in 2005 appeared good and some recruitment was detected by US Fish and Wildlife beach seining and trawling surveys (www.Delta.dfg.ca.gov/data/rtm2005/), so low Fall Midwater Trawl abundance was not expected and remains to be investigated. Splittail are known to spawn on inundated terrestrial vegetation, and their recruitment appears most strongly associated with the magnitude and duration of floodplain inundation during the spawning period (Sommer et al. 1997, Moyle et al. 2004). In September 2003, US Fish & Wildlife removed splittail from the list of threatened species. The silvery-gold minnow, found only in tributaries to the S.F. Estuary and the Delta, is the only fish species to be de-listed for reasons other than extinction. Although splittail was de-listed, it remains a species of concern because of its limited access to spawning habitat during low flow years and the potential for future water management decisions to exacerbate its situation.

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Pacific Herring

Until 2005, the spawning biomass of Pacific herring (*Clupea pallasi*), which supports the Bay's largest commercial fishery, has remained below the long-term (since 1978) average of 52,234 short tons. In response to this decline, the Fish and Game Commission, which manages the fishery, lowered catch quotas. Although ocean productivity has been favorable for herring over the last several years, a large recruitment of young fish to the spawning population has yet to occur, and older age classes have been declining. Following record high biomass levels of 99,050 short tons in 1995–1996 and 89,570 short tons in 1996–1997, spawning biomass plunged to 20,000 short tons following the 1997 El Niño. Since then, spawning biomass estimates have been 39,500 short tons for 1998–1999, 27,400 short tons for 1999-2000, 37,300 short tons for 2000–2001, 35,400 short tons for 2001–2002, and 34,400 short tons for 2003–2004 (a biomass number was not finalized for 2002–2003 because of discrepancies

between spawn deposition survey data and hydroacoustic survey data). The 2004–2005 spawning biomass estimate was 58,934 short tons, a 71% increase from the previous season and the first estimate to exceed the long-term average of 51,825 tons used to set fishery quotas since the 1996–1997 season.

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Green Sturgeon

Limited evidence suggests that overall, the population of the anadromous green sturgeon (*Acipenser medirostris*) may be declining in California. It is known to spawn in the Klamath, Trinity, and Sacramento rivers, as well as the Rogue River in Oregon. Little is known about its historic or current distribution and movement throughout the Estuary, but abundance estimates do not suggest that the population has declined in the Estuary (Kelly & Klimley 2004, Cal Fish & Game 2001). While green sturgeon are long-lived (up to 70 years), delayed reproduction, combined with habitat destruction and pressure from fishing, makes it difficult for them to replenish their populations quickly. In 2001, a coalition of environmental groups petitioned NMFS to list the green sturgeon as either endangered or threatened. As part of its review, NMFS identified two distinct population segments: the northern population (found north of the Eel River along the coast) and the southern population (includes any coastal or Central Valley populations south of the Eel River, with the only known population in the Sacramento River). NMFS declined to list the green sturgeon in 2003, but placed both population segments on its list of species of special concern. Following litigation by the Environmental Protection Information Center and a March 2004 court decision remanding the determination, NMFS proposed listing the southern population segment as threatened in April 2005. The agency's supporting rationale included the concentration of spawning adults in a single river, loss of spawning habitat in the upper Sacramento and Feather Rivers, and negative trends in commercial bycatch and juvenile entrainment data since 1986. NMFS also noted that green sturgeons may be feeding on the exotic overbite clam which is known to bioaccumulate toxic selenium. A public hearing on the proposed listing has been held, and a final determination is pending. Meanwhile, scientists are studying parameters influencing sturgeon movement within the Estuary, preferred spawning locations and environments, and residence time within the river and Estuary system (Kelly & Klimley, 2004). The results of such studies could inform improved natural resource management and protection efforts for the species.

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Kern Brook Lamprey

Endemic to the San Joaquin Valley, the Kern brook lamprey (*Lampetra hubbsi*) is a primitive eel-shaped vertebrate with an unusual life cycle. Typical lampreys are predators, attaching to fish with suckerlike mouths, rasping a hole with a tongue covered with sharp plates, and feeding on the victim's blood and body fluids. However, several species have evolved a nonpredatory lifestyle. Instead of migrating to sea as larvae (ammocoetes), Kern brook lampreys and other nonpredatory species spend their entire lives in their natal streams. The larvae subsist on algae and detritus; after metamorphosing in the fall, adults spawn in spring in gravelly riffles and die without feeding.

First collected from the Friant-Kern Canal in 1976, Kern brook lampreys were later found in the lower Merced, Kaweah, Kings, and San Joaquin Rivers. As larvae, they occupy silty backwaters of foothill streams, preferring cool, shallow pools and other low-flow environments with sandy or muddy substrates. Many such habitats have been eliminated by channelization. Known populations are scattered through the San Joaquin drainage and isolated from each other. With one exception, all populations are below dams where sudden changes in flow may strand the larvae. Larvae have also been drawn into the siphons of canals from which they are unable to return to the spawning grounds.

A California species of special concern, the Kern brook lamprey was denied federal protection in a US Fish & Wildlife Service decision in January 2005. A listing petition for four western lamprey species had been submitted two years earlier by the Center for Biological Diversity and 10 other conservation groups. FWS claimed the petitioners had not provided specific information on threats to the Kern brook lamprey and another nonmigratory species, the western brook lamprey.

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Invasive Species

Green Crab

The European green crab (*Carcinus maenas*) is now established in every significant bay and estuary between Monterey, California and Gray's Harbor, Washington. It appeared in South S.F. Bay in the early 1990s and has spread north at least as far as the Carquinez Strait. Salinity limits the crab's distribution: crabs have been collected from water ranging from 5–31 parts per thousand (ppt) salt to water, but few have been collected from water with less than 10 ppt. A 10-year study in Bodega Bay found that in contrast to their slow growth rates in Europe, green crabs here grew rapidly and reached sexual maturity in their first year. Over the course of the study, the green crab severely reduced the abundance of three common invertebrate species, but did not impact the shorebird food web (Grosholz et al. 2000). Another consequence of green crab predation is the accelerated invasion of another invasive species, the eastern gem clam, which was introduced into Bodega Harbor nearly 50 years ago and is now much more abundant than it has been in past decades. While eradication is not possible at this point, the National Green Crab Management Plan includes several recommendations for local population control strategies. These include early warning methods for new range expansions, prevention measures against new introductions, and coordinated monitoring of population trends, new outbreaks, and losses to commercial fisheries.

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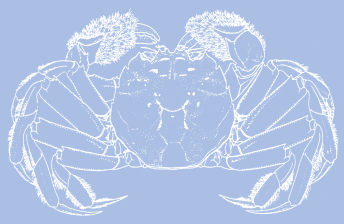

Chinese Mitten Crab

The Chinese mitten crab (*Eriocheir sinensis*) population has increased rapidly since it was first reported in the S.F. Estuary in the early 1990s. Numbers of downstream migrating adults peaked at the BurRec fish facility in 1998, while adult numbers in northern S.F. Bay peaked in 1998 and 2001. All data sources support a population decline from 2002 through 2004, with the 2004 count the lowest since 1996. No adult crabs were detected in Suisun Marsh in 2004, and only four public reports of sightings were made to the toll-free reporting line. When numbers are low, the mitten crab's major impact is stealing bait from sport anglers at some locations in the Delta and Suisun and San Pablo bays.

What controls mitten crab population in the Estuary is not understood, although winter temperatures and outflow are hypothesized to control larval survival and settlement time. A "boom-and-bust" cycle has been reported for some introduced species, although this may not be universally true for all introductions.

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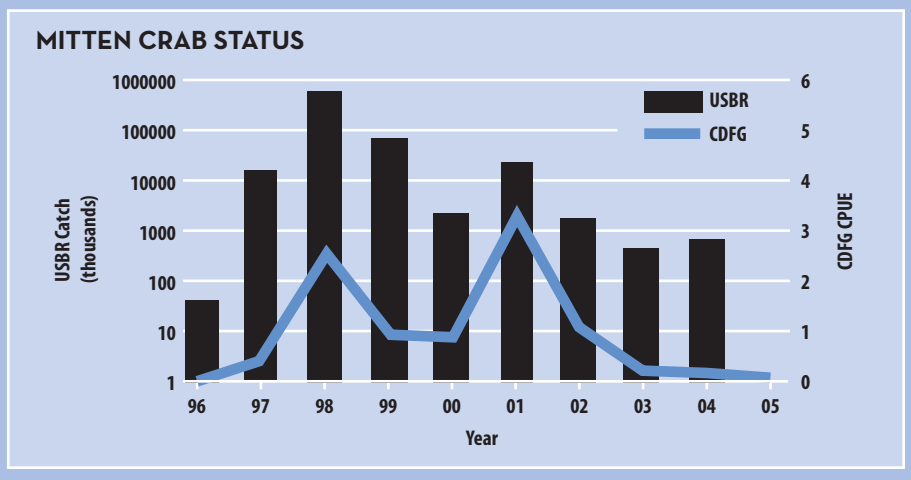
Northern Pike

The voracious Northern pike (*Esox lucius*), native to Canada and the Midwest, was illegally planted in the 85,000-acre-foot Lake Davis reservoir in the early 1990s. In 1997, the California Department of Fish and Game treated the lake with Rotenone to eradicate pike from the lake. The pike were significant predators on the rainbow trout and also presented a potential threat to the Delta ecosystem. The treatment temporarily shut the lake to all recreational uses and compromised local water supplies. In May 1999, about a year after more than a million trout were planted and the lake had reopened, the pike reappeared, possibly intentionally reintroduced. Biologists have pulled approximately 55,000 pike from the lake since 2000. In September 2005 DFG announced a new preferred pike-eradication proposal in which the lake's volume would be drawn down by 75 percent and another Rotenone treatment would be applied. This would not affect drinking water for the city of Portola, which now uses wells and springs. A joint EIR/EIS will be prepared by DFG and the Plumas National Forest. DFG is also working with community leaders to prevent



Total catch of adult mitten crabs at BurRec's fish facility (bars) and catch per unit effort (CPUE) of adult mitten crabs from Cal Fish & Game's S.F. Bay Study otter trawl survey (line), 1996-2005.

another reintroduction, a criminal offense with penalties including a fine of up to $50,000 and up to a year in jail. For current status, visit www.dfg.ca.gov/northernpike/index.html.

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Asian Clam

The Asian clam (*Corbula amurensis*) continues to be the dominant benthic organism in the North Bay. The seasonal decline of the bivalve continues to occur throughout the North Bay in winter of most years, and is followed by peaks in density after reproduction in spring and fall. There have been some short-duration phytoplankton blooms in the North Bay for the last several years during early spring, when *Corbula* biomass is at an annual minimum. These blooms have been earlier and shorter in duration than historic blooms. *Corbula* was first seen in the South Bay in 1988 and had become a dominant bivalve by 1990. Unlike in the North Bay, however, the South Bay phytoplankton bloom has not been depleted by *Corbula* filter-feeding. This is due to the seasonal cycle of *Corbula* in that part of the Bay—during the spring bloom period, clam biomass is very low and thus the clam's grazing pressure is too low to restrict phytoplankton bloom formation.

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Cordgrass

Species of *Spartina* (cordgrasses), introduced into the Estuary in the 1970s, have spread rapidly and pose a serious threat to the success of future tidal marsh restoration throughout the Estuary. The impacts associated with the spread of Atlantic cordgrass (*Spartina alterniflora*) include hybridization with and likely local extinction of native *Spartina foliosa*, regional loss of unvegetated tidal flat habitat, elimination of small tidal channels, and loss of pickleweed habitat essential to the endangered salt marsh harvest mouse. Infested acreage increased by 280 percent from 2001 to 2003, affecting both established and newly restored marshes—11,500 acres altogether. The rate of spread is greatest on mudflats and restored tidal marsh.

The invasion no longer consists of the pure parent genotype; many hybrid morphologies have been observed. Hybrids are more vigorous and reproductively fit than either of the parent species. Control efforts by the Invasive Spartina Project in 2005 targeted 132 subareas, with a goal of treating 70 to 80 percent of the infestation. Permits and funding are in place for 2006–2007. In the 2005 season, the previously used herbicide glyphosate (Aquamaster®, the aquatic version of Roundup®) was largely replaced by a new agent, imazapyr (Habitat®), only recently registered for use in California. Unlike glyphosate, treatment with imazapyr does not require a 6- to 12-hour post-application period without tidal inundation. Also, glyphosate tends to bind to sediment and become inactivated, and requires coating of the entire plant. Human health risks from imazapyr are reported to be low, and the herbicide is less toxic to aquatic organisms than glyphosate; however, there is a high risk of damage to non-target plants if inadvertently applied. One complication in the campaign against invasive *Spartina* has been the presence of high densities of the endangered California clapper rail (*Rallus longirostris obsoletus*) in some infested areas, including Arrowhead Marsh and Colma Creek. The presence of the rails will require treatment outside the birds' February-through-August breeding season and a phased approach involving revegetation with native species. With adequate funding, the Spartina Project expects to control the invasive *Spartina* by 2010.

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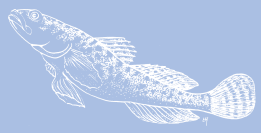
Gobies



Four species of non-native gobies inhabit the San Francisco Estuary, all believed to have been introduced via ballast water release. The California Department of Fish and Game's San Francisco Bay Study (Bay Study) catch-per unit-effort (CPUE) of the chameleon goby (*Tridentiger trigonocephalus*), shimofuri goby (*T. bifasciatus*), and shokihaze goby (*T. barbatus*) have been relatively stable since 2001. The yellowfin goby (*Acanthogobius flavimanus*) has historically been the most abundant and widespread of the introduced gobies. Yet in 2002 and 2003, Bay Study shokihaze goby catch exceeded yellowfin goby catch.

The shokihaze goby was first discovered near the Antioch Bridge in November 1997; it has since become one of the most abundant demersal fishes in Suisun Bay and the lower Sacramento River. The diet of juvenile and adult shokihaze gobies in the upper Estuary is dominated by gammarid amphipods, with isopods, clam siphons, copepods, barnacle cirri, polychaetes, mysids, and hydroids also contributing to a large part of the diet. The shokihaze goby is capable of killing and consuming fish, as observed in aquaria, yet fish are rarely found as a prey item. The impact of the shokihaze goby on native fishes in the Estuary by predation is believed to be minimal, yet its consumption of invertebrates and aggressive behavior could result in competition for resources with other fishes.

Shokihaze goby distribution has expanded downstream from the upper Estuary to the South Bay. Shokihaze gobies were collected near the Dumbarton Bridge in February 2002 and also in November and December 2004. Shokihaze gobies have been collected in salinities ranging from 0.09 to 28.81 parts per thousand in the Estuary. The potential exists for their range to continue to expand within the Estuary and also into other bodies of water within California.

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European Sea Squirt

A relative newcomer to San Francisco Bay, the European ascidian or sea squirt *Didemnum cf. lahillei* forms amorphous masses on docks, piers, rocks, gravel, and other hard surfaces. Taxonomy is controversial, and multiple species may be involved.

Ascidians, distant relatives of vertebrates, metamorphose from a tadpole-like larval stage into sessile filter-feeders. *Didemnum* is a colonial form and potentially one of the most significant fouling organisms in the Bay. Since its larval form is unable to survive long in ballast water, it most likely arrived on a ship's hull sometime prior to 1993 when it was first detected. It reproduces rapidly, tolerates a wide range of depths, and, like many exotics, has no known predators in local waters. Its spread appears to be limited only by salinity and substrate requirements.

Didemnum has already been identified as a problem on the Atlantic Coast, in Puget Sound, and in New Zealand and Japanese waters. Of particular concern to aquaculturists, it overgrows rafts and other structures on which mussels and oysters are grown. It poses a potential threat to oyster farms in Tomales Bay, where its presence was confirmed in 2001, and Drake's Estero. On the seabed, *Didemnum* smothers burrowing bivalves by growing over their siphons. It has been found covering more than 60 square miles of North Atlantic seafloor with a slimy monoculture at Georges Bank, and biologists fear it may become established on the Cordell Bank.

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Wetlands & Wildlife

Wetlands

San Francisco Bay Joint Venture partners completed several major acquisitions around the Bay, including Cargill properties in the South Bay (16,000 acres) and the Bahia wetlands in the North Bay(600 acres). Current efforts include restoration planning for the South Bay salt ponds and restoration projects on Petaluma and Triangle marshes, Simmons Slough, Pacheco Marsh, Hamilton Air Force Base–Bel Marin Keys, Napa-Sonoma Marshes, Cullinan Ranch, Napa River Flood Control Project, American Canyon, Dutch Slough, Eden Landing Ecological Reserve, West Stege Marsh, and Sears Point. In the North Bay, efforts are underway to acquire and permanently protect privately owned tidal wetlands and diked baylands. Nearly 300 other projects to protect and restore wetlands and riparian habitats are also in progress. Both the Central Valley and San Francisco Bay Joint Ventures are updating their implementation plans, and the Central Valley Joint Venture has identified the Delta as a high priority area for habitat work. In collaboration with Ducks Unlimited, the San Francisco Bay Joint Venture has created a new project tracking system. While waterfowl habitat will remain a key focus for both joint ventures, updated plans will also include specific goals for breeding and wintering waterfowl, shorebirds, grassland and riparian birds, and other wetlands-associated birds, and will address agricultural practices and protection. Central Valley partnerships have resulted in three North American Wetland Conservation Act (NAWCA) grants totaling nearly $3 million for wetland conservation activities in Suisun Marsh and in the Yolo and Delta basins. Meanwhile, regional interests continued with wetlands-related planning, partnerships, and fundraising. CALFED completed a draft regional implementation plan that includes eight restoration priorities and continued to provide significant funding for restoration projects and ecosystem planning and processes. As of 2004, CALFED had provided $177 million for restoration projects in San Francisco Bay, with additional funding under the Delta Regional Ecosystem Restoration Implementation Plan (DRERIP). The San Francisco Bay Area Wetlands Restoration Program (WRP), a partnership of 18 federal, state, and local public agencies, is working to implement the CCMP's wetlands action items and the broad recommendations of the *Baylands Ecosystem Habitat Goals Report*.

For a comprehensive list of wetland restoration projects that have been implemented around the Bay, see the database and maps compiled by Wetlands and Water Resources (www.swampthing.org). For wetlands creation, restoration, mitigation, and enhancement projects, see the San Francisco Estuary Institute's Wetland Project Tracker (www.wrmp.org/projectsintro.html), San Francisco Bay Joint Venture (www.sfbayjv.org), and Central Valley Joint Venture (www.cvjv.org). For detailed information about CALFED's extensive ac-

tivities and accomplishments, see the CALFED Bay-Delta Program Annual Report 2004 (http://calwater.ca.gov/AboutCalfed/AnnualReport2004). For information about restoration of the Cargill property, see www.southbayrestoration.org.

California Clapper Rail

Current Bay-wide population estimates of the endangered California clapper rail (*Rallus longirostris obsoletus*) are not available, but surveys in the 1990s estimated their numbers at 1,040 to 1,264, with up to 564 in Suisun and San Pablo Bays (1992–93 data) and up to 700 in South San Francisco Bay (1997-98 data). This represented an increase from a low of 300 to 500 individuals in the 1980s. A new Bay-wide survey began in January 2005. Results from the first year indicate the species has declined or been extirpated in some areas of the North Bay since the early 1990s. No clapper rails were detected at any of the nine Suisun Bay sites, or at the mouth of Sonoma Creek where the previous survey found approximately 25 individuals. Two former low-density sites, Richardson Bay and Point Pinole, also had no detectable rails in 2005. The population at White Slough near Vallejo also showed a sharp decline. It is unclear whether such small satellite populations are succumbing to predation or emigrating to other marshes. On the other hand, counts at Heerdt Marsh and Muzzi Marsh in South Marin were higher, and it is generally believed that numbers have increased in San Francisco Bay, especially the South Bay. In some San Francisco Bay locations such as Arrowhead Marsh and San Bruno Marsh, there appears to be strong association between increase in vegetation cover provided by *Spartina alterniflora* and increase in clapper rail densities (S. Bobzien, Pers. Comm., 2005). Studies by the Invasive Spartina Project suggest that rails have colonized *Spartina*-invaded sites in the South Bay that would otherwise have been too small to support them (H. Spautz, Pers. Comm., 2005). Whether this association is positive or negative in terms of clapper rail population viability is an open question. Further surveys in 2006 should provide a clearer picture of clapper rail distribution and population dynamics throughout the Bay.

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Black Rail

Tidal marshlands of the S.F. Bay region support most of the California black rail (*Laterallus jamaicensis coturniculus*) population in the western United States (Manolis 1978, Evens et al. 1991). For the most part, the breeding distribution of black rails, state listed as threatened, is confined to remnants of historic tidal marshlands in the Estuary's northern reaches, primarily those associated with San Pablo and Suisun bays (Manolis 1979, Evens et al. 1989, Evens et al. 1991). Black rails occur in the South Bay as well, but mostly during winter, and with breeding limited to very few locations (e.g., Dumbarton Marsh). Small numbers have also been discovered recently in small wetlands in the Sierra foothills and at a few isolated marshes in the Delta. A 1996 study estimated approximately 14,500 black rails in the entire S.F. Bay system, with approximately 7,200 black rails in the San Pablo Bay system and a similar number in Suisun Bay and Carquinez Strait, but the true number may be higher or lower (Evens & Nur 2002); new population studies are currently underway. Key predictive factors in black rail distribution are vegetation height, absence of amphipods (indicators of lower elevation marsh), and, in San Pablo Bay, presence of *Frankenia* (an indicator of high-elevation marsh habitat) (Evens et al. 1986). According to the 2002 study, other variables may include marsh size (rail abundance tended to increase as the size of the marsh increased), marsh distribution (the distributional relationship of each marsh to other marshes likely influences rail presence and abundance), marsh configuration (broader marshes tended to support rails in higher abundance than linear marshes), predator populations (sites bound by levees or riprap provide access and habitat to mammalian predators), hydrological cycles (tidal marshes with full tidal influence provide the best habitat for rails), and fluctuations in water level (inundation above a certain depth may exclude habitat to black rails) (Evens et al. 1989, Flores & Eddleman 1993, Evens et al. 1991).

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Least Tern

California least terns (*Sterna antillarum browni*), state and federally listed as endangered, continue to nest at Alameda Point, formerly the Alameda Naval Air Station. While disturbances from gulls and raptors have increased, human disturbance from trespassers has decreased to almost none. Although the number of tern pairs using the base increases each year, the number of successful fledglings continues to fluctuate. In

2005, 424 breeding pairs produced 260 fledglings, down from a previous all-time high of 320 in 2001. Those fledglings represented between 8 and 18 percent of the state's total fledgling population.

Farther north, the number of terns at the Southern Power (formerly PG&E) cooling ponds in Pittsburg decreased from 13 pairs in 2001 to four in 2005, none of which bred successfully. Southern Power is continuing PG&E's voluntary monitoring program at the site. A colony site was started in 2000 on Caltrans property in Albany, with somewhere between eight and 12 pairs in 2000; however, it has not been used since 2001. The East Bay Regional Park District recently established a least tern breeding site on the Hayward Regional Shoreline. Terns nested at this site for the first time in 2005, but all 8 nests failed due to disturbance and trampling by gulls. Least terns have abandoned the Oakland Airport as a breeding site probably due to predation by feral cats and the non-native red fox (last reported breeding attempt in 1995).

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Salt Marsh Common Yellowthroat

Surveys of tidal marshes in 2000 detected few yellowthroats (*Geothlypis trichas sinuosa*), a state species of special concern, in S.F. Bay itself; likely only a few hundred are present. In San Pablo Bay, the estimated density was also low, with an estimated total population of 3,000 or fewer breeding individuals. In many marshes in San Pablo Bay, yellowthroats were completely absent. In Suisun Bay, however, densities observed were quite high (10-fold higher than in San Pablo Bay); Point Reyes Bird Observatory scientists estimate 10,000 to 15,000 breeding individuals in Suisun Bay. An additional unknown number are present in brackish and freshwater marshes, which may be their primary habitat. Point count surveys in 2004 yielded results consistent with earlier findings: highest densities in Suisun Bay, lowest in San Francisco Bay. Based on a small sample, nest success rate in the 2004 study was a relatively low 21.9 percent. Salt marsh yellowthroats appear to respond to specific vegetation composition and are more abundant where there is a greater amount of alkali bulrush (*Scirpus maritimus*). In Suisun and San Pablo Bay, yellowthroats, unlike other salt marsh birds, show a positive association with the invasive perennial peppergrass (*Lepidium latifolium)*. In addition, they are more abundant where the vegetation structure is more complex; for example, where there is more diversity in the height of herbs. Finally, salt marsh yellowthroats are more numerous in marshes that are more compact in shape, rather than elongated or irregular in shape.

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Salt Marsh Song Sparrow

Reproductive success of salt marsh song sparrows has been increasing slowly since 1998, which was the poorest year recorded to date. Despite this increase, the overall success observed at most marshes (usually between 15 percent and 20 percent of nesting attempts result in any fledged young at all) may be below the level necessary to ensure a stable population. Reproductive success varies among marshes, with landscape characteristics (such as proximity to the water's edge) being good predictors of nest survival. Success is lowest in Suisun Bay. The greatest cause of nest failure is predation by both native (common raven, American crow, raccoon) and non-native (house cat, red fox, Norway rat) species; rodents are likely the most common predator in most marshes. In addition, about 10 percent of nests fail each year due to flooding during the highest tides. Nest survival rates in a 2004 study were similar to long-term averages. Estimated numbers of breeding Alameda song sparrows (*Melospiza melodia pusillula*), restricted to Central and South S.F. bays, range from 13,400 to 20,000 individuals; of Suisun song sparrows (*Melospiza melodia maxillaris*), found in Suisun Bay, from 43,000 to 66,000; and of San Pablo or Samuel's song sparrows (*Melospiza melodia samuelis*), found in San Pablo Bay, from 81,000 to 90,000. Population densities of the Alameda subspecies have increased since 1996, while densities of the Suisun and San Pablo subspecies appear stable. The presence of salt marsh song sparrows is not strongly linked to any one, or even several, species of plants, though the three subspecies of song sparrows do appear to respond positively to gumplant and coyote brush and negatively to rush. Nevertheless, the population density of song sparrows is well correlated with landscape features. Density is greatest where land adjacent to the marsh contains less urbanized areas and less agriculture and a greater extent of natural uplands. Conversely, density is lowest in small, isolated marshes. All three song sparrow subspecies are state species of special concern.

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Least Bell's Vireo

A small grayish neotropical migrant songbird, the least Bell's vireo (*Vireo bellii pusillus*) made national headlines in 2005 when a pair nested at the San Joaquin River National Wildlife Refuge, apparently rearing two broods. The birds were first detected by PRBO Conservation Science biologist Linette Luna, who recognized the male's distinctive song. This was the first confirmed breeding record for the San Joaquin Valley since 1919, and an encouraging sign of the effectiveness of riparian restoration.

Once common in riparian areas throughout the Central Valley, the endangered subspecies has suffered from loss of habitat and from brood parasitism by the brown-headed cowbird, a relative newcomer to California. Unlike songbirds that co-evolved with cowbirds, the vireo lacks an effective nest defense. Female cowbirds destroy or eject the hosts' own eggs and replace them with their own, leaving the victims to raise a clutch of cowbirds rather than vireos. By the time the least Bell's vireo was federally listed in 1986, the California population had fallen to 300 breeding pairs, mostly in San Diego County.

With effective cowbird control and riparian restoration, the vireo began to regain portions of its lost range. Appropriate nesting habitat had been created at the San Joaquin River refuge in a project coordinated by the US Fish & Wildlife Service, involving PRBO Conservation Science and River Partners. In addition to willows and other streamside trees, River Partners planted a herbaceous understory of mugwort and other species to attract songbirds such as the yellow warbler. The second vireo nest (a presumed second brood attempt), discovered by PRBO CS field biologist Julian Wood, was in an arroyo willow screened by mugwort.

The CALFED grant for the restoration expired in 2005. Refuge personnel and biologists are hoping for additional funding to monitor possible nesting attempts in the next breeding season, if the vireos return from their Mexican wintering grounds.

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Riparian Brush Rabbit

Populations of the federally listed (endangered) riparian brush rabbit (*Sylvilagus bachmani riparius*) are largely restricted to riparian habitat along the Stanislaus River in Caswell Memorial State Park, the San Joaquin River National Wildlife Refuge, and two small parcels of private land along the San Joaquin River. The rabbits were thought to be restricted to the habitat in Caswell until surveys discovered the two additional populations (one of which was recently found to be more extensive than first thought), and a cooperative state/federal effort began a breed-and-release program on the refuge. The captive breeding program was begun in early 2002, with three male and three female rabbits released into an enclosed pen during the winter. The rabbits successfully bred, and 49 young rabbits were later released into natural riparian habitat at the refuge. The program was expanded in 2003, with two additional enclosures and 194 young rabbits released into the refuge. As of December 2005, 100 more were waiting for release (M. Kinsey, Pers. Comm. 2005), and 30 had been released at a second site, on a privately owned ranch near Vernalis. The rabbits are not released into the wild until they are large enough to successfully survive the translocation. All rabbits are screened by a veterinarian before being released.

The numbers in Caswell were extremely low in 2001, but rebounded slightly in 2002 and 2003. The population remains too small to allow population size estimation tools to function properly, so the exact size of the Caswell population is not known. Efforts are underway in the park to improve the habitat for rabbits, as well as for federally listed (endangered) riparian wood rats (*Neotoma fuscipes riparia*).

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Harbor Seal

San Francisco Bay harbor seal (*Phoca vitulina*) numbers have remained fairly stable over the past decade, and are estimated to be over 600. Although approximately 12 haul-out sites are known in the Bay, harbor seals are found in the greatest numbers throughout the year at three sites: Mowry Slough, Yerba Buena Island, and Castro Rocks. Mowry Slough, the largest pupping site in the Bay, is used predominantly during the pupping (mid-March–May) and molting (June–mid-August) seasons. Since 2000, approximately 300 harbor seals and over 100 pups have been counted at Mowry Slough each pupping season. In the winter (mid-November–mid-March) months, when Pacific herring (*Clupea pallasi*) spawn in the Bay, the number of seals at Yerba Buena Island increases to 200 to 300 harbor seals (1998–2004).

Additionally, the number of seals using Castro Rocks, a chain of rock clusters just south of the Richmond Bridge and the second-largest pupping site in the Bay, has increased greatly during the winter season since 2000, with a maximum of 300 to 600 seals recorded during recent years. The increase in seals hauling out at Castro Rocks in the winter may be related to shifts or increases in herring spawning closer to Castro Rocks. Castro Rocks is used by an average of 100 seals year-round (2000–2004). Seismic retrofit work began on the Richmond Bridge in early 2001, and researchers from San Francisco State University monitored what effect the construction had on seal numbers and behavior. Despite an early shift in site use to rocks located farther from the bridge when construction was underway in the immediate area, and an increase in disturbances due to construction activity, seals maintained use of the Castro Rocks haul-out site for the duration of construction work (2001–2005). (Green, Pers. Comm., 2006)

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Salt Marsh Harvest Mouse

It is not known whether the population of the Bay's endangered salt marsh harvest mouse (*Reithrodontomys raviventris*) has changed significantly over the past five years. Population studies are conducted only when development projects or changes in land use threaten the mice, and few such studies have been required during this time. When such studies are conducted, their piecemeal nature makes it difficult for scientists to get a take on overall population trends. Several marsh restoration projects that could impact mouse populations are underway in the North Bay, and large scale salt pond restoration has begun in the South Bay, but it will take years to decades for new marshes to be produced and hence increase mouse populations. Meanwhile, recent surveys document that there is very little mouse escape cover left in the South Bay, where what was once miles of high marsh vegetation has been reduced to a maximum width of 8 to 9 feet or eliminated completely. (Shellhammer, Pers. Comm., 2005)

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California Red-Legged Frog

The once-abundant California red-legged frog (*Rana aurora draytonii*), federally listed as threatened, has disappeared from approximately 70 percent of its historical range. It is now found only in coastal wetland areas and freshwater streams from Marin County south to Ventura and in scattered streams in the Sierra Nevada. Range-wide, only four populations contain more than 350 adults. Habitat loss, stream sedimentation, pesticides, and predation all threaten the frog, the largest native to the western United States. In spring 2004, the US Fish & Wildlife Service renewed a proposal to declare 4.1 million acres across California, including parts of the Bay Area, as critical habitat for the frog. Following litigation, FWS issued a revised proposal in November 2005 which eliminated 82 percent of the area in the original proposal, including many of the core areas delineated in the 2002 recovery plan. In the Bay Area, the new proposal eliminates almost all critical habitat in eastern Contra Costa County based on a habitat conservation plan. The revision also exempts routine ranching activities on private land from federal coverage. In 2005, a court decision required the Environmental Protection Agency to consult with FWS on the registration of 66 pesticides with potential impacts on the frog.

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Western Snowy Plover

In the Bay Area, the federally threatened Pacific Coast western snowy plover (*Charadrius alexandrinus nivosus*) is primarily associated with commercial salt evaporation ponds and levees, which means that land managers have not to date been able to actively manage habitat or resources for this species. However, the recent purchase of more than 15,000 acres of salt ponds in south S.F. Bay by Fish & Wildlife and Cal Fish & Game could aid in plover recovery. Future pond management will include managing several of these ponds as plover nesting and foraging habitat, as well as conducting predator control and minimizing human disturbance. These actions are outlined in Fish & Wildlife's draft recovery plan for the plover, which calls for increasing the S.F. Bay breeding population from its current level of 150 to 200 individuals to 500. While the Bay did not historically support 500 snowy plovers, managing salt evaporation ponds for plovers is an opportunity for it to play a significant role in the recovery of this species, especially because many of the plover's historic coastal breeding and wintering sites have been degraded by human disturbance and

urban development. Off-leash dogs also pose a significant threat to snowy plovers at coastal breeding sites. Breeding season surveys conducted in 2004 by the S.F. Bay Bird Observatory and the Don Edwards National Wildlife Refuge indicate that approximately 113 plovers used Bay salt ponds during the breeding season, an increase from 2003, with the highest concentration in DFG's Eden Landing Nature Reserve. In that year 59 nests were found and followed through to completion to determine hatching success. Due to late rains in 2005, plover breeding habitat was severely reduced as many of the ponds were flooded until midsummer. Twenty nests were found in 2005. Many were on Refuge property, since much of Eden Landing was flooded. The breeding season window survey conducted in May 2005 found 124 plovers mostly in salt pond habitats around the Bay (Strong Pers. Comm., 2006). Avian predator surveys were conducted in 2004 and 2005 to determine which predators may be posing the highest risk to plover success. Common ravens were found to be the primary avian predator of concern in both years, but California gulls may also become a problem due to the exponential growth of their colony in salt pond A6. The US Fish & Wildlife Service's final determination of critical habitat for the plover, issued in 2005, eliminated half of the area originally proposed, including all Bay Area habitat: the South Bay salt pond restoration area was excluded because it must also provide habitat for least terns, clapper rails, harvest mice, and waterfowl, and resource managers will therefore need flexibility in managing the site. Concurrently, a petition to de-list the plover is under agency review.

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Western Burrowing Owl

The diminuitive, long-legged western burrowing owl (*Athene cunicularia hypugaea*) was once common throughout the West but has declined precipitously in California in the last several decades—breeding owls have been eliminated from at least 8 percent to 10 percent of their former range in the state and are trending toward extinction in another 25 percent. Currently, estimates are that more than 70 percent of California's breeding owls live in the margins of agricultural land in the Imperial Valley. Locally, burrowing owl population declined 50 percent from the 1980s to the 1990s. The owl has been extirpated as a breeding bird from San Francisco and Marin counties and from most of San Mateo and Sonoma counties. Breeding owls can still be found in scattered spots in the East Bay, primarily in eastern Alameda and Contra Costa Counties, and in Santa Clara County, where a census seven years ago estimated only 120 to 141 pairs remained. Burrowing owls nest in the burrows of ground squirrels and other mammals. They require open fields with adequate food supply for foraging, low vegetative cover (to watch for predators), and adequate roosting sites. Burrowing owls are threatened primarily by habitat loss due to urban development and by the corresponding eradication of ground squirrels and other burrowing rodents. Other factors contributing to the decline of owls statewide include burrow destruction through disking and grading, pesticide impacts, increased predation by non-native or feral species, habitat fragmentation, and other human-caused mortality from vehicle strikes, electrified fences, collisions with wind turbines, shooting, and vandalism of nests. The state-approved practice of relocating owls from development sites is accelerating local extirpations from rapidly urbanizing areas. Owls typically nest in the same burrow year after year and often try to return to their former homes. One study found that only one relocation in eight resulted in successful nesting at the new site. The owl was listed as a state species of special concern in 1994. In December 2003, the California Fish & Game Commission denied a petition seeking threatened or endangered status for the owl under the state Endangered Species Act. A statewide census is planned for 2006, and a new petition may be filed if continuing decline is documented.

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Soft Bird's-Beak

Soft bird's-beak (*Cordylanthus mollis ssp. mollis*), state and federally listed as endangered, survives in only 19 widely scattered sites in the coastal salt and brackish tidal marshes around San Pablo and Suisun bays and in Contra Costa, Napa, and Solano counties, with individual populations fluctuating from year to year.

The hemiparasitic bird's-beak is photosynthetic and can fix its own carbon for growth requirements. It also attaches to a variety of hosts, including pickleweed, saltgrass, and exotic forbs and grasses. In turn, it supports native bee pollinators and moth species whose larvae eat its seeds. Ninety percent of its historic habitat has been lost with conversion of tidal marsh to farmland. Water pollution, muted tidal hydrology, host association with exotic winter annual plants, competition with invasive plants, habitat fragmentation, exces-

sive seed predation associated with reduced tidal hydrology, mosquito abatement activities, trampling by over-grazing or human activity in sensitive marshes, and naturally occurring events also threaten the plant.

Researchers planted soft bird's-beak seeds in test plots at Rush Ranch in 2000. They found that the plant does best in patchy habitat, with gaps to provide sunlight for seedlings, and that clipping back the vegetative canopy gives the parasites a crucial boost, although exotic plants take advantage of the gaps. High seedling mortality at the reintroduced and natural population sites was linked to host association with non-native plants. The Rush Ranch population is expanding by natural dispersal, and many seedlings have established outside the experimental plots. However, other populations have been displaced by invasive plants within the last two years. (B. Grewell, Pers. Comm. 2005)

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Water & Sediments

Bay Contaminants

Water and sediment of the Estuary meet cleanliness guidelines for most pollutants. However, a few problem pollutants are widespread in the Estuary, making it rare to find water or sediment in the Estuary that is completely clean. Several pollutants are present at levels of concern. A fish consumption advisory remains in effect due to concentrations of mercury, PCBs, dioxins, and organochlorine pesticides of potential human health concern in Bay sport fish. A duck consumption advisory is also in effect due to selenium concentrations of potential human health concern.

Over the long term, the Estuary has shown significant improvements in basic water quality conditions, such as oxygen content, due to investments in wastewater treatment. Contamination due to toxic chemicals has also generally declined since the 1950s and 1960s. Long-term trends for pollutants of current concern vary from pollutant to pollutant. Mercury concentrations in striped bass, a key mercury indicator species for the Estuary, have shown little change in 30 years. PCB concentrations appear to be gradually declining. Concentrations of DDT, chlordane, and other legacy pesticides have declined more rapidly and may soon generally be below levels of concern. On the other hand, concentrations of chemicals in current use, such as pyrethroid insecticides and polybrominated diphenyl ethers (PBDEs) are on the increase. Aquatic toxicity has declined in the past few years, possibly associated with reduced usage of organophosphate pesticides. Sediment toxicity, on the other hand, has consistently been observed in a large proportion of samples tested over the past ten years.

There are indications that the current levels of contamination may be harming the health of some wildlife species. Mercury concentrations appear to be high enough to cause embryo mortality in clapper rails, an endangered species found in Bay tidal marshes. PCB concentrations may be high enough to also cause low rates of embryo mortality in Bay birds and to affect immune response in harbor seals. Selenium concentrations appear to be high enough to cause abnormalities in early life stages of Sacramento splittail and white sturgeon. Pollutant mixtures appear to similarly affect early life stages of striped bass. Assessments of benthic communities in the marine and estuarine regions of the Bay indicate that some areas may be impacted by pollutants. The frequent occurrence of sediment toxicity is another indicator of pollutant impacts in Estuary sediments.

During the past two years considerable progress has been made on several cleanup plans ("TMDLs") for pollutants of concern. The San Francisco Bay Regional Water Board is nearing completion of TMDL projects addressing mercury, PCBs, diazinon, pathogens, and sediment. There are currently 270 San Francisco Bay Region listings on the State's 303(d) list of impaired waters. Upon completion of these TMDL projects that are scheduled for Water Board action by June 2006, we will have resolved over 100 impairment listings in the Region. Other projects in the works include TMDLs for mercury in the Guadalupe River Watershed, and sediment in San Francisquito Creek and Sonoma Creek.

MORE INFO? www.waterboards.ca.gov/sanfranciscobay/tmdlmain.htm

Delta & Upstream Contaminants

The freshwater side of the Estuary does not have a systematic monitoring program to evaluate contaminant levels in water, sediment, or biota. However, contaminants documented to exceed either water quality objectives or concentrations toxic to aquatic organisms in the Delta have been given the highest priority by the Central Valley Regional Water Quality Control Board for development of regional load reduction and control programs (TMDLs) under the Clean Water Act.

In 2004–2005, the Board adopted amendments to its Basin Plan to address water quality problems in the Delta associated with elevated levels of diazinon and chlorpyrifos, and low dissolved oxygen levels in the Stockton Deepwater Ship Channel. The Basin Plan amendments for each include an implementation plan with a schedule, and monitoring to assess compliance. Each plan contains a reopener clause after about five years to ensure that monitoring results and new scientific findings are incorporated into the revised implementation plans. A methyl mercury basin plan amendment is scheduled for Board adoption in the summer of 2006.

In the Sacramento basin in 2005, the Regional Board adopted Basin Plan amendments to control methyl mercury in Harley Gulch and Cache Creek. An amendment to control methyl mercury levels in fish in the lower American River is scheduled for 2006–2007.

In the San Joaquin basin, the Board adopted amendments for chlorpyrifos, diazinon, boron, and salt in 2005. The pesticide basin plan amendment included a formula for additivity when multiple insecticides were simultaneously present in water. Ongoing monitoring shows that concentrations of diazinon and chlorpyrifos continue to fall throughout both the Sacramento and San Joaquin watersheds, most likely because of decreased agricultural use.

MORE INFO? www.swrcb.ca.gov/rwqcb5/

Photo courtesy of PWA.

Big Picture; Warning Bells

Photo courtesy of David Hart and John Sanger

"The Delta is the most subsided landscape in the world relative to its total size. Once we put homes in the Delta, all bets are off: public safety trumps everything."

— Jeff Mount, UC Davis

"All of our restoration efforts will be futile if we are unable to stem the tide of urbanization in the Delta. Restoration can wait—but the time for acquisition is now."

— John Cain
Natural Heritage Institute

"Funding for restoration and environmental programs will increasingly become a challenge as bond monies dry up."

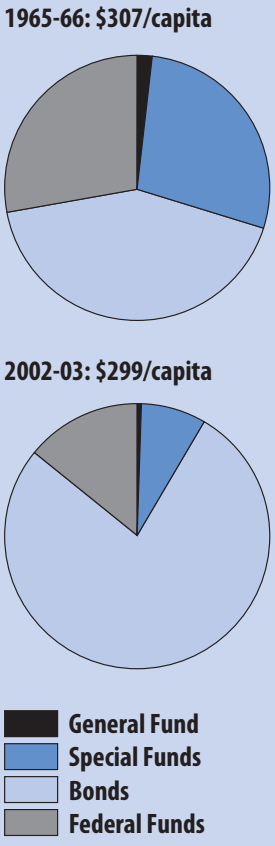
— Ellen Hanak
Public Policy Institute
of California

California 2025: the Estuary in the Big Picture

HANAK, ELLEN
PUBLIC POLICY INSTITUTE OF CALIFORNIA

In the near future, money for restoring the Estuary—and for environmental programs in general—will be harder to find, as existing bond money runs out. *California 2025: Taking on the Future*, a study published by our institute in June 2005, provides context for thinking about the funding challenges and strategies in support of the San Francisco Estuary. The study considers whether the state is facing a growth and infrastructure crisis and how to best think about planning for the future. It looks at population and economic growth; patterns of infrastructure financing; current estimates of infrastructure needs; governance and institutional challenges for planning; issues of equity; and the public's perceptions of the future; preferences regarding schools, water, and transportation; and willingness to pay higher taxes or fees to fund those preferences.

STATE RELIES INCREASINGLY ON BONDS TO PAY FOR PUBLIC INVESTMENTS



Findings relevant to the Estuary concern the overall picture for public investment and the specific picture for water resources. Overall, California's levels of public investments are largely on par with those elsewhere in the nation. In recent years, however, the state's contribution to this spending has been predominantly funded through general obligation bonds. High projected debt ratios suggest that alternative sources may be needed over the years ahead.

In the area of water supply and quality, the study finds that the state's numerous water and wastewater utilities are largely on track to fund anticipated capital needs. Moreover, utilities have a straightforward way to raise revenues through user fees, which are still low relative to median income. Although the state's population continues to grow, demand management and water markets can lessen demand for new water, and there are many options available for generating new supplies. The thorniest challenges relate to environmental programs, including the restoration of the San Francisco Estuary and non-point source pollution programs. To date, restoration and non-point source programs have largely been funded with state bonds. As existing bond monies dry up, the question of appropriate contributions from water users will become increasingly important. Despite funding challenges, a survey we conducted in 2003 showed that 65 percent of Californians—compared to 45 percent of U.S. residents—strongly support protecting the environment, even if it curbs economic growth. That same survey showed that water quality issues are a big concern of more than half of the Californians surveyed.

MORE INFO? hanak@ppic.org; www.ca2025.org

TAKE HOME POINTS

- **Funding for restoration and environmental programs will increasingly become a challenge as bond monies dry up.**
- **Despite funding challenges, a majority of Californians surveyed support environmental protection and are concerned about water quality.**
- **Californians strongly support protecting wetlands, improving water quality, restricting private development of coastal land, creating more marine reserves, and selling environmentally safe fish or seafood.**
- **Although the state's population continues to grow, demand management and water markets can lessen water demand growth.**

Changing Bay Area Economics and the Estuary

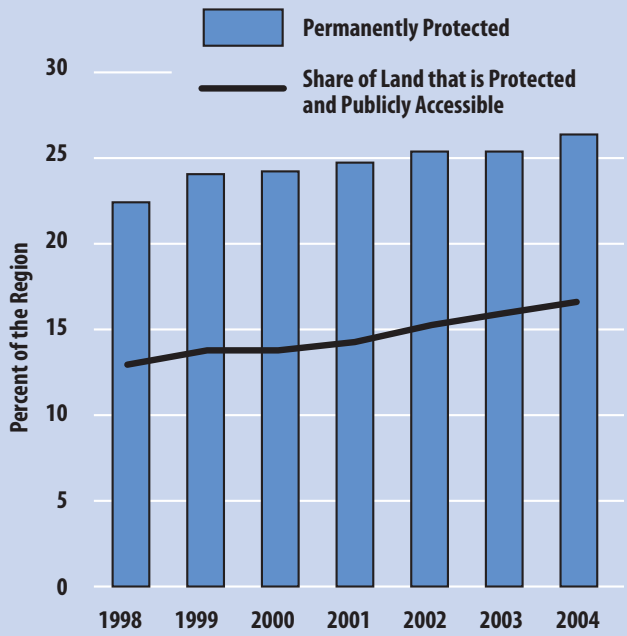
RUSSELL HANCOCK
JOINT VENTURE:
SILICON VALLEY NETWORK

It is important for people who care about the environment to care about the economy too. The Estuary Conference focuses on a number of environmental performance indicators for San Francisco Bay. However, these indicators—as well as our ability to influence them—are shaped in important ways by some larger considerations, including the region's job growth, economic performance, and the ability of our public bodies to balance economic and environmental stewardship.

The Silicon Valley has a huge influence on the Bay Area economy. At the height of its boom, the "dot com" industry created 350,000 jobs. Since then, we have lost 220,000 jobs—the Internet bubble wasn't real or sustainable, with its never-ending spiral of prosperity. Yet Internet-based commerce was a real revolution, and important companies came out of it—Google, Yahoo, EBay, to name a few, and we tend to forget the net gain of 130,000 jobs. A newly emerging paradigm for the region in a globalizing economy is that of small start-up companies—those with seven people or less. There are 7,000 of them in the Silicon Valley. But while Valley productivity is 2.5 times the national average, that is not translating into job growth or payroll increases, in large part due to intense competition from India and Asia where we are outsourcing many of our jobs, including white collar jobs. Yet our new, scaled-back economy is more viable from a sustainability standpoint, and the Valley will compete with its high-end work force. The Silicon Valley is committed to sustainability issues such as open space and quality of living. If we are serious about competing with other regions of the country, the best way for us to do that is to provide a fabulous place to live, and that means continuing to steward the Bay.

That commitment can be seen in the increase in the amount of open space that has been protected since 1998 — from 22 to 26 percent of the region.

PROTECTED OPEN SPACE IN SILICON VALLEY



TAKE HOME POINTS

- **The new economy in the Silicon Valley is better from a sustainability standpoint. We are no longer talking about growth management strategies.**
- **Silicon Valley businesses and community leaders show a high commitment to environmental stewardship.**
- **A high-end workforce is often characterized by heightened environmental sensibilities.**
- **Environmental stewardship is our best competitive strategy.**

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Can Serial Engineering of the Delta be Stopped?

JEFF MOUNT
CENTER FOR WATERSHED SCIENCES
UNIVERSITY OF CALIFORNIA, DAVIS

The Sacramento-San Joaquin Delta has become one of the most highly-engineered estuaries of the Americas. For the past 150 years, interventionist approaches have dominated the extraction of ecosystem services from the Delta and its tributary watersheds. The over-dependence on structural and technological "fixes" to enhance ecosystem services has locked management into a cycle of serial engineering. Every engineered intervention appears plagued by the law of unintended consequences, creating an ever-escalating demand for more engineering fixes. With CALFED at a political and economic crossroad, it is reasonable to question whether this approach is sustainable.

The Delta is the regional archetype for serial engineering. The reclamation of more than 500,000 acres of tidal marsh involved the engineering of 1,100 miles of levees, 1,800 water diversions, and 250 agricultural drain returns. The serial engineering challenges associated with this effort are well known, including managing the most subsided landscape in the world at the juncture of two large, flood-prone river systems. The second great ecosystem service engineered in the Delta—the CVP and SWP water supply pumps—created a cascade of serial engineering projects throughout the watershed. Use of the Delta for shipping, flood control, disposal of urban and agricultural runoff, and as a thermal dump for power plants has spawned demand for multiple fixes, both within and outside of the Delta. Even recreation—including fishing, hunting and messing around in boats—has its own unique suite of engineering efforts and unintended consequences.

Rather than waning due to its lack of success, the interventionist culture of Delta management is only growing, with new, more elaborate, and more expensive proposals. This engineering approach is predicated on the assumption that conditions will remain the same. That is, historic imperfections in ecosystem services can be engineered out of the system in the future. Yet landscape change, including fundamental shifts in hydrologic conditions, subsidence, changes in land use activity, and successive waves of non-native invaders, makes the Delta a rapidly moving target, with prospects for even more dynamic conditions in the future. Institutional viscosity, limited resources, and relying on the past as a predictor of the future limits our ability to keep up with the pace of change. The grand plans of today will be obsolete within a generation or two, demanding new, more fantastic engineering fixes. Breaking out of the cycle of serial engineering may involve making politically unpalatable decisions about which ecosystem services can be provided by the Delta and which will have to be curtailed.

MORE INFO? **mount@geology.ucdavis.edu**

TAKE HOME POINTS

- **The Delta is the most subsided landscape in the world relative to its total size.**
- **Once we put homes in the Delta, all bets are off: public safety trumps everything.**
- **We have enough science to estimate the probable state of the Delta for the next 50 years—to predict critically dry years and how to save fish.**
- **The Delta is warming up. It will be a vastly changed place over the next 100 years; we will see changes within the next 15-20 years.**
- **Working hard on today isn't going to change things for tomorrow.**
- **We could also see punctuated change versus gradual change, meaning that change could take place abruptly. Gradual change is a certainty. Punctuated change is likely.**
- **We will have a physical collapse of the Delta.**
- **The Delta was designed based on hydrology 20 years old, with no consideration of the future.**
- **South Delta improvements and barriers will adapt poorly to changes in the Delta.**
- **Serial engineering of ecosystem services is not working and won't work in the future.**
- **Some of the Delta's ecosystem services cannot be sustained over the long term.**
- **A peripheral canal will create its own cascade of ecosystem effects.**

A Delta Perspective on the Delta Improvement Package

TOM ZUCKERMAN
CENTRAL DELTA WATER AGENCY

The Delta Improvement Package, or "DIP," is a CALFED proposal based upon an integrated regional management plan that grew out of the stakeholder negotiations that formed the basis of HR 2828, the federal reauthorization bill for CALFED. Environmental interests were notably absent in the negotiations, and the whole process preceded recognition of the precipitous decline of the pelagic fishery in the Bay-Delta system.

Nevertheless, the DIP recognizes and includes topics that must be addressed to improve water supply and quality issues in the Delta and in the Lower San Joaquin River. Those issues, which have resulted largely from water export operations, include:

- Water quality at sensitive diversion points in the Delta
- Water supply and channel level sufficiency at sensitive diversion points in the Delta
- Upstream water quality and flow in the San Joaquin River below the mouth of the Merced River
- Drainage regulation from farmlands and wildlife refuges in the San Joaquin Valley
- Levee protection in the Delta

Correction of these existing problems, and avoidance of any aggravation, are conditions of any increase in allowable export levels. Similar protections for fish and wildlife resources must be developed through the NEPA-CEQA process applicable to the DIP, recognizing that much of the burden of addressing these issues falls upon the exporters as mitigation for problems created or aggravated by the exports.

MORE INFO? **tmz@talavera.us**

Photo courtesy of USGS

TAKE HOME POINTS

- **The problems in the Delta aren't going to change that much. The issue is how to get the federal and state governments to focus on them.**
- **We need to avoid making poor decisions such as putting people behind levees in tract homes.**
- **We have an opportunity to preserve the standard of living and way of life in the Delta, but we need to give the Delta priority. It is an environmental and recreational treasure.**
- **We cannot go on thinking of the Delta as an inexhaustible water supply for southern California.**
- **We need to figure out how to maintain Delta water quality, keep enough water in its channels, and how to restore the lower San Joaquin River, where water quality is critical for the river and for its users and exporters.**
- **The emphasis always seems to be on exports. We need to focus instead of restoring pelagic fish, salmon, and striped bass to the Delta.**
- **Solutions need to be Delta-centric.**

Challenges Facing the San Joaquin Valley

CAROL WHITESIDE
GREAT VALLEY CENTER

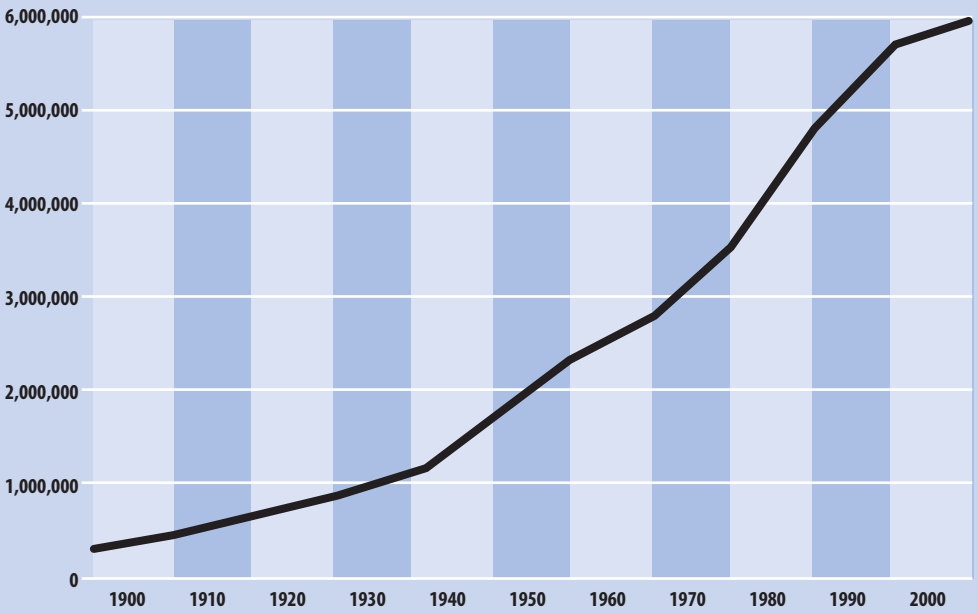
The San Joaquin River runs through a valley 450 miles long and 50 miles wide—an area the size of the state of Kentucky—and it is a region that is rapidly changing, with implications for the entire state and the Bay-Delta Estuary. Within the last 150 years, the valley has been transformed from a place characterized by seasonal wetlands, deep tules, and roaming grizzly bears into one of the richest agricultural areas in the world. Now changes are flowing again, this time from different sources. Waves of new residents—immigrants from faraway places and migrants from the coastal parts of California—plus a high birth rate in the valley are swelling the population at a growth rate that exceeds that of Mexico. People come to the valley to seek affordable housing and new opportunities, prompted in part by high housing costs in coastal areas. The impacts of the valley's growth are evident in traffic delays—up 52 percent in the north San Joaquin Valley and 577 percent in the southern San Joaquin Valley since 1998.

Some people have created a false dichotomy between protecting the environment and economic well being. The short-term response most often opts for the economy over the environment. The environmental health of the entire San Joaquin Valley will depend in part on local politics as

TAKE HOME POINTS

- **Habitat Conservation Plans have met with very mixed results in the valley. There is a belief that if people just wait long enough, the Endangered Species Act will go away.**
- **The focus of the region is on jobs and economic development. The environment is not seen as a Republican issue.**
- **Public concern about the "environment" is limited to issues with immediate impacts on people, such as air quality and asthma and water quality and taste.**
- **We need to frame environmental and resource/watershed conservation in terms of their economic payback.**
- **We have a chance to develop a strategic long-term view of the valley—we urge Bay-Delta Estuary folks to help us. Otherwise, the future of the valley environment looks very shaky.**
- **Why are farmers and environmentalists not partners? Some farmers fear costly environmental regulations that make them feel vulnerable, plus it is hard to turn down $1 million an acre from developers.**
- **We need to put some certainty back into farming and create buffers between farmland and urban areas.**

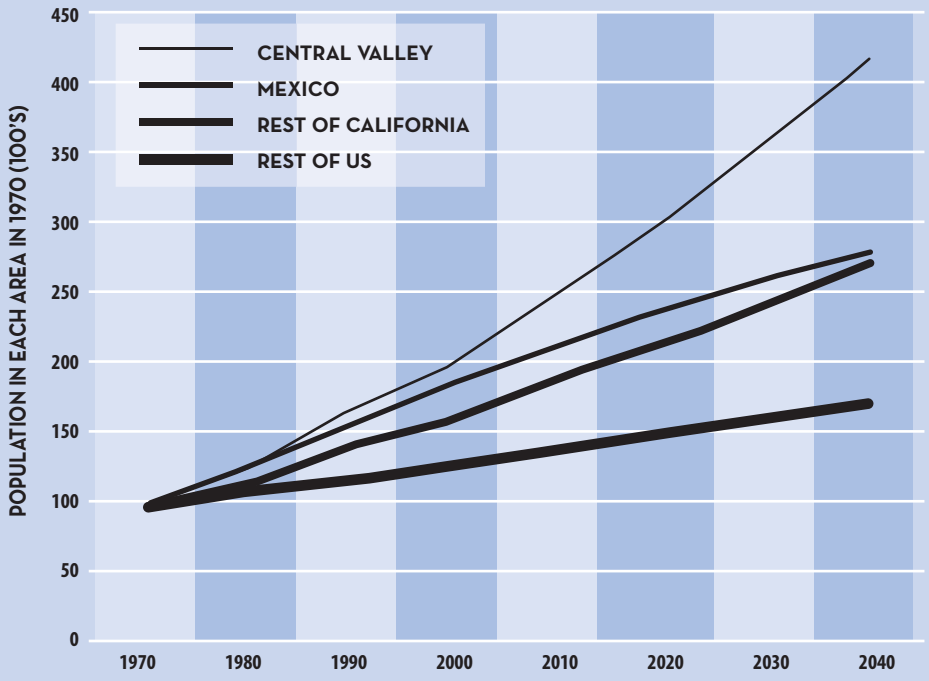
CENTRAL VALLEY POPULATION GROWTH



well as on the engagement and attention of the rest of the state. People who live in the region see resources in abundance and don't understand the value of those resources to the world. Those who are often in the best position to protect and conserve resources are often resentful of having to make economic sacrifices for others, whose economic well being is already secure and is not limited by the environment. Finding fair and balanced ways to meet all the legitimate needs of this growing and changing region is not impossible, but it will be darn hard.

MORE INFO? carol@greatvalley.org

CENTRAL VALLEY'S PROJECTED GROWTH RATE



CENTRAL VALLEY STATS

- **The valley produces more than 300 crops, 57 percent of the state's $30 billion agricultural output. If the valley were a state, it would rank first in agricultural production in the nation.**
- **Twenty percent of valley jobs depend directly or indirectly on agriculture.**
- **The valley's population has doubled every 30 years since 1900 and now stands at 6.3 million. Its projected growth rate outpaces Mexico, California overall, and the U.S.**
- **By 2020, more people will live in the Central Valley than the San Francisco Bay Area.**
- **By 2040, there will be the equivalent of 10 new Fresnos.**
- **By 2050, the population will be up by 131 percent.**
- **Despite the rapid growth rate, regional per capita income relative to the state has dropped: the San Joaquin Valley has the highest percent of children under 18 living in poverty: 26 percent, compared to 20 percent U.S. and 17 percent California overall.**

Where Have All of the Pelagic Fishes Gone?

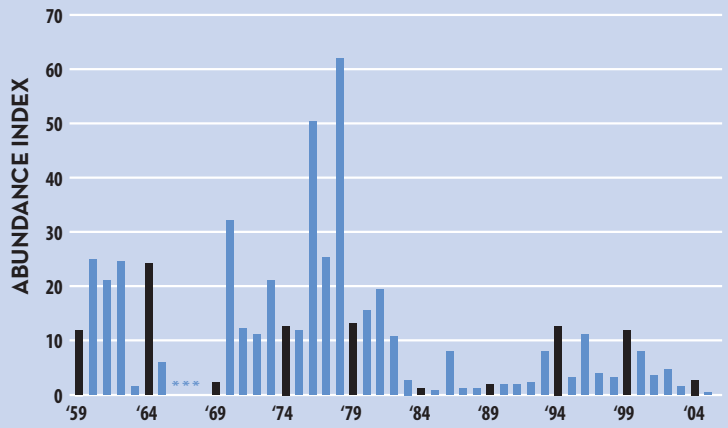
TED SOMMER, ET AL.
DEPARTMENT OF WATER RESOURCES
INTERAGENCY ECOLOGICAL PROGRAM

Abundance indices calculated by the Interagency Ecological Program (IEP) suggest recent marked declines in numerous pelagic fishes (Delta smelt, longfin smelt, threadfin shad, and striped bass) in the Delta and Suisun Bay through 2004. Initial statistical analyses of the data for these pelagic species indicate that there are statistically significant long-term declines in the Delta/Suisun Bay, and evidence of a recent step-change—a very rapid decrease in population. Similar analyses for the fishes of the San Francisco Bay showed no clear decline. Recent abundance estimates for the summer tow-net survey suggest that low Delta smelt abundance continued in 2005.

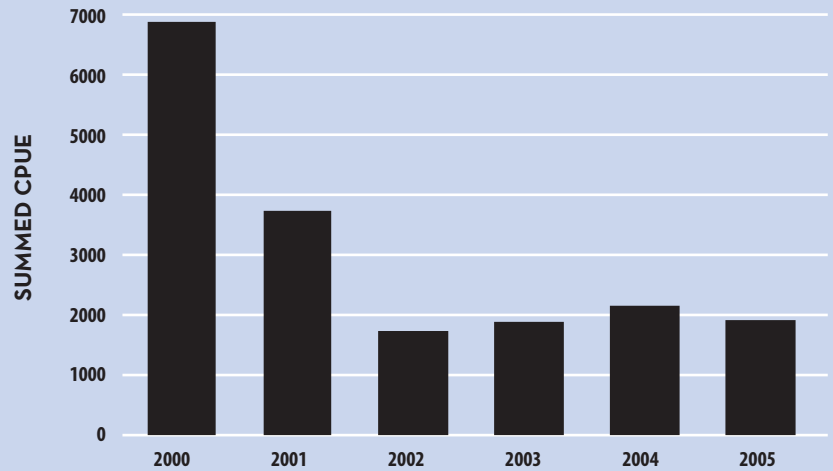
The low levels of Delta/Suisun Bay pelagic species are unexpected given the relatively moderate hydrology over the past three years. Our conceptual model includes at least three general factors that may be acting individually or in concert to lower pelagic productivity. Those include toxins, invasive species, and water project operations. IEP has undertaken an interdisciplinary, multi-agency study effort to evaluate these stressors. The overall approach is based on a "triage" model to identify the most likely causes of the decline, and to assign priorities to projects on the basis of where funds and resources can be best used. The proposed work falls into four general types: an expansion of existing monitoring (four expanded surveys); analyses of existing data (nine studies); new studies (six studies); and ongoing studies (four studies).

MORE INFO? tsommer@water.ca.gov

SUMMER TOW-NET SURVEY – DELTA SMELT 1959-2004



INITIAL CLUES FROM 2005 20MM-DELTA SMELT SURVEY
GREAT HYDROLOGY, LITTLE IMPROVEMENT



TAKE HOME POINTS

- **Abundance of pelagic fishes still hasn't improved much, despite favorable hydrology in 2005 and relatively moderate hydrology during 2002-2003.**
- **The IEP is investigating three stressors—contaminants, water exports, and invasive species—as major causes.**

Clues to the Delta Pelagic Food Web Decline

WIM KIMMERER AND JOHN DURAND
SAN FRANCISCO STATE UNIVERSITY

The recent decline in abundance of several species of fish in the Sacramento-San Joaquin Delta has prompted an unprecedented cooperative effort aimed at identifying the causes. Public and media attention to this decline has been great: pictures of copepods are appearing on the front pages of newspapers!

Determining the cause or causes of the decline is an extraordinarily difficult problem, exacerbated by the intense pressure on agency scientists and their university colleagues to find "the answer." One way to begin delimiting the problem is to investigate where changes have occurred across each of several dimensions. The most obvious of these are space and time, and these give clues: the declines have occurred generally in fresh to brackish water; since 2001, more in Suisun Bay and the Delta than in Suisun Marsh. Another key dimension is species: only some of the species present within the spatial-temporal box of concern have declined, while others have not. Contrasting life histories may give a clue to why some have declined and others not.

An additional dimension is trophic position. The species that have declined include the copepod *Pseudodiaptomus forbesi* and several species of fish. *P. forbesi* is important food for at least some of these fish during summer, implying a causal link. Chlorophyll concentration, used to indicate the availability of food for copepods, has not changed over the same period. The lack of decline in chlorophyll would indicate that the breakdown is occurring in the population dynamics of the copepods, but phytoplankton species composition has also changed. *P. forbesi* seems to have a very low reproductive rate, so a small decrease in food consumption could have a big impact on abundance. Our ongoing work on population dynamics may shed some light on these issues.

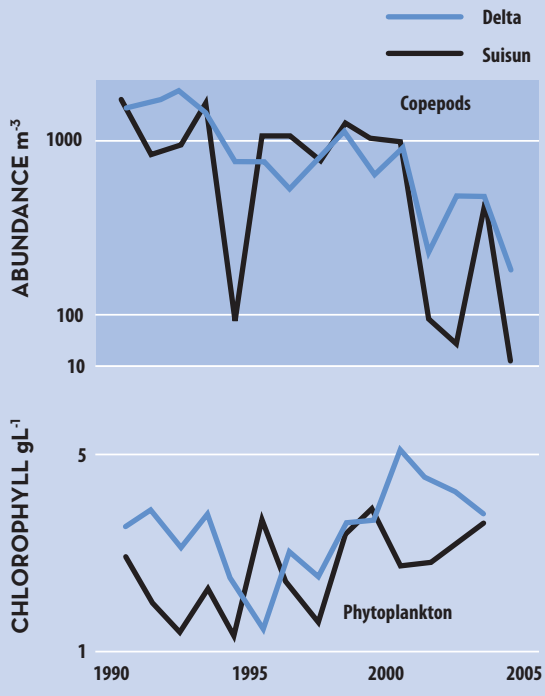
The next dimension is "stressors," i.e., factors that might have negative impacts on populations. Although there is a strong tendency to point fingers at recent changes in water export patterns in the south Delta, temporal changes in actual volume exported do not correspond with the observed population changes. Other potential stressors include anthropogenic contaminants and toxic releases from the cyanobacteria *Microcystis aeruginosa*, which has bloomed in the Delta since 1999. These stressors have their own suite of dimensions, and the extent of their potential effects on the foodweb may be difficult to determine, especially in retrospect.

Illustration: Joe Eaton

Figuring all this out will take more than expanded monitoring, although there are some key system elements not being monitored. Measuring processes such as growth, fecundity, and sensitivity to contaminants will be required if we are to go beyond status and trends. These efforts are beginning, but must be adaptive if results are to be achieved soon.

MORE INFO? kimmerer@sfsu.edu

PLANKTON PATTERNS - GLIMPSES INTO THE FOODWEB



TAKE HOME POINTS

- **Possible influences on the pelagic organism decline include water project effects, climate effects, contaminants, toxic algae, and introduced species.**

The Delta: A Case Study in Management Adaptability

JERRY JOHNS
CALIFORNIA DEPARTMENT OF WATER RESOURCES

The concept of adaptive management has worked its way into the interface between water and biological sciences. Adaptive management allows water and biological managers to modify environmental conditions, develop data on the effects of these changes, and then adapt operations or standards to reflect the knowledge gained. This works well when the system being evaluated is staying relatively constant. However, recent events in the Bay-Delta Estuary have shown us that this system has changed markedly in the last few years, both from an ecological point of view and a funding and institutional perspective. The issue now is not so much adaptive management but management adaptability to respond to these changes. Can water and fishery managers change directions as fast as the political and ecological changes around them and adapt their approaches to problem solving fast enough to resolve conflicts?

CALFED has been the institutional pillar upon which we have built today's relationships between agencies and programs to protect and enhance both environmental conditions in the Bay-Delta Estuary and to provide the water for those who rely on the Bay-Delta watershed. However, the funding for the CALFED programs has been less than expected, and this program is undergoing extensive review and possible "refocusing" to evaluate its successes and to hone its mission to concentrate on resolution of Bay-Delta conflicts. Most importantly, CALFED will attempt to develop appropriate user contributions to the CALFED Programs so that it has sustainable funding.

In the past three years there has been a decline in the relationships between the abundance of many open water fish inhabiting the upper Bay-Delta Estuary and the ecological factors that have historically affected their abundance. This unexpected decrease in abundance of these pelagic organisms has sparked an intensive effort by agency, university, and outside scientists to determine the cause or causes. Making water management decisions in light of this uncertainty requires us to be pragmatic and cautious. In addition, the sustainability of the current Delta levees infrastructure has been brought into question by the 2004 Jones Tract levee failure, funding issues, and by scientists studying the long-term subsidence, earthquake probability, and prospects for sea level rise due to global warming. Given these questions, the state needs to reevaluate what the Delta will look like in the next 50 to 100 years and develop a strategic plan towards that vision.

Water planning in general in California has taken a new shift with the release of the latest California Water Plan in spring 2005. Two new initiatives, Integrated Regional Water Management and Improving the State's Water Management System, build upon the principles of increased water use efficiency, improved water quality, and environmental stewardship. A water resource investment fund is needed to help meet California's water investment strategies for the future. A partnership with funding is needed between local and regional entities and the state to meet California's growing water needs.

The environment in which we find ourselves is changing rapidly. It will test our water management adaptability. Our ability to pass these tests will determine our future.

MORE INFO? jjohns@water.ca.gov

TAKE HOME POINTS

- **Adaptive management works when the ecosystem is relatively stable.**
- **The Delta ecosystem is changing rapidly. Salmon numbers are up, but pelagic organisms have declined.**
- **The state's new water plan encourages environmental stewardship. That concept hasn't been discussed in past water plans but will be—more so—in the future.**
- **It may be that we should put off decisions about water export operations in the Delta until we have more data and a new Record of Decision.**
- **We need to make "no regrets" decisions that improve flexibility.**
- **In 50 to 100 years, the Delta will be a different place. We probably can't have everyone on the island. How are we going to protect all of the infrastructure that crosses the Delta? We need to take a comprehensive view.**

The Role of Science

"The interactions between tidal wetlands and pelagic areas are still not well understood."

—Charles Simenstad
University of Washington

"Eighty percent of our stream reaches are now behind impassable barriers. Only tiny remnant [chinook and steelhead] populations are left. We are going to have to do some creative thinking about how to preserve ESUs."

—Steve Lindley, NOAA

Photo courtesy of David Hart and John Sanger

Why Track Environmental Performance?

BRUCE WOLFE
S.F. BAY REGIONAL WATER QUALITY CONTROL BOARD

The water board's mission is to preserve, protect, enhance, and restore the waters of the state for all. But it's clear we can't just say we're going to keep working to protect the Bay and expect to get all the funding we need to do it. Decision-makers and the public want to know how we're doing, they want to know what we've done, and they want to hear the message in easy-to-understand terms. "Restoring creeks" resonates better than "minimizing the hydrogeomorphic impacts to riverine functions"—indeed, Los Angeles passed a $500 million bond last year when it was pitched as restoration of the LA River rather than as controlling the impacts of stormwater runoff.

At the S.F. Bay Regional Water Quality Control Board, the Board members themselves make all the big decisions on permits, TMDLs, cleanup plans, and the like, but the staff carries out the mission by learning and understanding the impacts to our region's waters, determining whether those impacts are related to waste discharges, and, if the answer is "yes," recommending that the Board take the appropriate regulatory action. It is our job to assess whether the action taken gets the desired results.

This used to be a fairly straightforward task. For example, in the 1960s and 1970s, when the water board became aware that parts of the Bay had high bacterial counts, we responded by requiring the waste dischargers to disinfect their effluents. In this instance the cost of compliance or environmental performance was relatively modest, and the results of that performance were clear and easy to track. Levels of coliform bacteria in the Bay dropped dramatically. We had a nice link between the environmental problem, the environmental performance required, and a measurable water quality result.

Another example is dissolved oxygen in South San Francisco Bay below the Dumbarton Bridge. The water board found that dissolved oxygen was at times well below what fish needed to survive, and studies indicated that the culprit was ammonia in sewage effluents from the three treatment plants in the area. Fish kills were a straightforward problem, as was the environmental performance needed: the Board required that those effluents receive additional biological treatment to convert ammonia to nitrate. Once new facilities went on line, tracking of the dissolved oxygen levels demonstrated the problem had been solved.

Today it's not always so simple. Issues that face us now—legacy pollutants, crashing fisheries, and emerging contaminants—are not as straightforward in terms of what we need to do, and how to measure progress, let alone success.

On the other hand, we have far better tools to assess the state of our waters. The restoration of Peyton Slough by Rhodia is a case in point. Peyton Slough was identified some years back as a toxic hot spot, due to extensive cooper and zinc-impregnated sediments in and adjacent to the slough. Rhodia, as successor to the parties responsible for the waste, responded to our requirements for cleanup with the innovative approach of moving the slough away from the contamination, rather than the other way around. In so doing, they're immobilizing the contamination, creating new wetlands, restoring other wetlands, improving circulation to McNabney Marsh, and a host of other benefits. It's an approach we probably wouldn't have accepted ten years ago, but their ability to demonstrate the anticipated environmental performance and how that would be tracked sealed the deal for us.

The Regional Monitoring Program, which is funded by the public, private waste dischargers, and dredgers and implemented by the San Francisco Estuary Institute, involves not only monitoring for compliance with water quality standards, but also interpreting the results in ways people can understand. But even with a tool like the RMP, there will always be issues that resist easy answers. An obvious one that we've been wrestling with for years is mercury in the Bay. We know mercury moves up the food web and concentrates in fish, and in people eating the fish. We also know mercury impacts bird populations by affecting their eggs. Relying on RMP data, our Board adopted a long-term

TAKE HOME POINTS

- **In most cases we will not have certainty as to problem cause and will have to use a weight of evidence approach. Nonetheless, we need to track performance to move forward, changing our actions when needed.**
- **We must start science long before we can expect to make a decision.**
- **We need to be clear in our message about what environmental performance is needed and how we're going to track that performance: we need the public's trust and support.**

cleanup strategy for mercury in the Bay, but the State Board remanded that strategy back to us. In this case, everyone agreed the science we relied on was appropriate and recognized to be the best available. Our study indicated that it could take up to 120 years for the Bay to fully recover, but that the actions we were requiring would reduce new loads of mercury by half in less than 20 years. Politics or no, 120 years was a measure of environmental performance the decision-makers found too easy to attack. We'll need to change our message as we move forward.

There are more issues we are now learning about that need to be fit into a structure of clarifying the environmental performance needed, simplifying the message, and tracking that performance. One is ammonia. We know that ammonia is no longer causing dissolved oxygen impairment, but there is some new research that indicates that it may be suppressing nitrogen uptake by diatoms.

We know that diatoms are extremely important at the base of the food web—they partly drive the biological productivity of the entire system. However, before we require all sewage treatment dischargers to provide the additional treatment needed to convert ammonia to nitrate, we will need more evaluation of environmental performance—do we know what action to take and how to track that action? Even if ammonia is shown to be a problem, we want to be sure that removing it does not create the opposite problem, that of nuisance levels of diatoms.

We need to be clear as to what our baseline is and/or what our endpoint is. Our Board's mission takes us in two directions—"preserve" and "protect," where we're trying to make sure we don't allow water quality to get any worse; and "enhance" and "restore," which implies that we improve water quality, but to what level? 1750? 1850? 1950?

We've classically focused more on "preserve" and "protect" than "enhance and restore," but it's clear through TMDLs, expanding needs for mitigation from project impacts, and just about every poster at this conference, that we need to ramp up "enhance and restore."

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What Should the Role of Science Be in the Estuary?

TIM QUINN
METROPOLITAN WATER DISTRICT OF SOUTHERN CALIFORNIA

What are policy makers looking for from scientists? It is pretty straightforward. I'm looking for objective accurate information about the consequences of alternative policy choices. That sounds easy enough, but we did it wrong a great deal of the time.

There's a division of labor that is important to keep in mind. The policymaker's job is to choose amongst alternative outcomes that are available to them in difficult policy choices. The scientist's job is to make sure there is accurate information, and to protect the integrity of that information. Too often in California water you have people sitting at policy-making tables trying to cross over that line and control the science for their own negotiating advantage. Similarly you have scientists who cross the line, making judgments about what information should be out there based on what they think should happen in the proper realm of the policy maker. The policy maker shouldn't have control over the information flow; the scientist's job is to stay away from the policy choices.

The best way to drive that point home is to recall the development of the Bay-Delta Accord in 1994, which included the creation of CALFED, and was a major reversal of policy at that time. Up until December 1994 it was far from clear that we would be able to negotiate an accord because of how we were handling science—science as driven by political positions and negotiating positions. Betsy Rieke, the Assistant Secretary of Interior for Water and Science, recognized that it would be impossible to come to agreement if we continued to politicize the science. So she convened a science meeting in Monterey, pulling all the scientists and all the policy makers and most of the stakeholders into the same room. For the first time there were very short lines of communication between the scientists and the policy makers. All too often we try to separate those groups of people. The Accord was one of the few times in California water we got it right.

Good science done well is a conflict reducer: it gets people to agree on consequences, even if you don't like some of them. When you politicize science, you grow the conflict. I don't think the *San Francisco Chronicle,* the *Contra Costa Times,* or the *Sacramento Bee* are very good places to initially publish your conclusions and findings. But there's a lot of that going on and it's not a healthy thing for California water policy or for the environment. I'm hopeful that with all of the warning signs we're getting from the Estuary we will starting asking the right questions—did we get the facts right, did we do the right thing, set the right policy?

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Long-term, Large-scale Monitoring: Needs and Prospects

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WETLANDS & WATER RESOURCES

Are we giving migratory birds more and better habitat? Are fish getting more food from productive marshes? Do we have more connected parcels reflected in greater overall species support? The only way to know is to monitor natural and restored wetlands beyond status and trends to data collection designs based on cause and effect models and scalable from specific sites to sub-regions to the Estuary. Monitoring is a way to observe change in the environment. With it, we can evaluate our past investments in resource restoration and management, prioritize and carry out the most effective future restorations, address potential problems, and support regional planning. Weaving science into estuarine management demands that we evaluate past investments, rebalance the focal point of our political capital when we learn what is more effective, and be prepared for surprises with early warnings of potential problems. At present, the San Francisco Estuary has no long-term, large-scale wetland monitoring in place, though several separate efforts contribute key elements.

Monitoring is more than collecting data on status and trends – it is analyzing, integrating, applying, and distributing information. This list presents our most pressing monitoring needs for the Estuary.

1. Distribute monitoring results widely and easily via the internet to facilitate their utility.
2. Continue to develop unbiased lessons learned from older and more recent restorations; restoration evolution demands revisiting older projects periodically as lessons can change after project-specific monitoring ends.
3. Conduct field- and laboratory-based problem evaluation monitoring to support problem resolution.
4. Conduct periodic regional assessments combining remote sensing with focused rapid field assessments to inform regulatory program effectiveness and support planning initiatives.
5. Finish protocols for data collection, QA/QC, and analysis and develop decision trees for selecting protocols applicable to the many circumstances we encounter, so we do not keep reinventing the wheel and so that we have confidence in data.
6. For regional and sub-regional efforts, include conceptual models explaining how what is being monitored is linked to things that could change; monitoring data (QA/QC, storage, and public access); a data analysis sub-program (looks for trends, patterns, covariance, and frames the "why" research); and a research sub-program (tests the conceptual models and explains why you see what you do), and identifies clear, agreed upon goals and management questions amongst funders and major customers.

Funding is the major impediment to successful monitoring. Monitoring typically costs more than is desired, and decision makers often do not place high value on monitoring especially with competing demands for implementation dollars, leaving us not knowing whether "build it and they will come" is true and, if so, why. There is a lack of collaborative governance: many divergent views exist about monitoring and restoration; currently, no forum exists to address and resolve those views. We need information centralized and available. Aggregating results in a publicly accessible manner has not occurred, though a structure now exists (www.wrmp.org) that awaits a significant information upload effort.

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TAKE HOME POINTS

- **Regional goals for restoration and species recovery need to be informed by monitoring.**
- **All monitoring needs to be science-based, driven by hypotheses, and informed by conceptual models.**
- **One size does not fit all. A suite of complementary efforts is essential.**
- **Easy access to information is vital.**
- **Funding is the number one impediment to monitoring.**
- **Avoid power struggles and collaborate to achieve best monitoring results.**

Evaluating Restoration Holistically

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PRBO CONSERVATION SCIENCE
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In examining the success of tidal wetland habitat restoration, we need to evaluate how well we have restored ecological processes as well as community assembly, rather than basing our evaluations on the mere presence or the lack of detection of target species. Understanding ecological processes and the pace of tidal marsh restoration can help restoration project engineers evaluate the design and implementation of future restoration projects and manage unexpected outcomes of restoration projects in progress. Regulatory agencies need to establish empirical, yet meaningful performance criteria for the purpose of permitting and evaluation. Restoration objectives for tidal marshes are often framed with respect to special-status wildlife, fish, and plant species with relatively narrow requirements for particular habitat structure, habitat dynamics, or specialized sub-habitats. Aligning tidal marsh restoration projects to achieve these requirements is important to justify to the general public major investment of public funds.

These competing objectives provide a challenge to the development of restoration success criteria. We outline a framework for developing restoration performance criteria that considers multiple spatial scales (local project, project complex, regional, and Estuary-wide) and multiple temporal scales. We highlight a basic dilemma: mandated monitoring of restoration projects is generally short-term (less than two decades, often around five years), yet the time course for achieving most important ecological objectives associated with mature marsh community structure is generally long-term (over two decades). We emphasize the importance of biological criteria that reflect restoration of ecological processes and community assembly, rather than the mere presence or the lack of detection of target species. For example, for birds that breed in tidal marsh, desirable criteria include breeding density and achieved reproductive success at restoration sites. Finally, we recognize the need for cost-effective, efficient monitoring programs that can be sustained in the long-term, and the limitations of intensive but short-lived monitoring.

Recent studies of restoring wetland sites indicate the ecological value of intermediate seral stages (transitional states of restoration sites). It is therefore valuable to develop success criteria that focus on evaluating young restoration sites, both to enhance the ecological value of such habitat and to provide early evaluation of restoration practice in a timely fashion, so that corrective steps may be taken. We use recent studies of restored and restoring tidal marshes to illustrate conceptual performance criteria that assess success on short-term and long-term scales and support management decisions regarding all phases of restoration projects. In 2005, for example, young restoration marshes demonstrated similar reproductive success for song sparrows as mature tidal marshes. Young restoration marshes do not appear to be ecological traps.

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TAKE HOME POINTS

- **In evaluating restored marshes from the perspective of plants and animals comparisons should be made with multiple—and the most appropriate—reference sites.**
- **The same parameters must be measured.**
- **Habitat connectivity is important, and taking a regional perspective is vital.**
- **Long-term effort is needed—several years of data collection.**
- **Restoration success should not simply be judged as pass/fail. Asking what kind of success — or what kind of bottleneck prevented success — may be more informative.**
- **Tidal marsh restoration proceeds stage by stage. Monitoring and evaluation should be developed appropriately and include success criteria that focus on important ecological processes for intermediate restoration stages as well as mature sites.**

Fish Advisories and You

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The Office of Environmental Health Hazard Assessment (OEHHA) issues fish consumption advisories for local water bodies in California. Fish advisories are useful as environmental indicators of water quality, but they need to be put in context as a measure of change in the San Francisco Estuary. The very first fish advisory in California (1971) was for striped bass in the Bay-Delta and advised fishermen to eat no more than one meal per week of striped bass due to mercury in these fish. That advisory was updated in 1985 (children and pregnant women were advised to consume NO striped bass from the Bay-Delta) and again in 1993, resulting in a 303(d) listing and TMDLs for mercury in the Bay and Delta and PCBs in the Bay. It also resulted in signs being posted around the Bay and communication efforts being increased. In 1994 specific advice was added for fish and shellfish from the Richmond Harbor Channel area based on data for pesticides and other chemicals. Later in 1994, the current advisory was developed using data from a Regional Board study. This advisory was based on mercury and organic contaminants (e.g., PCBs) in fish species from San Francisco Bay, and recommended that adults should eat no more than two meals per month of Bay fish and no striped bass over 35 inches. Women and children under six were advised to eat no more than one meal per month of Bay fish, and no large shark (over 24 inches) or striped bass (over 27 inches). The advisory was amended in 1996 to clarify that the same advice applied to striped bass and sturgeon in the whole Bay-Delta area.

Based on the decreasing meal recommendations it may at first appear that water quality in the Estuary has degraded since 1971. Since advisories, and their underlying data, do impact water management and agencies responsible for water quality through the 303(d) list and Total Maximum Daily Load process, it is important to understand these changes. Evidence indicates that in general concentrations of organic chemicals have decreased and that mercury concentrations in fish have remained about the same. Changes in the advisory are due to improvements in analytical methodology and new studies expanding our understanding of the toxicology of methylmercury and other chemicals.

The primary goal of fish consumption advisories is to provide information to the public so that people can reduce their exposure and risk to contaminants already in the environment, while still enjoying fishing as a natural resource and health benefits from fish consumption. Advisory awareness through outreach activities is a critical ongoing component for public health and safety because processes aimed at reducing chemical concentrations in fish take a long time.

OEHHA is working to move beyond focusing on water bodies with known or suspected contamination problems to identifying water bodies in which one can catch and eat more fish, and developing safe eating guidelines for them. This requires a coordinated California program to monitor a variety of chemical contaminants in fish from the water bodies in which people are catching them. This type of monitoring would provide a statewide baseline for contaminants, help identify emerging risks, and track trends in water quality as indicated by more fish that can be safely eaten from more water bodies.

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TAKE HOME POINTS

- **There have been no significant changes in mercury concentrations in fish in the Estuary.**
- **Organic chemical concentrations are declining in the Estuary but not enough to affect consumption guidelines yet.**
- **New chemicals are being found in fish.**
- **Consumption guidelines are still protective of human health.**
- **We need to continue to educate and inform the public about contaminants in fish.**
- **We need to improve the effectiveness of our advisories.**
- **We need to continue to improve conditions in the Estuary.**
- **We need to continue to monitor, expand our efforts geographically, and update our advice with an emphasis on safe eating guidelines.**

Do Contaminants Harm Estuarine Habitat?

SUSAN ANDERSON, ET AL.
DAVIS BODEGA MARINE LABORATORY

For decades, managers have used chemical analyses and laboratory-based sediment toxicity tests (with standard test species) to predict the effects of contaminants in the Bay. However, the responses of organisms actually living in the Bay are what managers, scientists, and the public care most about. Managers and scientists alike have been frustrated by the lack of consensus on how pollutant effects should be characterized in fish, invertebrates, and plants of the Estuary. It is an opportune time for cooperative investigations that will lead to a solution to this problem.

The Pacific Estuarine Ecosystem Indicator Research (PEEIR) consortium advocates the development of an integrated portfolio of contaminant exposure and effects responses using indicator species selected for various habitat types. We developed a portfolio of techniques for salt marshes that are integrated within fish (mudsucker, *Gillichthys mirabilis*), invertebrate (shore crab, *Pachygrapsus crassipes*), and plant (cordgrass, *Spartina foliosa*, and pickleweed *Salicornia virginica*) indicator species. We performed sediment and tissue chemical analyses and analyzed biomarker responses in these species at five marshes in Northern and Southern California. A comparison to toxicity test responses and benthic population surveys was performed at a more limited number of stations. While the widely used Sediment Quality Triad approach is a useful screening tool, we found that this approach does not predict the range of effects in resident species. Specifically, we noted reproductive impairment in shore crabs and/or ovarian tumors and endocrine disruption in mudsucker fish at two sites where toxicity was either relatively low or nonexistent. We have also developed toxicity identification procedures that can be used to predict what chemicals cause endocrine disruption and other reproductive harm in fish.

Our Resident Species Portfolio approach is a first step in making monitoring of Bay species more practical, and hence minimizing extrapolations inherent in ecological risk assessment of contaminated sediments. Numerous emerging contaminants are being discovered, such as personal care products and flame retardants; techniques are needed to prioritize the contaminants that cause the greatest harm to aquatic life and to help focus regulatory action. Through highly integrated research and improved cooperation between research and management, it will be feasible to create a new paradigm for determining when and how contaminants impair the quality of our estuarine habitat.

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Gillichthys mirabilis

TAKE HOME POINTS

- **Contaminants cause harmful effects on fish and invertebrates—just because certain organisms are present in a marsh does not mean they have not been impacted. The fact that we don't measure contaminants in fish and invertebrates doesn't mean there aren't harmful effects.**
- **We need better knowledge of the effects of contaminants on resident species. We need to start monitoring their health. Such information will aid in regional monitoring and wetland restoration efforts.**
- **Sediment toxicity tests, chemical analysis, and invertebrate surveys are useful but limited tools. There are new methods available to discern contaminant effects in salt marshes.**
- **In the past, large-scale interagency efforts have usually not considered the impact of contaminants on species like the Delta smelt.**
- **We need a new, integrated approach linking ecology and toxicology. Integrated science is powerful and is the wave of the future.**

Linking Bay Health to National Ecosystem Indicators

ANITRA PAWLEY
THE BAY INSTITUTE

In October 2003, The Bay Institute released the first comprehensive report card for San Francisco Bay. The San Francisco Bay Index, part of the Ecological Scorecard project, illustrates a unique approach for interpreting science in clear and powerful public messages. Nearly 40 indicators were chosen based on a conceptual framework that ties condition to anthropogenic stressors. The indicators are aggregated into eight multi-metric indexes that track the Bay's environment (Habitat, Freshwater Inflow, Water Quality), its fish and wildlife (Food Web, Shellfish, Fish), our management of its resources (Stewardship), and its direct value to the people who use it (Fishable-Swimmable-Drinkable). Each index is illustrated by a letter grade, a numeric score that reflects the aggregated results of the component indicators for the most recent data period (e.g., Freshwater Inflow in 2004), and arrows indicating short-term (within the past 5 years) and long-term trends (over the past 20 or more years).

The 2005 update of the Scorecard's Bay Index allows us to reflect on recent changes in the Bay's health and to compare ecological conditions in different regions of the Estuary. In general, long-term downward trends have stabilized or are slowly being reversed for the Indexes that track the health of the Bay's environment. The Habitat, Freshwater Inflow, and Water Quality Indexes all showed some improvement, reflecting our ongoing investments for restoration of shoreline habitats and pollution control, as well as the wetter hydrological conditions in the last two years. In contrast, the Scorecard's measures for the Bay's aquatic biota were decidedly mixed. The condition of the upper Estuary's planktonic food web remained very poor and the Fish Index declined. Only the Shellfish Index improved, reflecting increases in the abundance of crabs and shrimp in the Bay. These biological indicators also tell another important story – the health of the Bay, as measured by the conditions and trends for its biota, varies dramatically along a geographic and environmental continuum in the Estuary. In the lower Estuary, Central and South Bays, indicators for phytoplankton, shrimp populations, and fish all showed fair and generally improving conditions. But in the upper Estuary, San Pablo and Suisun Bays, these same indicators were low and declining.

Indicator development is an iterative process that depends on sound science and sustained support. We now have a report card and framework approach that can serve as a basis for indicator refinement, but its success depends on continued use and refinement as our scientific knowledge evolves. Today, working as a coalition of national (San Francisco Estuary Project) and local entities (The Bay Institute, San Francisco Estuary Institute, Center for Ecosystem Management and Restoration), we continue to refine, augment, and improve upon this concept and approach. For example, the Water Quality Index is being evaluated, refined and expanded upon to become a Contaminant Index that incorporates measures of sediment quality. The Fish Index is being evaluated by a larger team of researchers and improved by adding additional data sources and sub-regional analyses. Wetland quality and bird resources are being evaluated to augment our

TAKE HOME POINTS

- **The San Francisco Bay Index synthesizes the results of nearly three dozen science-based indicators that measure the ecological health of the Estuary. Key to its success and media attention is its simple and easily understood Scorecard. However, the tiered approach for reporting results (2003 and 2005 reports and technical appendices) allows the reader to obtain a deeper view of condition for each attribute and component indicator (see www.bay.org).**
- **Multi-metric indexes and their component indicators, when organized in a consistent framework, can be used to evaluate and summarize ecosystem health across multiple geographic scales. The 2005 Bay Index covered the entire Estuary and, using several individual indicators, also detected and compared the variations in ecological conditions and trends in different regions of the Bay.**
- **Tracking ecosystem health through scientifically derived indicators is essential for long-term economic and political public support for the Bay's environment. Without such communication tools, the San Francisco Bay environmental and research communities will find it increasingly difficult to procure funds for restoration and monitoring in light of a reduction in available monies for environmental issues.**

current list of indicators. Additional indicator development efforts are occurring at the California Bay Delta Authority and at the state level. These efforts will inform and be informed by the "Indicators Consortium;" however, progress in this important work can be slowed by limited resources, data gaps, and political impediments.

Meanwhile, other large-scale ecological restoration programs across the nation, such as the National Estuary Program, are planning and developing suites of ecological indicators or "report cards." While our success is serving as one model for these efforts, it also challenges us to link our efforts to other national indicator frameworks to enable us represent and compare San Francisco Bay health to other large-scale ecosystems. Our involvement in other national level indicator efforts, ongoing research, and synthesis also offers important opportunities to improve the scientific underpinnings of the indicators and multi-metric indexes. Finally, increased visibility through widely supported, easily understood indicators will enhance public understanding of and support for San Francisco Bay conservation and restoration efforts.

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ECO-INDICATORS

An ecological indicator is a measurable characteristic related to the structure, composition, or functioning of an ecosystem.

Indexes are composed of multiple indicators and can be used just like economic indexes to summarize status and trends for a concise public communication tool.

THE SCORECARD'S BAY INDEX, 2005

AREA	GRADE	SUMMARY	SHORT TERM	LONG TERM
	D+ Score = 31	**Habitat** Bay habitat loss is slowly being reversed, but pace of restoration unchanged since 2003 – at current rate, more than 150 years to reach tidal marsh restoration goal.	▲	▼
	C+ Score = 58	**Freshwater Inflow** Reduced inflows still degrade the Bay ecosystem – inflow improved in 2004, but overall conditions since 2000 are worse than two previous decades.	◀▶	▼
	B- Score = 65	**Water Quality** Open waters are cleaner than in 2003, but not all standards are met in parts of the Bay. Toxic sediments, stormwater runoff are major problems. South and San Pablo Bays are most polluted.	▲	▲
	F Score = 10	**Food Web** Plankton levels in Suisun Bay are still critically low, reducing food resources for fish and birds. Phytoplankton levels in all other parts of the Bay are improving.	◀▶	▼
	B Score = 73	**Shellfish** Crab and shrimp numbers rise in Central and South Bays, but not in the upper Bay. Estuarine species lose ground to marine shellfish.	▲	▼
	C- Score = 45	**Fish** Recent upward trend reverses, fish populations return to critically low levels. Estuarine species of the upper Bay are hardest hit.	◀▶	▼
	C- Score = 38	**Fishable-Swimmable-Drinkable** More fish were caught but most are still unsafe to eat. Beach closures continue to rise, drinking water violations hold steady.	◀▶	▼
	C- Score = 46	**Stewardship** Little progress towards conserving more water, reducing pesticide use, and restoring freshwater inflows, but some efforts to issue pollution limits move forward.	◀▶	▼

How Science Is Guiding Restoration of the South Bay Salt Ponds

LYNNE TRULIO
SAN JOSE STATE UNIVERSITY

The Science Program for the South Bay Salt Pond Restoration Project provides direct scientific input into planning for short-term and long-term project actions. The project's Science Team has worked to identify key scientific uncertainties associated with the project and, through technical workshops and focused literature reviews, has collated information on what is known and not known about these questions. Using this information, as well as material developed by the consultant team and stakeholders, the Science Team drafted an Adaptive Management Plan (AMP) for the Project. This draft AMP illustrates how monitoring and applied studies, beginning now in the planning stage, can be used to address uncertainties. The data produced during planning will be applied directly in the design of Phase 1, to be implemented beginning in 2008. The draft AMP also describes how adaptive management will be integrated into project implementation to track the project's ecological and social goals and collect data to address key questions. Adaptive management—a cyclic process for learning from management decisions and applying that knowledge as we move forward—will help reduce uncertainty in such areas as mercury, sediment and mudflat dynamics, bird use of changing habitat, invasive and problem species, and benefits to non-avian species. Adaptive management is central to guiding the design and success of the project.

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PROJECT OBJECTIVES

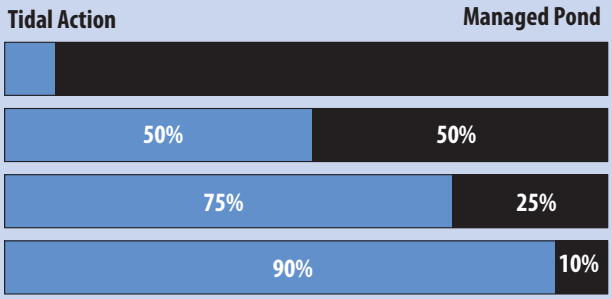
Create, restore, and enhance habitats to:

- **Assist in recovery of special-status species.**
- **Maintain current migratory bird species.**
- **Support increases in native species abundance and diversity.**
- **Maintain or increase flood protection.**
- **Provide for wildlife-compatible public access.**
- **Maintain or improve water and sediment quality.**
- **Maintain or improve invasive or nuisance species management.**

TAKE HOME POINTS

- **The South Bay Salt Pond Restoration Project is ecosystem restoration on a landscape scale—15,100 acres.**
- **It is a long-term restoration project and will be implemented in phases over approximately 50 years. Planning is underway, and implementation of Phase 1 will begin in 2008.**
- **Adaptive management will tell us how far we can go along the way—how much tidal marsh we should restore, taking into account the fact that salt ponds are habitats in their own right.**
- **Adaptive management is not trial and error; it is based on an understanding of the system.**

DRAFT PROJECT ALTERNATIVES AS LANDSCAPE VISIONS



Works in Progress

"Trends going the wrong way can be reversed. In Oakland, we're taking the Lake Merritt channel and returning it to a tidal slough. We've dammed and culverted most of our creeks, yet Measure DD set aside $198 million that will do lots of good for water quality and restoration. Measure DD passed by 80 percent of the vote—it was a mandate for restoration.

Many of the 6.4 billion of us on Earth live in urban areas, which can exacerbate environmental problems but also provide solutions. The biosphere we live in is a thin, fragile layer—only as thick as a coat of paint on a football. We're starting to see the body of Mother Earth get spastic—droughts, tornadoes, heat waves like we've never seen before. David Brower talked about the 'great ecological U-turn.' When you're standing on the edge of a cliff about to fall off, the solution is not very complex. You turn around and take a very different direction. Recently, ten cities across the country were named as the top ten green cities—San Francisco, Berkeley, and Oakland were all on the list. But we're at best light green. We can work toward medium and deep green. In Oakland, the mayor's office is committed to making environmental changes, bold changes, paradigm changes. We need to reduce greenhouse gas emissions. In Oakland, we've set a goal of getting to 15 percent below 1990 levels by 2010. We want to reduce landfill waste by 20 percent by 2010. We can help over-consuming people get down to a sustainable level. If we can reduce waste, we can reduce energy use as well. I'd like to see each generation leave less of an ecological footprint. We can shift from basic levels of change to paradigm shifts. We can set the tone for the United States."

— Randy Hayes, City of Oakland, founder RainForest Action Network

Photo courtesy of David Hart and John Sanger

Stewardship: Volunteers in Urban Restoration

MARILYN LATTA
SAVE SAN FRANCISCO BAY

Restoring habitat in highly urbanized regions with dense populations and layers of infrastructure poses special challenges. But urban areas also present opportunities and resources that can be applied to advance habitat restoration projects. Even highly altered and degraded urban landscapes hold habitat creation and enhancement possibilities, and densely populated urban areas hold another great resource: thousands of potential volunteers. Finding and mobilizing these "hidden" urban resources can be the essential ingredient for a successful habitat restoration project.

Urbanized estuaries can offer numerous and varied potential partnerships with federal, state, regional and local landowners, agencies, businesses, and organizations. Even small projects can create large interest and present opportunities to combine talents and resources, or to match funds among diverse partners.

The greatest urban resource of all is people. Find ways to utilize volunteers in a restoration project and they will participate. The key is developing a sustainable program of volunteer outreach and coordination with the restoration project. Here are some examples of the different types of habitat restoration projects we do in the San Francisco Bay-Delta Estuary:

1. Wetlands Enhancement Site Partnerships: Save The Bay partners with local, state, and federal resource agencies at six sites in San Francisco Bay to involve 5,000 community volunteers each year in wetlands restoration projects. These projects involve local schools, community and religious groups, corporations, and Bay Area residents in Bay education and on-the-ground habitat restoration of tidal wetlands.

Source: Save The Bay

2. Implementing Revegetation Plans with Community Volunteers: Many agencies do not have the staff time or funding to do such time-intensive tasks as manual removal of invasives, site-specific seed collection, and site monitoring. By implementing sound plans that educate people while they participate, both people and habitat benefit.

3. Regional Native Plant Nursery Program: We enhance educational values for our volunteers and save money on plants by growing them ourselves. We engage volunteers in site- and watershed-specific seed collection, plant propagation and transplanting, and planting more than 20,000 wetland plants each year in native watersheds.

4. Islands and other unique and sensitive sites: Save The Bay partners with the U.S. Fish and Wildlife Service at the Marin Islands and Bair Island to engage volunteers in habitat restoration via canoe and kayak.

5. Subtidal Restoration and Monitoring Projects: Save The Bay is partnering with the NOAA Community-based Restoration Program and San Francisco State University to monitor the status of oyster and eelgrass habitats in the Bay and small pilot restoration projects that are generating needed information for large-scale regional efforts.

6. Non-Traditional Partners: We also partner with groups not traditionally included in the environmental movement—businesses, industry, hunting associations, military reserves, and others. In order to truly save the Bay, we need everyone to participate in the effort and become part of the solution.

These examples all highlight diverse partnerships among state and federal public resource agencies, private businesses, community foundations, civic groups, non-profits, and local schools. They offer a wide variety of ideas and models for anyone pursuing urban estuarine habitat restoration.

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Volunteers Restore Marshes and Uplands

MICHAEL LEE
GOLDEN GATE
NATIONAL PARKS CONSERVANCY

Since its inception in 1981 as a Congressionally designated cooperative association, the Golden Gate National Parks Conservancy has provided the Golden Gate National Parks with nearly $78 million in aid to improve park sites, provide services and education programs for visitors and local communities, engage diverse audiences in the parks, and encourage those who use and value these parklands to take a role in their preservation. The Golden Gate National Parks Conservancy is a nonprofit membership organization created to preserve the Golden Gate National Parks, enhance the experiences of park visitors, and build a community dedicated to conserving the parks for the future.

The Parks Conservancy recruits and manages volunteers for conservation stewardship projects park-wide. In 2004 alone, nearly 16,000 individuals provided 382,000 hours of service in support of park programs — the equivalent of 184 full-time employees.

Volunteers perform a variety of tasks, ranging from restoring habitat (site stewardship) and trails, monitoring and banding birds of prey (Golden Gate Raptor Observatory), growing native plants (Native Plant Nurseries), leading interpretive walks and talks, and doing administrative work.

Nearly 3,000 volunteers were involved with the Parks Conservancy's most ambitious and visible project to restore Crissy Field into a premier urban National Park site. Under the supervision of Park staff volunteers planted almost 100,000 native plants at Crissy Marsh.

"They get a first hand experience with the resource. For many of them it's the first time. It's a way for them to connect both personally and intellectually."

Mike Lee

Taken as a unit, Golden Gate is one of the largest urban national parks in the world. Established in 1972, as part of a trend to make national park resources more accessible to urban populations and bring "parks to the people," Golden Gate's 75,398 acres of land and water extend north of the Golden Gate Bridge to Tomales Bay in Marin County and south to San Mateo County, encompassing 59 miles of bay and ocean shoreline and distinctive coastal habitats. These lands represent one of the nation's largest coastal preserves and attract 17 million visitors each year, making Golden Gate one of the most visited National Parks in the nation.

It is the dedication and hard work of volunteers that create the visible and lasting impacts benefiting the cultural and natural resources of the Golden Gate National Parks, today and into the future. Proper orientation, training, and skillful, personal supervision; investing in the continuing education of volunteers; and genuinely recognizing volunteers for their contributions are key ingredients to successfully recruiting, managing, and retaining volunteers.

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VOLUNTEERS = $

The Stevens and Permanente Creeks Watershed Council has at least 80 full-time volunteers engaged in watershed stewardship, including monitoring water quality. In 2005, 1,460 volunteers helped clean up 46 miles of creeks in Santa Clara County, removing 40,000 pounds of trash.

"Funding for volunteers to stay involved—and to attend stakeholder meetings—is a challenge. The collaborative process tends to be dominated by the agencies. There should be a mechanism for the general public to participate."

Mondy Lariz
Stevens and Permanente Creeks Watershed Council

According to the U.S. Fish & Wildlife's Mendel Stewart, volunteers at the S.F. Bay National Wildlife Refuge complex represent 19 full-time staff people, at a dollar value of $470,000. At the South Bay salt ponds, 15 active docents regularly take the public on guided walking tours. Volunteers also take resource managers by boat to the Farallones. Citizens to Complete the Refuge continue the volunteer and advocacy work they started 40 years ago.

"Citizens like these define what volunteerism is all about."

Mendel Stewart
U.S. Fish & Wildlife Service

North Bay Restoration: Napa Salt Ponds and Hamilton Airfield

AMY HUTZEL AND TOM GANDESBERY
CALIFORNIA COASTAL CONSERVANCY

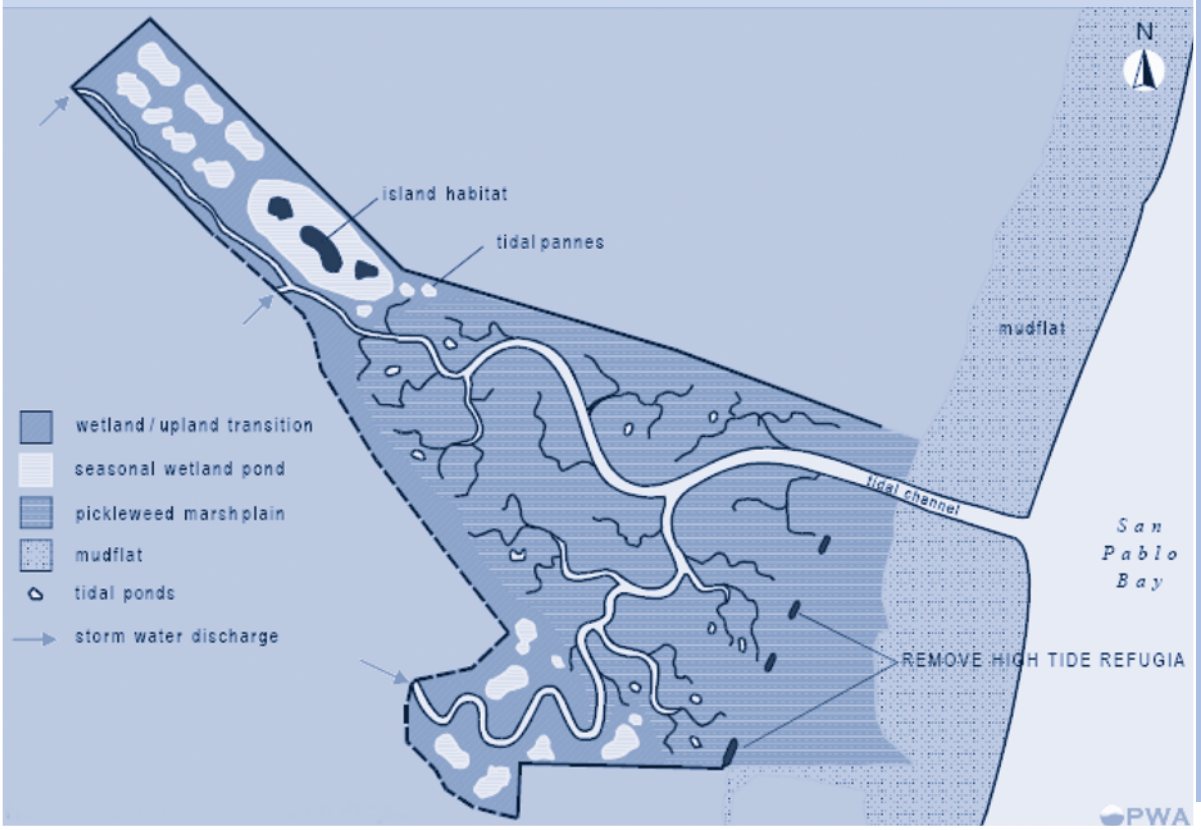
Before the Gold Rush, over 50,000 acres of tidal marsh ringed the Bay. Today, less than 20,000 acres exist, but we have the potential to almost double that amount. Two such large-scale restoration opportunities are coming to fruition in the North Bay: the Napa Salt Ponds and Hamilton Airfield. The two projects have similar objectives but involve very different sites and different designs. At both projects, we want to restore tidal and non-tidal habitats.

In 1994, the Cargill Salt Company ceased the production of salt in the North Bay and sold almost 10,000 acres of ponds and adjoining lands to the State of California for $10 million. The Coastal Conservancy, California Department of Fish and Game, and U.S. Army Corps of Engineers have completed a Feasibility Study for the reduction of salinity and restoration or enhancement of habitats in the former salt ponds. Some of the inactive salt ponds currently provide significant habitat for fish and wildlife, while the salinity levels in others exceed that which is beneficial to wildlife. The project objectives for the Napa Salt Ponds are: (1) to restore large patches of tidal habitats in a band along the Napa River, in a phased approach, to support a wide variety of fish, wildlife, and plants, including special status species, and (2) to effectively manage water depths and salinity levels of remaining ponds to benefit migratory and resident shorebirds and waterfowl. Restoration began in Fall 2005 with the commencement of tidal restoration of 3 ponds (3,000 acres) and enhancement of 3 additional ponds. The work is being conducted by Ducks Unlimited using grant funds from the Wildlife Conservation Board and the California Bay Delta Authority. A potential addition to the Project is the use of recycled water to dilute

POTENTIAL FOR LARGE-SCALE RESTORATION

	ACRES
Napa Salt Ponds	9,850
Hamilton & SLC	990
Bel Marin Keys	1,585
Napa Plant Site	1,400
Skaggs Island	3,300
Sears Point	1,400
Cullinan Ranch	1,564
TOTAL	20,000

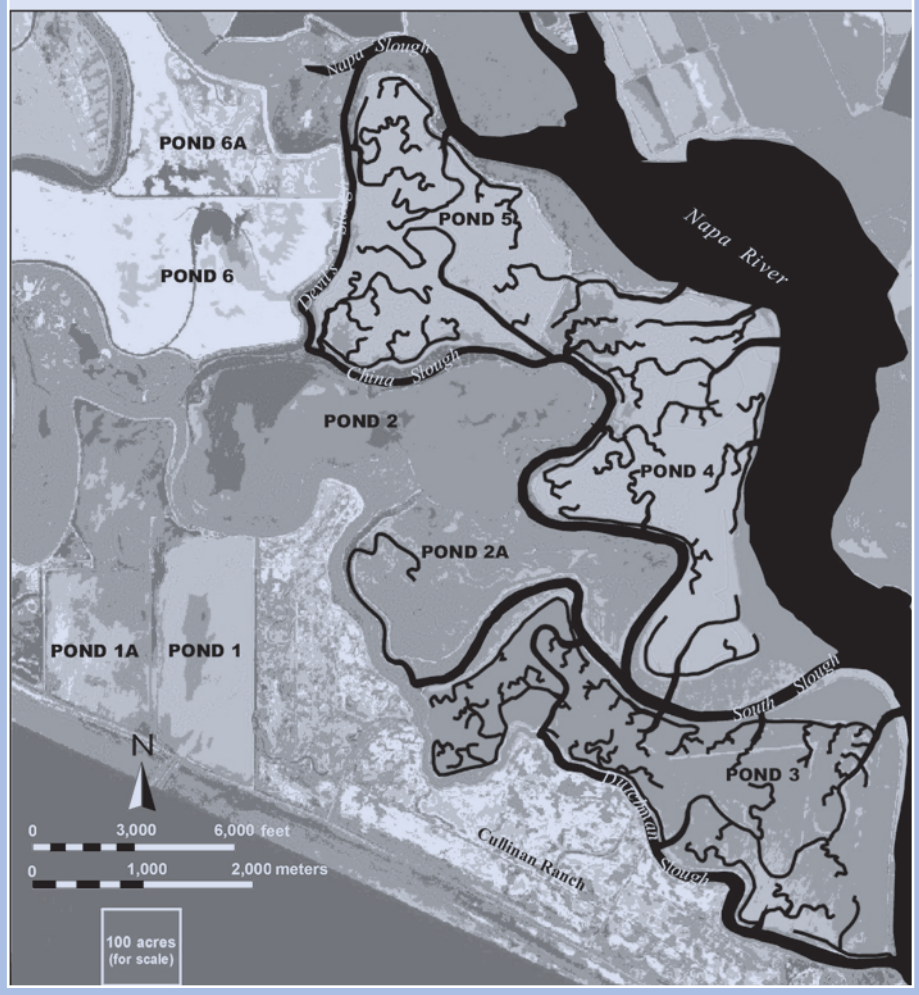
PREDICTED HABITAT AT YEAR 50, HAMILTON AIRFIELD



TAKE HOME POINTS

- **The Napa Salt Ponds and Hamilton Airfield projects both include a mix of tidal and non-tidal wetlands.**
- **Both sites are worthy of restoration but require different treatments.**
- **Other North Bay projects (from Pond 2A to Sonoma Baylands) have provided lessons.**
- **We are using two different designs to achieve vegetated tidal marsh and other tidal habitats in a reasonable time frame.**
- **The designs are based on site conditions such as elevation, existence of a historical template, proximity to development, and existing non-tidal wetlands.**
- **Design complexity and costs increase with constraints such as subsidence, proximity to development, lack of historical template, flood control issues, existing non-tidal wetland resources, etc.**

PREDICTED LONG TERM HABITAT AT THE NAPA SALT PONDS



bittern, a salt production by-product, in partnership with the Sonoma County Water Agency.

The first phase of the Hamilton Wetland Restoration Project will provide 620 acres of restored tidal and seasonal wetlands at a former Army airfield and adjacent taxi areas on San Francisco Bay in the city of Novato, Marin County, California. The Corps of Engineers and State Coastal Conservancy are planning to add the adjoining State Lands Commission parcel and the Bel Marin Keys V property to the project to expand the wetlands project size to almost 2,500 acres. The phased approach will be used to complete the design and construction tasks in conjunction with the availability of land and dredged material. This wetland restoration project will advance the beneficial reuse of dredged material from San Francisco Bay as part of the Long Term Management Strategy (LTMS). The U.S. Army Corps of Engineers, San Francisco District, is the lead federal agency for the project and the California State Coastal Conservancy is the local sponsor.

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South Bay Restoration

CARL WILCOX
CALIFORNIA DEPARTMENT
OF FISH AND GAME

Over the last several years, significant progress has been made toward preservation and restoration of tidal wetlands in the South Bay. With the Cargill Salt Ponds acquisition, 17,700 acres of diked former Baylands are in the planning process for restoration. These projects include the Eden Landing Restoration Project, Bair Island, and the South Bay Salt Ponds. These projects build on restoration efforts over the past 30 years that have resulted in substantial tidal wetland restoration in the South Bay.

The Baylands Ecosystem Habitat Goals Report recommended the restoration of between 16,000 and 21,000 acres of tidal marsh habitat in the South Bay and the management of 10,000 to 15,000 acres of salt pond habitat. With the current projects, the objectives for tidal marsh restoration may be achieved within the foreseeable future.

The Eden Landing Restoration Project is currently under construction and is scheduled to be completed in the summer of 2006. This project will restore 650 acres of former crystallizers and salt ponds to tidal marsh while enhancing an additional 200 acres of managed ponds. One element of the project will be the restoration of approximately four miles of large tidal channels.

The Bair Island Restoration Project is in the final stages of planning and permitting. This project will restore approximately 1,700 acres of diked Baylands to tidal influence. The timing of restoration is being coordinated with nonnative Spartina control efforts to minimize the potential for colonization once restoration is implemented. The project will use dredge material to accelerate tidal marsh development to minimize potential bird strike concerns associated with the nearby San Carlos Airport. Tidal barriers will also be installed in two major sloughs to address potential sedimentation concerns at the Port of Redwood City.

The South Bay Salt Ponds Restoration Project is developing the restoration plan for the 15,100 acres of salt ponds acquired from Cargill Salt in 2003. This planning effort will be completed and a first phase restoration project implemented in 2008. In the interim, the Department of Fish and Game and U. S. Fish and Wildlife Service are managing the ponds under an Initial Stewardship Plan. Implementation of this plan has resulted in substantial increases in wildlife use but also highlights the complexity of managing large ponds while complying with water quality objectives.

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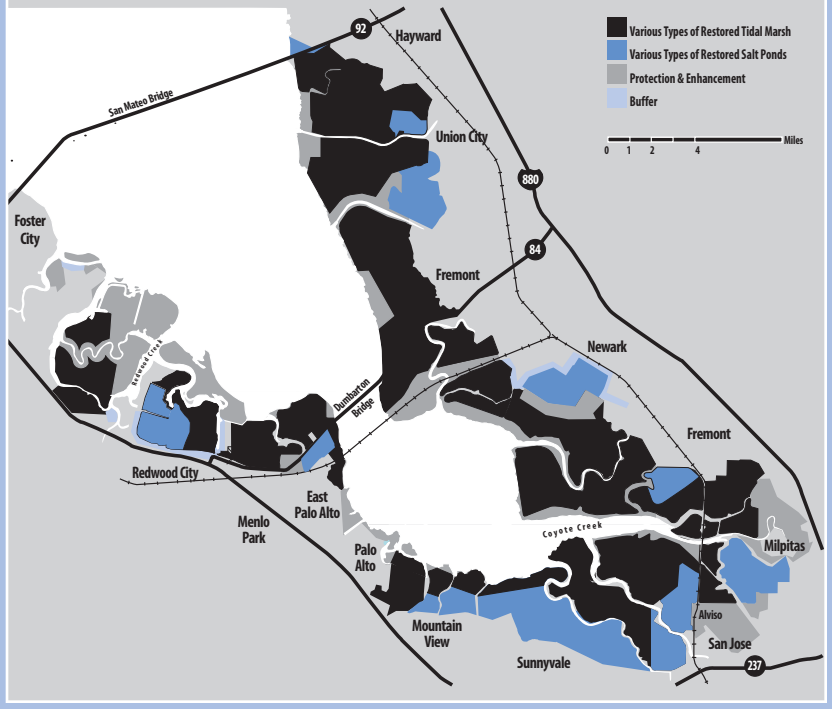
PRELIMINARY RESTORATION RECOMMENDATIONS



TAKE HOME POINTS

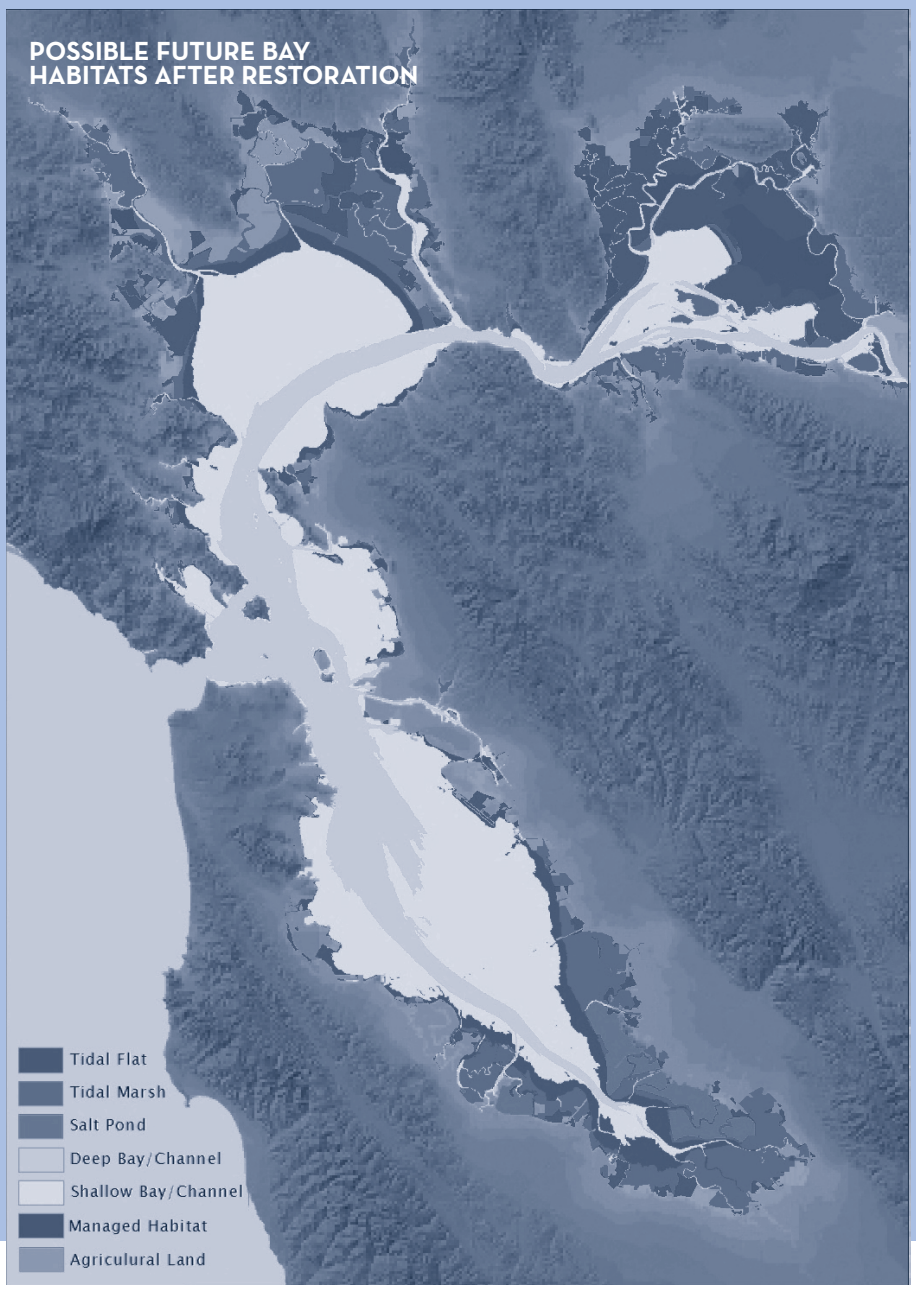
- **Tidal restoration will be advancing at a rapid rate in the next three years, with approximately 2,500 acres restored at Eden Landing, Bair Island, and the Island Ponds.**
- **Planning is well underway for first phase implementation of the South Bay Salt Pond Restoration Project in 2008.**
- **Managing pond habitat is an art that is developing as to how to optimize values for individual species and species groups while maintaining pond health and staying within permit conditions for discharges to the Bay.**
- **We need to perform additional investigation into mercury issues associated with South Bay pond restoration.**

Evaluating Restoration Success: The Human Angle

STEVE RITCHIE
SOUTH BAY SALT POND RESTORATION PROJECT

Most of the attention on habitat restoration projects is focused on the success or failure in producing the desired biological and physical results: achieving target populations of birds, fish, plants, etc. CALFED and others have long recognized that humans are a part of the ecosystem that must be considered as part of any restoration project, but in most projects, the human angle is not well-defined or considered.

In the South Bay Salt Pond Restoration Project, successful restoration must fully integrate the human element for a number of reasons. The most obvious reason is that the former salt ponds are literally surrounded by more than two million people. Restoration of the 15,100 acres of ponds now owned by the state and federal governments must be carried out in a way that enhances the quality of life for residents of the South Bay area. This is particularly critical at a time when large-scale public funding is hard to come by.



TAKE HOME POINTS

- **We need to monitor changes in community values and interests, just like we monitor species' use of habitat.**
- **We need to make sure restoration works for humans as well as animals, to be sensitive to human concerns from the outset, and to work actively to understand and address those concerns.**
- **We need to use every opportunity to educate folks about the values of restoration and to cultivate community ownership.**

Through its Stakeholder Forum and other processes the Project is working to identify what the broader community desires as a result of the restoration. Those broader public desires need to be considered within the constraints of federal ownership (the Don Edwards San Francisco Bay National Wildlife Refuge) and state ownership (the Eden Landing State Ecological Preserve).

Equally important with the result is the process by which the restoration plan is developed. Transparency of decision-making is key to building public trust and support for the Project. This is true both in restoration planning and in long-term adaptive management. The Restoration Project is working hard to ensure that it earns that trust and support.

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Successes in Protecting and Restoring the Bay

BETH HUNING AND SANDY SCOGGIN
SAN FRANCISCO BAY JOINT VENTURE

The San Francisco Bay Joint Venture (SFBJV) is a partnership of non-governmental organizations, utilities, landowners, and agencies working to acquire, restore, and enhance wetlands on San Francisco Bay and the coasts of San Mateo, Marin, and Sonoma Counties. The San Francisco Bay Joint Venture is one of the 12 wetland habitat Joint Ventures operating under the North American Waterfowl Management Plan (NAWMP), a Congressional agreement between the United States, Canada, and Mexico. The SFBJV Implementation Strategy, Restoring the Estuary, was completed and approved by NAWMP in 2001.

Based on the Habitat Goals Project, SFBJV goals include:

- Acquisition: 63,000 acres of Bay habitats, 37,000 acres of seasonal wetlands, and 7,000 acres of creeks and lakes (107,000 acres total);
- Restoration: 37,000 acres of Bay habitats, 7,000 acres of seasonal wetlands, and 22,000 acres of creeks and lakes (49,000 acres total);
- Enhancement: 35,000 acres of Bay habitats, 23,000 acres of seasonal wetlands, and 22,000 acres of creeks and lakes (80,000 acres total).

The focus of SFBJV for the past four years has been implementation of projects toward the established goals. Analysis of accomplishments since the founding of SFBJV indicate significant progress toward the established acreage goals for acquisition; protection of 43,000 acres (40 percent of the total goal and 63 percent for tidal wetlands); restoration of 5,023 acres (10 percent of total goal); and enhancement of 4,982 acres (6 percent of total goal). These accomplishments are being analyzed to correspond with each habitat type to help assess future focus and priorities of SFBJV and locations in focal areas of San Pablo Bay, the South Bay, Central Bay, and the coast.

Based upon the above information, the SFBJV Restoration Strategy/Technical Committee has recommended a shift in focus toward restoration. This emphasis would include funding, planning for restoration, and monitoring and assessment to guide decisions about the habitat types needed to accomplish the vision and goals established in *Restoring the Estuary*. A new project tracking data system has been developed by Ducks Unlimited for SFBJV to provide partners with the ability to track the progress of each project and to analyze each project and accomplishment in the context of the overall goals. The NAWMP assessment has also identified additional monitoring and evaluation needs to better understand (a) whether wintering conditions in San Francisco Bay contribute to the continental scaup and scoter declines; (b) the overall quality of Bay habitat for wildlife; (c) the impacts of human disturbance on waterfowl and other wildlife species; (d) the impacts on wildlife of converting one type of habitat to another type of habitat; and (e) the relationships of migratory wildlife that use SFBJV habitats to the habitats within other joint ventures.

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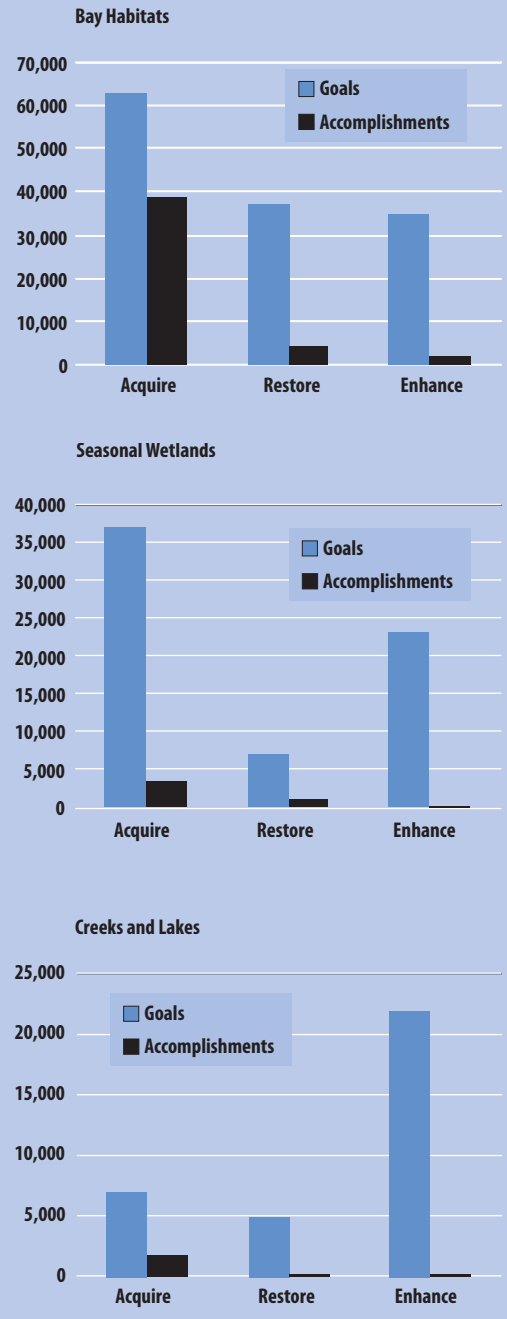
SFBJV ACREAGE GOALS AND ACCOMPLISHMENTS OCTOBER 2005



Science, Learned & Needed

"The certainty of our predictions about restoration varies by habitat type. We will learn and adjust as we go forward."

—Michelle Orr, PWA

"Revegetation is working to restore a diversity and abundance of songbird populations along the Sacramento, Cosumnes, and San Joaquin Rivers."

—Geoff Geupel,
PRBO Conservation Science

Photo courtesy of David Hart and John Sanger

A Landscape Ecology Perspective on Bay Wetland Restoration

MAGGI KELLY
UNIVERSITY OF CALIFORNIA, BERKELEY

San Francisco Bay is the largest estuary on the Pacific Coast; its wetlands provide crucial habitat for a wide range of species, and have a long history of human impacts. The wetland landscape is a complex mosaic of remaining historic wetlands, recently restored wetland sites, and potentially restorable diked bayland sites (farms, former salt ponds, and managed and unmanaged seasonal and perennial wetlands), all arranged in one of the state's largest urban areas. The diverse mosaic separating Bay from upland is crucial in many ways to the future of the San Francisco Bay Area: for example, these wetlands are an important component of the Bay's ecology, and they are part of the natural open space valued by a highly urban population.

While it has long been recognized that wetlands are ecotonal features between upland and open water, we also think of this complex of wetlands in the greater San Francisco Bay as wetland patches with ecotonal areas between them, and displaying within-patch variability that is important for species (bird, fish, mammal, etc.) diversity and survival, and other wetland functions. A landscape ecology approach is useful for setting the stage for large-scale wetland restoration in the Bay; the approach incorporates multiple scales and considers interactions between patches and flows between and across ecotones and patches. Landscape ecological principles such as adjacency, connectivity, heterogeneity, and spatial configuration can be useful guiding principles for future restoration.

TAKE HOME POINTS

- **By increasing the spatial scale we use, landscape ecology can help us see how individual wetlands function together. It can also help us determine how existing marsh patches can be revisualized for certain species.**
- **On a temporal scale, the future of the Bay—a mosaic of wetlands in an increasingly urbanized watershed—has to be planned for.**
- **We need a vision for planning for the ecosytem services provided by wetlands. Context and adjacency affect wetland functions.**

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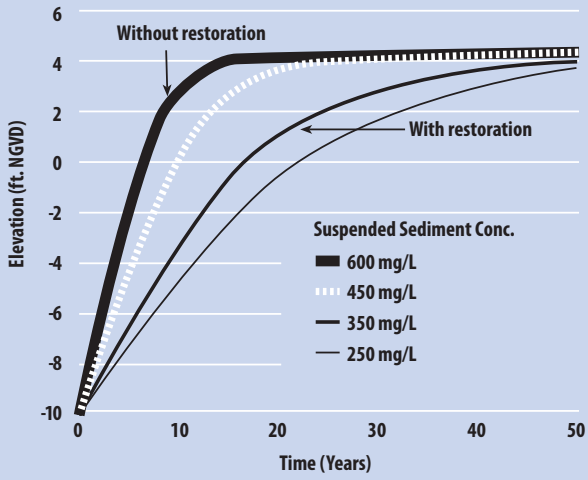
Predicting Habitat Changes in Wetland Restoration

MICHELLE ORR, ET AL.
PHILIP WILLIAMS & ASSOCIATES

Tools that integrate system-wide physical and ecological processes can be useful for large-scale restoration planning by informing decisions about where, how much, and which types of habitat to restore. In the 15,100-acre South Bay Salt Pond (SBSP) Restoration Project in South San Francisco Bay, successful design requires an understanding of how the ecosystem will evolve over time in response to possible management actions such as restoring tidal inundation to salt ponds to create tidal marsh.

The SBSP Landscape Scale Assessment is a geomorphic approach to predicting long-term (50-year) habitat changes within South San Francisco Bay without restoration as well as for different restoration scenarios. Given the inherent complexity of the processes involved, there are no standard "off the shelf" tools for this type of prediction. The assessment combines a sediment budget approach with existing analytical models, historical analysis, and empirical tools. The project planning timeline precluded development of new detailed models, such as a fine-grid numerical model, for the assessment. The physical-processes part of the assessment is an examination of the rate at which the restored South Bay salt ponds are expected to evolve from tidal mudflat to marsh, and how the restoration may affect the South Bay sediment budget and ultimately the extent of tidal mudflat and shallow-water habitats within the South Bay. The ecological part of the assessment uses the physical-processes results to predict vegetation, habitats, and wildlife use. Even when the large uncertainty inherent in this kind of assessment is considered, preliminary results suggest that sufficient sediment is available for tidal marsh restoration and that even the most subsided ponds are expected to provide tidal marsh habitat within the fifty-year planning horizon.

HABITAT EVOLUTION IN THE TIDAL PONDS: LONG TERM SEDIMENTATION



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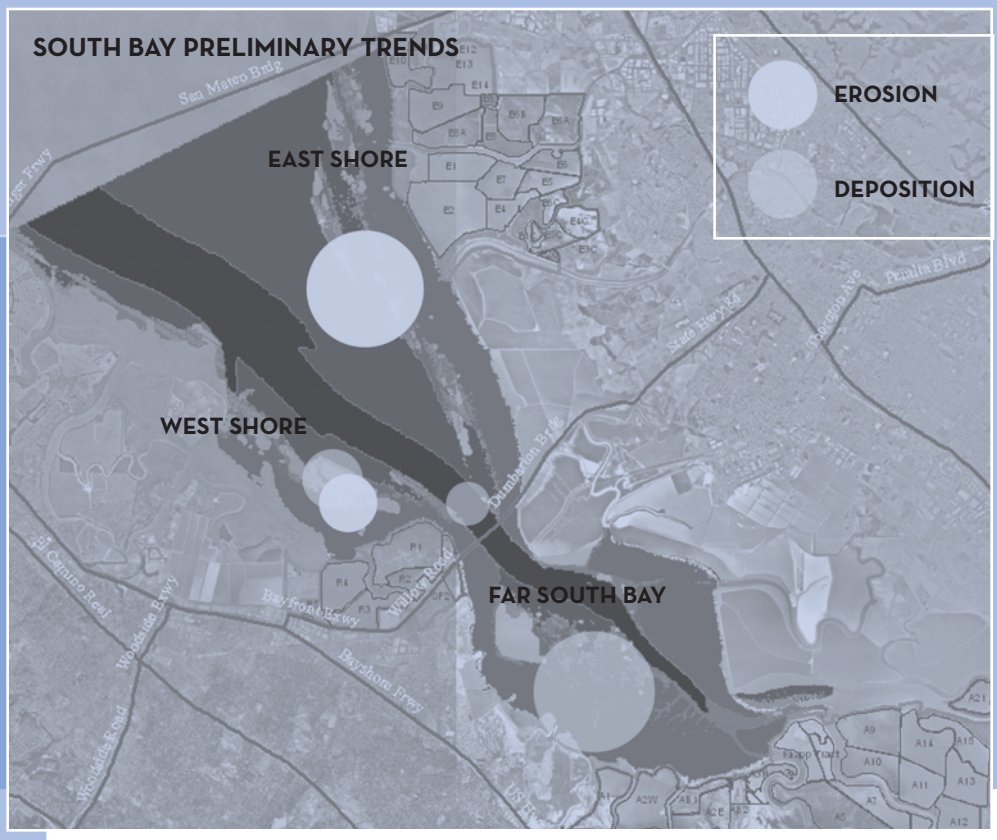
TAKE HOME POINTS

- **The certainty of our predictions about restoration varies by habitat type.**
- **Our restoration plan must be resilient.**
- **We will learn and adjust as we go forward.**

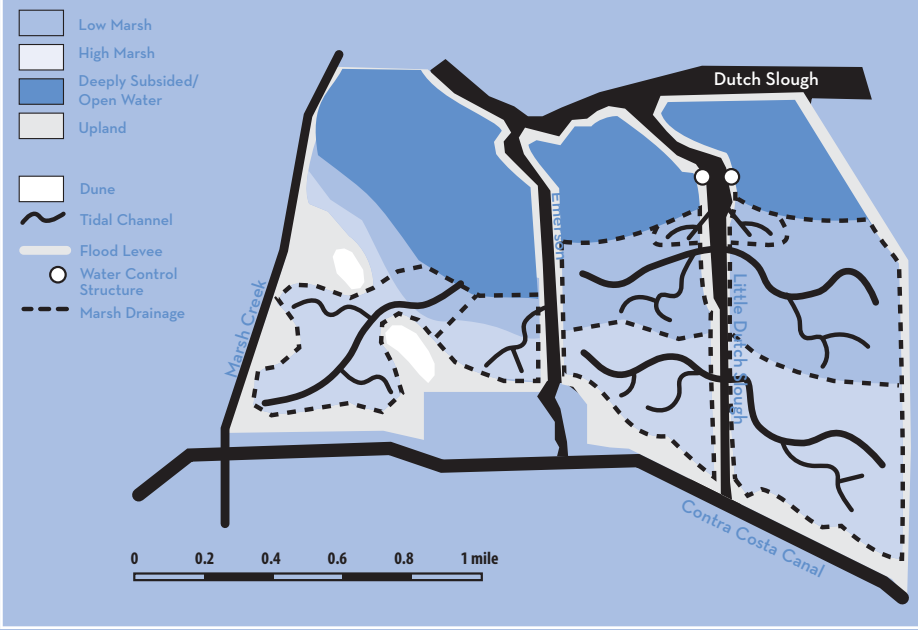


Dutch Slough: Restoration and Adaptive Management

JOHN CAIN
NATURAL HERITAGE INSTITUTE

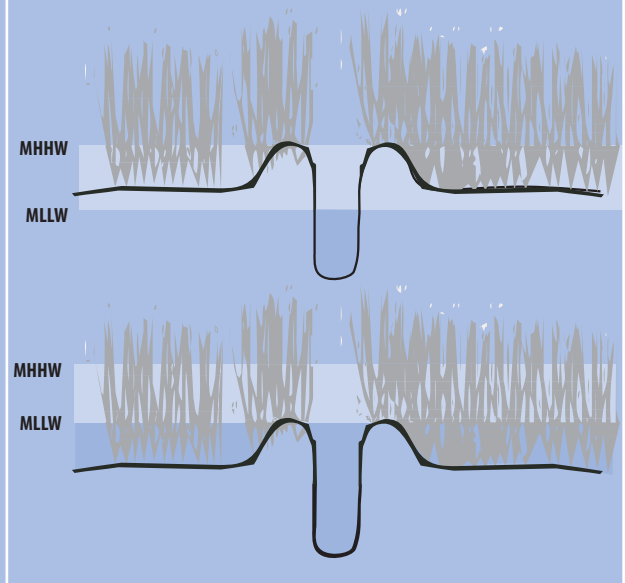
The CALFED Bay Delta Authority and the State Coastal Conservancy provided $28 million to acquire a 1,166 acre parcel along Dutch Slough in northeastern Contra Costa County for tidal marsh restoration. The parcel was previously levied dairy and ranch land that was slated for development of 4,500 residential units. The California Department of Water Resources has assumed ownership responsibilities and is working collaboratively with the State Coastal Conservancy, CALFED, the Natural Heritage Institute, and the City of Oakley to plan and implement the restoration project within an adaptive management framework. The goals of the project are to: 1) provide shoreline access, recreational, and educational opportunities, 2) restore a mosaic of wetland and upland habitats for native species, and 3) increase understanding of ecosystem function through an adaptive management approach.

DUTCH SLOUGH TIDAL MARSH RESTORATION - ALTERNATIVE 2B



The property is divided into three levied tracts that could be separately treated and restored to tidal action in a unique opportunity to design the restoration project as an adaptive management experiment. The project partners are working with an interdisciplinary group of scientists to physically design the project to test hypotheses regarding the role of marsh plain elevation and associated inundation frequency in 1) avian utilization; 2) growth and survival of juvenile salmon and splittail; 3) colonization of submerged aquatic vegetation; 4) production and flux of methyl mercury and dissolved organic carbon; and 5) the role of vegetation in freshwater marsh plain accretion and slough channel evolution. Different portions of the project site will be restored to different marsh elevations in an attempt to isolate the role of marsh plain elevation in these various processes.

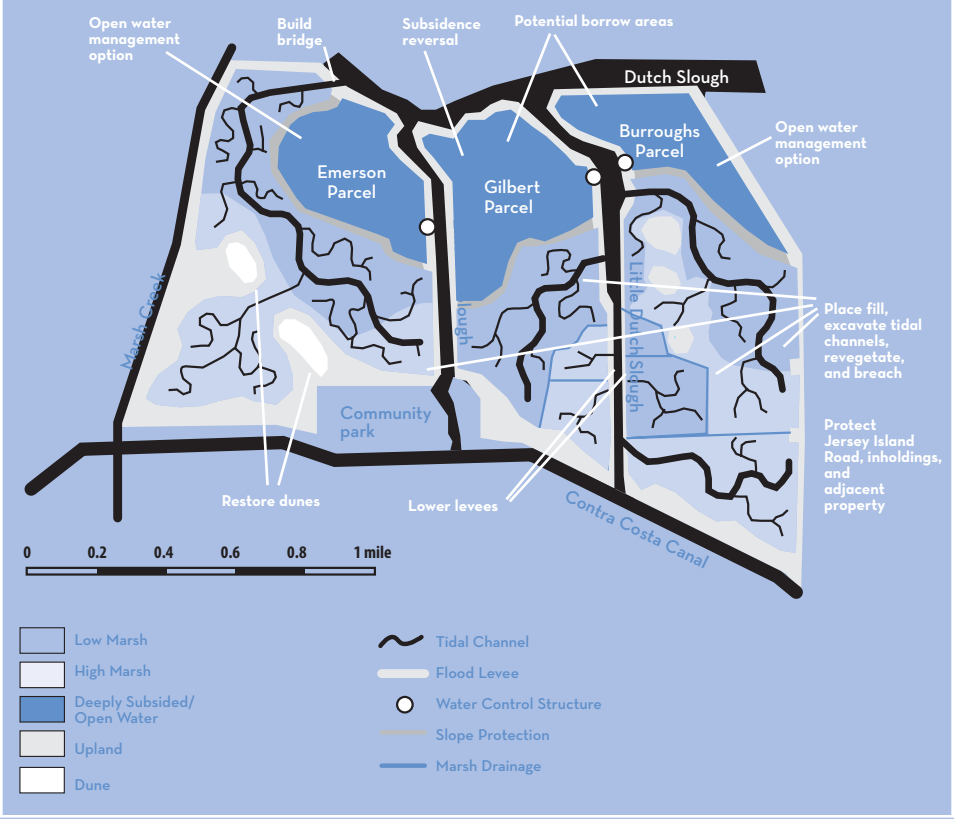
HOW LOW SHOULD WE GO?



TAKE HOME POINTS

- **Restoration is contagious—we have new partners every day. Yet all of our restoration efforts will be relatively futile if we are unable to stem the tide of urbanization in the Delta.**
- **Restoration can wait, but the time for acquisition is now.**
- **We need to expand the Delta Protection Commission to protect the Delta's secondary zone from development.**

DUTCH SLOUGH TIDAL MARSH RESTORATION - ALTERNATIVE 3



The planning process has revealed several challenges and potential tradeoffs that can arise when designing a restoration project as an adaptive management experiment. Designing an experiment into the restoration design is an ideal opportunity to learn but can create conflicts between optimal experimental design and optimal restoration design. For example, dividing the restoration site into numerous cells of different elevations could help tease out the role of elevation in numerous ecosystem processes, but fragmentation of the site into smaller cells could reduce connectivity of various habitat types and potentially preclude important scale dependent processes.

Adaptive management presumably implies that managers will change their management if the project does not perform as desired. This paradigm makes obvious sense with efforts to manage fishery harvest, cattle grazing, or exotic species, but is more complicated for capital intensive earth moving projects in highly regulated environments. If the initial design does not perform as desired, is it realistic to assume that managers will or should physically modify the Dutch Slough restoration? Or should the Dutch Slough project be viewed as a one time management intervention designed to inform future restorations in the larger Bay-Delta system?

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QUESTIONS WE HOPE TO ANSWER:

What is the relationship between marsh plain elevation and

- **Salmon and splittail growth and survival**
- **Fish food production and availability**
- **Splittail and Delta smelt spawning**
- **Mercury methylation**
- **Dissolved organic formation and export**

What is the relationship between marsh scale and channel order and

- **Salmon and splittail growth and survival**
- **Fish food production and availability**
- **Splittail and Delta smelt spawning**

OUR HYPOTHESES:

- **Juvenile salmon and splittail will have higher survival rates on high marsh because there will be fewer fish predators.**
- **Food resources will be greater in lower marsh due to increased residence times.**
- **Fish survival will be greatest with intermediate scale channel network because higher order networks will harbor predators, and lower order networks lack sufficient refuge during low tides.**

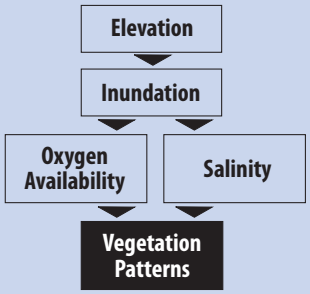
Elevation, Inundation, Vegetation — and Restoration

JOHN CALLAWAY, ET AL.
UNIVERSITY OF SAN FRANCISCO

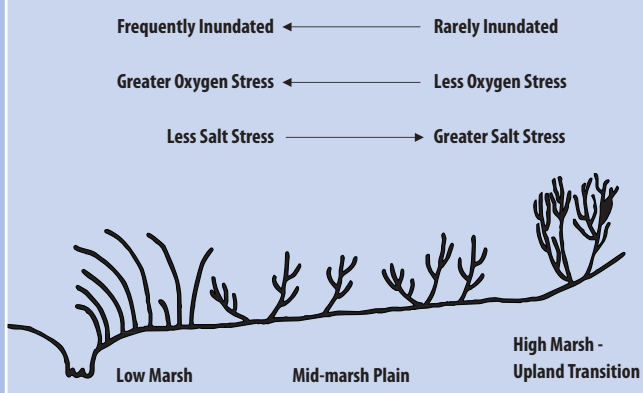
Tidal wetland restoration efforts have focused on establishing the appropriate elevation for plant colonization, with the assumption that elevation determines inundation rates and other critical factors for plant establishment and growth, including soil redox status and salinity. While elevation is the key factor driving inundation rates, within-site variation due to impoundments, pannes, and other features may affect local flooding and draining. Substantial research has evaluated elevational distributions of tidal wetland plants in San Francisco Bay wetlands; however, very little work has directly linked elevation to patterns of inundation across a tidal wetland.

As part of the Integrated Regional Wetland Monitoring Program (IRWM), we evaluated distributions of plant species across six tidal wetlands in the north San Francisco Bay Estuary, working closely with the IRWM Physical Processes Team to connect these distributions to elevation and inundation patterns across each wetland. Plant distribution and elevations were determined at 200-500 locations in each wetland and were related to inundation patterns from three to four water level stations on the marsh plain. Inundation data were collected for approximately one year at each wetland and were also compared to water level data from instruments in adjacent tidal channels.

FACTORS AFFECTING VEGETATION



SPATIAL VARIATION ACROSS WETLANDS



Patterns of vegetation zonation were apparent from our data, with species showing peaks in distributions across the tidal wetlands. For example, at Coon Island, *Salicornia virginica* had the most widespread elevational distribution, with a number of species occurring at slightly lower elevations, including *Spartina foliosa*, *Typha angustifolia*, *Bolboschoenus maritimus* (formerly *Scirpus maritimus*), and *Schoenoplectus acutus* (formerly *Scirpus acutus*). There was substantial overlap and spatial variability in both the elevational distributions and inundation patterns for some of the dominant species, including *S. acutus*, *Schoenoplectus californicus* (formerly *Scirpus californicus*), and *T. angustifolia*. We found little evidence for critical thresholds for plant distributions across all wetlands. Other factors that are likely to affect distribution include soil salinity (being measured this year), initial vegetation establishment, and competition. With the IRWM Bird Team, we also are comparing vegetation patterns to bird use so that we can evaluate how inundation affects habitat characteristics that are linked to wildlife use. In order to effectively restore tidal wetlands throughout the Estuary it is critical that we better understand the factors that affect both large- and small-scale patterns of plant distributions. There is evidence that minor shifts in elevation and inundation (presence/absence of creeks) can affect plant distributions, and our research will help to further understand these patterns.

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TAKE HOME POINTS

- **Elevation is important, but other factors also affect plant distribution.**
- **More analysis is needed to evaluate the relationship of inundation and plant distribution.**
- **Plant diversity increases with elevation up to mean high higher water in Napa River wetlands.**
- **Plant distributions—along with physical factors—can be good predictors of wildlife use of tidal wetlands. These relationships give valuable insight into restoration design.**

Monitoring Bird Response to Restored Marshes

MARK HERZOG, ET AL.
PRBO CONSERVATION SCIENCE

Significant restoration is occurring around the Bay. We need to evaluate restoration success, and birds offer an excellent way to do that. The presence and function of particular species of birds in a given marsh are determined by physical and biotic factors, as well as demographic constraints imposed by their life histories. Collaboration with research teams in other disciplines, working at the same locations, has greatly enhanced our ability to study interactions of birds with vegetation, which provides food for prey species and substrate for nesting. As part of our multi-disciplinary studies, we are investigating how bird populations may be limited or influenced by landscape-level factors, and hydrological and geomorphic processes. We are building models that examine how heterogeneity of physical processes,

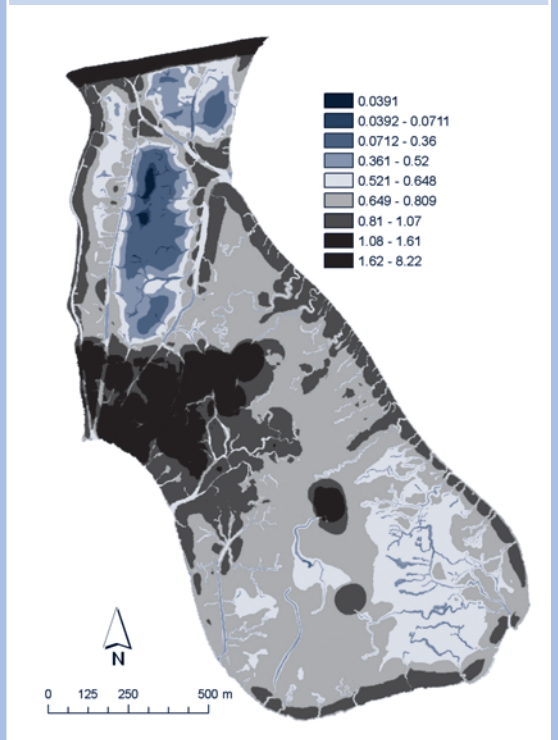
plants, habitat, and landscape affect the structure and ecological function of the tidal marsh bird community. While not an exhaustive list, specific variables we examined included salinity, vegetative species composition, distance to specific landscape features (such as pond, channel, urban, Bay, etc.), and a variety of channel metrics (channel order, linear density, areal density, etc.).

Using spatially predicted models, we are able to provide resource managers with current information on species abundances and distributions within restored and mature marshes and to assess the conservation and restoration efforts within the region. In addition, these analytical tools allow us to locate areas of the marsh or types of marsh where our predictions are less certain (i.e., where the model performance is poor), and therefore will benefit from additional sampling and research.

The PRBO adaptive monitoring protocol, which is currently being developed for the tidal marshes in the San Francisco Estuary, will provide a powerful, yet cost-effective approach to monitoring avian populations.

MORE INFO? **mherzog@prbo.org**

PREDICTED COMMON YELLOWTHROAT DENSITY
BIRDS/HA AT COON ISLAND



TAKE HOME POINTS

- **Spatial modeling provides an excellent tool to evaluate restoration.**
- **Spatial modeling also provides a way to address the uncertainty in our model predictions.**
- **Adaptive monitoring will enable researchers to monitor more efficiently, where the goal is as much to learn as it is to monitor.**

Design Guidelines for Tidal Wetland Restoration

PHYLLIS FABER, ET AL.
PHYLLIS M. FABER AND ASSOCIATES

Since the early 1970s, over 45 tidal marsh restoration projects have been implemented around San Francisco Bay, restoring tidal action to more than 2,800 acres. More than 20,000 acres are now being planned and designed. As of 2005, we have 33 years of restoration history and up to 19 years of systematic monitoring data from projects in San Francisco Bay. We have sufficient information from these monitoring efforts, and from 'snapshot' observations of other restored sites, to provide guidance on pragmatic practical design questions often encountered in restoration practice.

Funding from the State Coastal Conservancy to The Bay Institute has allowed the evaluation and documentation of this experience to produce a Design Guidelines report. The target audience is all those concerned with practical restoration questions in San Francisco Bay and includes resource management and regulatory agency staff and environmental professionals involved in tidal wetland restoration. Many of these design questions are relevant to resource managers in other estuaries.

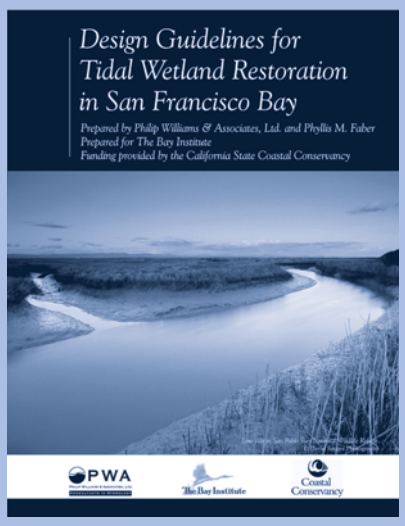
We structured the Guidelines to identify and assess key design issues by

1. Explaining our conceptual model of how restored marshes evolve and function based on our own observations and other researchers' assessments of restored marshes.

2. Describing the planning context used in restoration practice that creates the framework for design decisions and considering site-specific factors as well as geographic variability in the environmental setting and variation in project objectives.

3. Addressing the major design questions that dictate the grading of the site 'template' prior to reintroduction of tidal action.

We recognize that restoration practice is still in its infancy, with considerable uncertainties and unknowns. Early projects were focused on achieving a vegetated marsh as soon as possible; we now know that interim habitats and an evolving mosaic of habitats are also important. We anticipate that new insights will be provided in future years by continued monitoring data from restored sites.



MORE INFO? **pmfaber@comcast.net**

DESIGN QUESTIONS

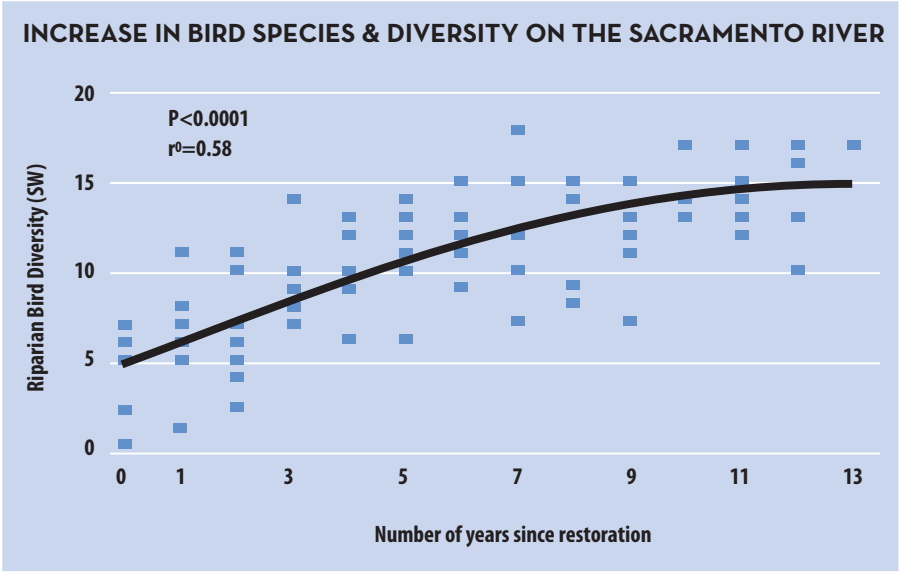
- **Should the site be filled?**
- **Should fill be removed?**
- **Should a levee breach and outboard channel be excavated?**
- **Should wave breaks be constructed?**
- **Should the bayfront levee be lowered?**
- **Should new tidal channels be excavated?**
- **Should the pre-existing drainage system be modified?**
- **Should the site be graded to encourage panne formation?**
- **How should the wetland-upland transition be designed?**
- **Should soil be treated?**
- **Should plants be planted?**
- **How do we provide habitat features for target species?**
- **How should public access be provided?**
- **How should we integrate flood management issues?**

TAKE HOME POINTS

- **Examine physical processes carefully.**
- **Link design decisions with predictions of how the site will evolve.**
- **Have clear objectives at the outset.**
- **Better understand the functions and habitat values of the transition zone.**
- **Consider the legacy of past human actions.**

Using Birds to Assess Habitat Restoration

GEOFFREY GEUPEL
PRBO CONSERVATION SCIENCE



PRBO Conservation Science has been monitoring songbird populations using multi-tiered methods in restored and remnant riparian habitat in major watersheds of the Central Valley for the past thirteen years. Objectives include identifying existing areas of high bird diversity for protection and enhancement, establishing habitat relationships, and quantifying population response to changes in habitat including pre- and post- restoration, as reflected in the distribution, abundance, and demographic parameters of a broad spectrum of species. In addition, we study stopover use and weight gain during migration and site persistence during winter. Results are used to guide specific restoration practices and develop quantitative performance measures and biological objectives for bird populations at various spatial scales across the Central Valley. At mature sites along the San Joaquin River nest substrate selection for three species was positively correlated with forb cover and shrub cover, underlining the importance of planting and managing for understory species and structure. The novel focus on restoring understory on a three year-old restoration site on the San Joaquin National Wildlife Refuge has influenced the return of two locally extirpated species: the yellow warbler (from 0 to 14 nesting pairs) and the first documented pair of least Bells' vireos breeding in the Central Valley in over 60 years. While abundance of birds at restored sites show promising increases in abundance and species diversity during spring, fall, and winter, nest success of many species, especially in remnant forests, remains problematic and may be too low to sustain populations over time in the absence of restoration of floodplain dynamics or other conservation actions.

TAKE HOME POINTS

- **Birds are indicators of ecosystem health. Different species have different requirements that represent a range of critical ecosystem and habitat elements.**
- **Monitoring ecosystems with birds uses cost-effective, established methods that can be applied across multiple scales.**
- **Results from bird monitoring may be used to adaptively manage restoration and enhancement projects.**
- **Birds can be used to "audit" the success of restoration and help set quantifiable biological objectives.**
- **We plan to maintain long-term monitoring sites as reference sites for new sites and to assess the sustainability of bird populations.**
- **We recommend including extensive bird monitoring in all restoration projects, and continue to adapt and test recommendations at multiple sites.**
- **National Wildlife Refuge is attributable to planting large dense patches of shrubs and groundcover—which prevent invasive species—interspersed with trees, as well as meadow species (forbs and sedges) that increase understory diversity. It is important to provide seed source areas for future dispersal.**
- **Birds are responding positively to restoration activities. Revegetation is working to restore a diversity and abundance of songbird populations along the Sacramento, Cosumnes, and San Joaquin Rivers.**
- **To ensure diverse and viable population of songbirds, we need to manage for a mosaic of riparian habitat that includes a healthy proportion of early-successional stage habitat (e.g. contains dense herb cover and a diverse understory). This may require intensive management (e.g. mechanical disturbance) if the site is not periodically disturbed by flooding and/or if the river is disconnected from its floodplain.**

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Will Restored Tidal Wetlands Benefit Bay Food Webs?

CHARLES SIMENSTAD, ET AL.
UNIVERSITY OF WASHINGTON, SCHOOL OF AQUATIC AND FISHERY SCIENCES

Understanding food webs in complex estuaries such as the San Francisco Bay-Delta requires comprehensive knowledge about how heterogeneity of the Estuary creates subsystems or compartments of interacting food web sources and consumers, especially when we are trying to predict or evaluate the potential role of restoration actions. The dominant base of our knowledge about the food web structure of San Francisco Bay is founded on a phenomenal accumulation of knowledge about open water, pelagic food webs based on phytoplankton—the "classic" food web of Hardy (1924). Even the complexities of the heterotrophic/microbial aspects are focused in the pelagic realm. The paradigm is that the Bay "runs" on phytoplankton.

However, there are shallow water and wetland ecosystems that once comprised, and now and could in the future comprise a significant compartment in the Bay's food web, that likely integrates with the pelagic compartment. Recent research using both traditional methods (food habits) and conservative biomarkers (stable isotopes) indicate that tidal emergent marshes not only support closely-coupled internal food webs but also provide linkages to the open Bay through direct and indirect exchanges of transient consumers and very likely organic detritus. Contrasting marsh residents (e.g., benthic invertebrates such as *Macoma balthica, Corophium spp.*, and *Ischadium demissum*; Pacific staghorn sculpin, yellowfin goby, Shimofuri goby, threespine stickleback, tule perch, rainwater killifish), and nursery residents (e.g., splittail, Chinook salmon) with more transient planktivores (e.g., Sacramento splittail, northern anchovy, Pacific herring, inland silversides, topsmelt) and predators (e.g., striped bass) indicates that not only does autochthonous production dominate the emergent wetland food webs but also that it contributes to the broader Bay food web. Evidence from stable isotope analyses suggests that both edaphic microalgae and emergent marsh macrophytic organic matter contribute significantly to transient species, while phytoplankton is a comparatively minor contributor.

The highly dynamic nature of these food web "loops" is evident from the variability in contributions of organic matter sources, and is often tied to consumer life histories and behaviors, as well as responses to disturbance events, such as freshwater flooding.

The magnitude and significance of both wetland "outwelling" and influx of organic detritus and living algal cells is still unresolved. From the "marsh perspective," there is emerging evidence of both nekton and food web interactions between peripheral (and restoring) wetlands and Bay-Delta open water ecosystems, but we lack a system view of their significance. A landscape view that considers fluxes of organic matter and organisms across the estuarine mosaic, and considers tidal and freshwater flooding forcing, would be a more appropriate assessment of the role of both open water and wetland food web contributions and interactions. Such a more integrated "intercompartmental" and dynamic view of San Francisco Bay-Delta food webs would enhance our ability to understand both the basis of and variability in support of important consumer organisms as well as the comprehensive role of wetland restoration in the Bay-Delta.

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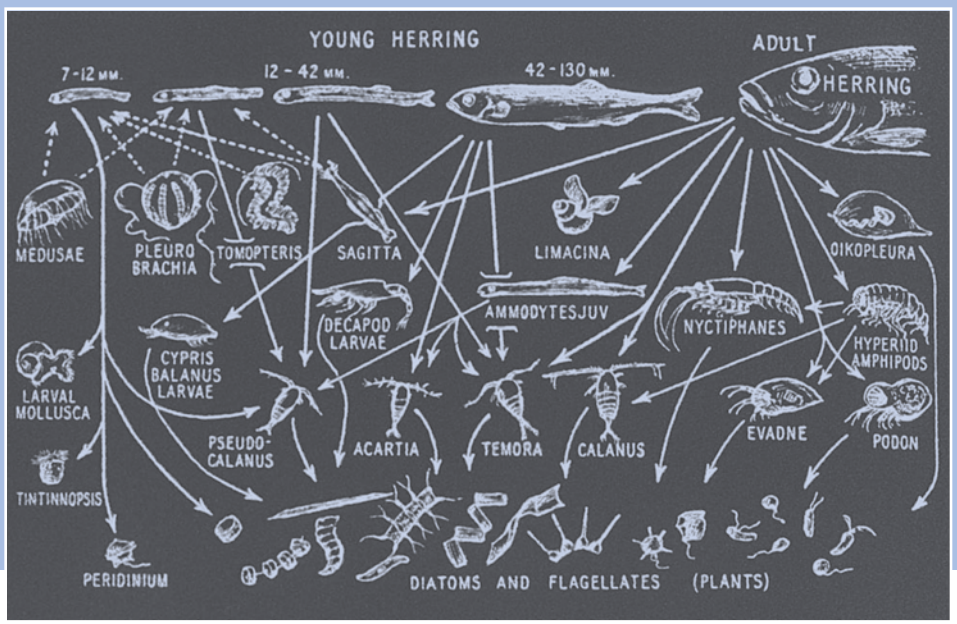
TAKE HOME POINTS

- **The Delta is a detritus mill for the Bay, exporting 30-40 percent of its organic matter to the downstream food web.**
- **We still do not know all of the sources of that organic matter but are using stable isotopes to try to determine them.**
- **The interactions between tidal wetlands and pelagic areas are still not well understood.**



Hardy's Food Web, 1924

The Importance of Suisun Marsh in Estuarine Productivity

ROBERT SCHROETER AND PETER MOYLE
UNIVERSITY OF CALIFORNIA, DAVIS

Estuarine tidal marshes are productive habitats that provide the conditions and microhabitats necessary for successful invertebrate and fish rearing and recruitment. They may also provide, through export, a source of productivity to surrounding habitats. Tidal marsh habitat in the San Francisco Bay-Delta Estuary has decreased by 90 percent over the past 150 years. The impact of this loss and the ecological contribution of the remaining tidal marsh habitat in the Estuary are not well understood. We investigated the productivity of tidal channels in Suisun Marsh, Solano County, the largest contiguous brackish tidal marsh on the West Coast of the United States, and compared our findings to data collected by the California Department of Fish and Game in adjacent bay and river habitats (*neomysis* and zooplankton surveys).

Primary production, as measured by chlorophyll a, indicates several regions of high productivity within the interior of the marsh, likely due to high residence time of water, nutrient availability, and absence of alien clams. Surrounding bay and river channel habitats had very low levels of primary production. Invertebrates, including mesozooplankton and benthos are most abundant within the interior sloughs and channels, often reaching very high densities. Macrozooplankton abundance patterns are more variable, but are also high within the marsh interior and rivers with declines observed in some bay and large slough habitats. These data suggest that Suisun Marsh plays a significant role in estuarine productivity by providing an abundant source of primary production and pelagic invertebrates, both of which are significantly depleted in bay and river channel habitats. These localized areas of high productivity may transfer benefits up the food chain, as fish abundance for select species remains high in the tidal marsh sloughs despite considerable declines observed elsewhere in the Estuary. There is little evidence that this productivity is directly transported to the exterior bay and channel habitats, although migratory invertebrates and fish may export considerable quantities of biomass from the marsh through their movements.

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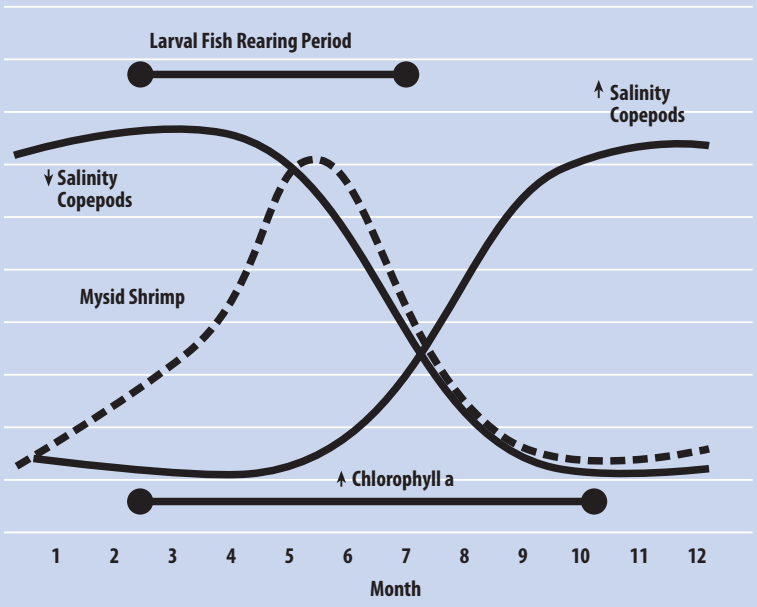
TAKE HOME POINTS

- **Tidal marshes are important rearing areas for fish and invertebrates.**
- **They are refuges for native species and are highly productive—maybe the most productive—habitats.**
- **Many key fish species—Delta smelt, longfin smelt, splittail, and striped bass—are declining throughout the Estuary.**
- **Fish abundance in Suisun Marsh does not follow Estuary-wide trends—Suisun Marsh had increases in striped bass and splittail.**
- **The differences are likely due to good prey availability during key seasons and high phytoplankton biomass within Suisun Marsh. This abundance is related to the complexity of the tidal marsh habitat found there.**
- **Factors limiting productivity in the bay and river channels surrounding Suisun Marsh include the overbite clam, an efficient filterer of the water column, and discharge from duck ponds of organically rich waters, resulting in poor water quality.**

SEASONAL PREY AVAILABILITY IN SUISUN MARSH



Chinook Salmon and Steelhead in the Bay and Central Valley Rivers

STEVE LINDLEY, ET AL.
NATIONAL OCEANIC
AND ATMOSPHERIC ADMINISTRATION

To help guide recovery planning for threatened and endangered chinook salmon and steelhead in the Central Valley and San Francisco Bay, we are developing biological viability goals for populations and evolutionarily significant units (ESUs) of these species. We infer the historical population structure from a combination of historical records and GIS-based habitat modeling, develop simple criteria for population status based on genetic and demographic models, and assess historical and current spatial structure of ESUs in relation to sources of catastrophic risk using tools from graph theory.

The winter-run chinook salmon ESU consisted of four populations prior to the dam building era; all four were extirpated from their natural spawning range, but are represented by a single population utilizing the tailwaters of Shasta Dam. This population of winter chinook satisfies the criteria to be considered a viable population, but cannot be considered a viable ESU by itself, because it is vulnerable to several catastrophic risks that could easily extirpate the population, and therefore, the ESU. The spring-run chinook salmon ESU is represented by two or three extant independent populations, and over 20 have been extirpated. Like the winter-run chinook population, the extant populations are probably viable in the short term, but because these populations are quite close together, this ESU is at elevated risk of extinction due to catastrophic risks that would not have threatened the historical ESU with extinction.

The situation with steelhead is much murkier. There may have been on order of 80 or more independent populations of steelhead, and much of the spawning habitat used by these populations now appears to be behind impassable dams. It is possible that descendents of the historical steelhead populations persist as resident trout, and new populations may exist in tailwater areas below some dams.

Overall, it appears that habitat conditions in accessible areas have improved, as indicated by the improving status of extant populations. More broadly, however, the large majority of historically used habitat is not accessible to anadromous fish, and the presently restricted distribution of the ESUs keeps them at elevated risk of extinction. Further improvements in the status of chinook salmon and steelhead may require access to currently inaccessible habitat.

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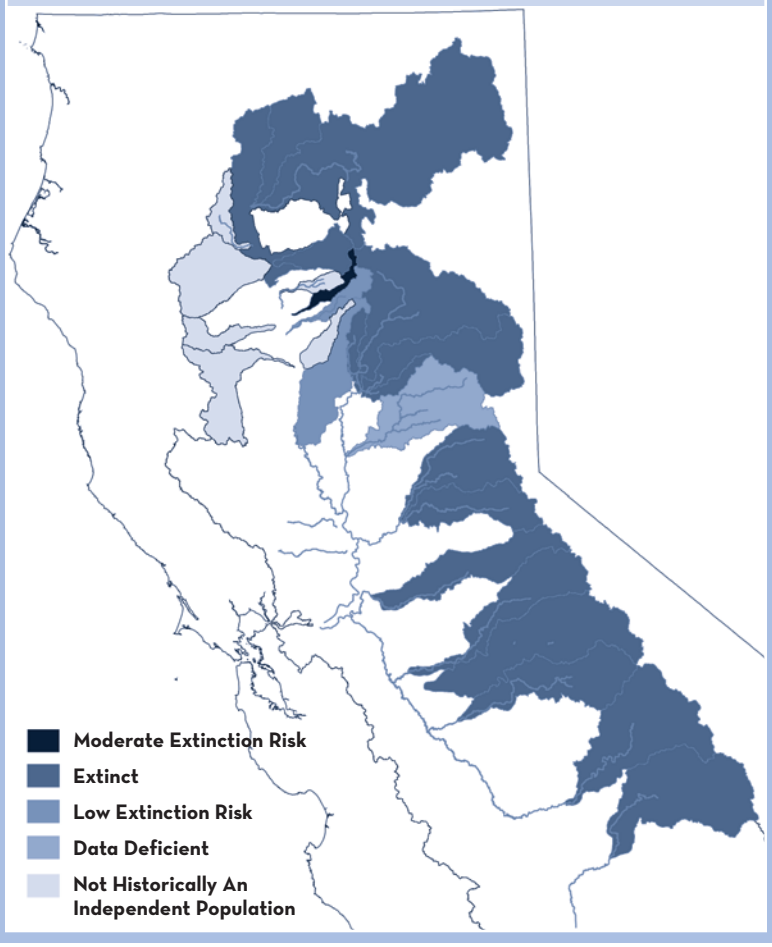
STATUS OF CENTRAL VALLEY SPRING-RUN CHINOOK SALMON POPULATIONS



TAKE HOME POINTS

- **Only tiny remnant populations are left. We are going to have to do some creative thinking about how to preserve ESUs.**
- **Eighty percent of our stream reaches are now behind impassable barriers.**

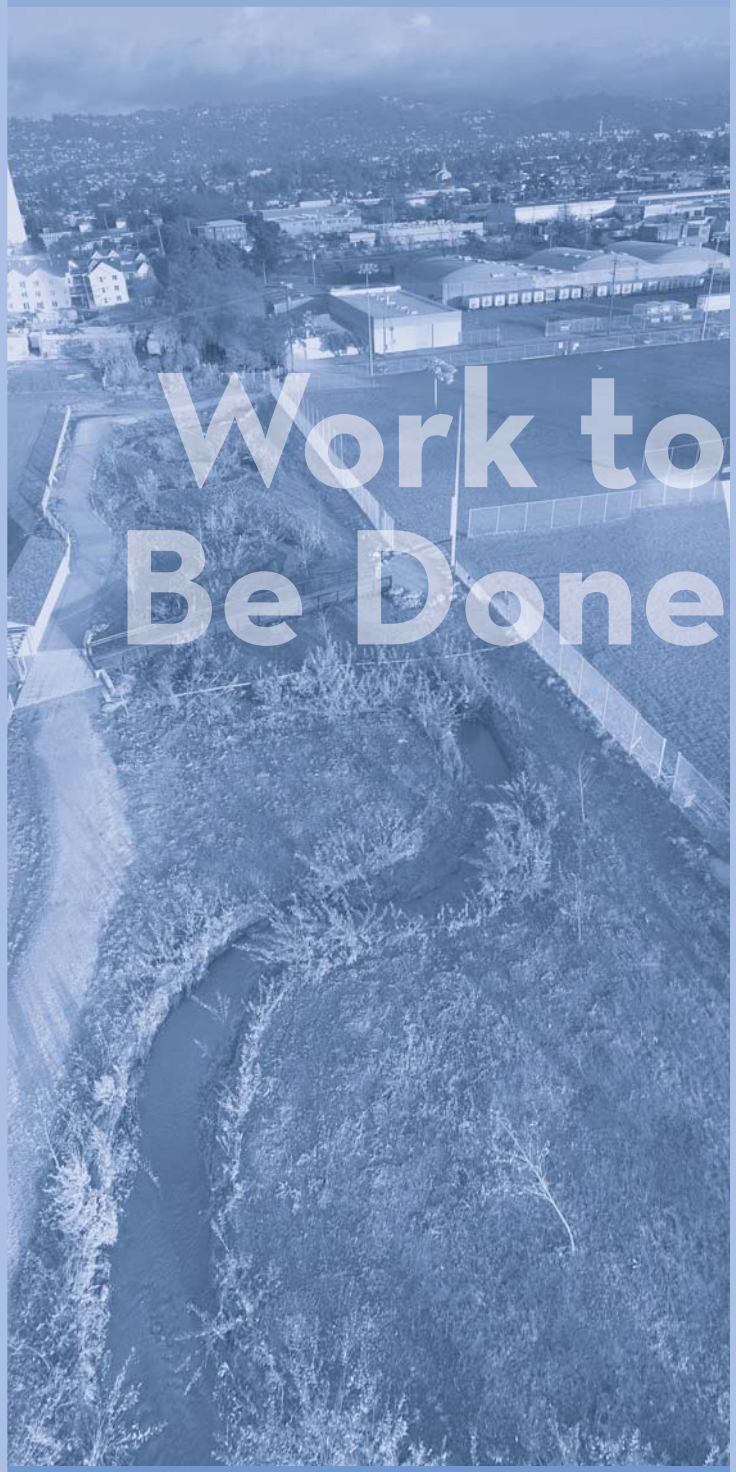
Work to Be Done

"The future of the Bay and its Baylands depends on watershed restoration to control the quantity and quality of local water and sediment supplies vital to the Bay and Bayland ecosystems. The challenge is to put the Bay, its Baylands, and watersheds together again."

—Josh Collins, SFEI

"We need to better explain, in economic terms, why protecting the natural environment is important to solving [our] other problems. Our job is to become the evangelists who put the environmental ethic into the economic equation."

—Will Travis, BCDC



Kite photo of the newly graded Codornices creek channel by Chris Benton

California's Marine Invasive Species Program

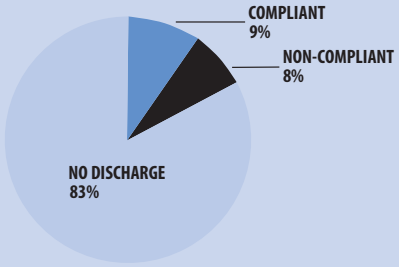
MAURYA FALKNER
CALIFORNIA STATE LANDS COMMISSION

In October 1999, California enacted the first statewide mandatory ballast water management law designed to prevent or reduce the introduction and spread of nonindigenous aquatic species via ships' ballast water into California state waters. While the program's initial focus was on foreign ballast water management, during the 2003 Legislative session the law was reauthorized and is evolving into a multi-faceted program that more comprehensively pursues the prevention of nonindigenous aquatic species via the commercial shipping vector. The program melds education and outreach with enforcement efforts, resulting in compliance rate levels exceeding 90 percent. Stakeholder involvement has become integral to policy development. Technical Advisory Groups (TAGs) consisting of scientists, regulators, and shipping industry representatives are regularly convened to inform management strategies. Two TAGs are currently formulating recommendations on new issues for the program; ballast water treatment technology standards; and management of aquatic nuisance species through vessel fouling. In areas where priority information gaps have been identified, the program provides limited logistical and financial support. Projects have included onboard testing of ballast water treatment technologies, research on open ocean exchange verification, and research on the vessel fouling risk for the Pacific Coast. Finally, the program maintains a database that has tracked ballasting practices of vessels entering California since 2000. The system contains a valuable time series of data that can be used to advance the management of invasives and research in the field.

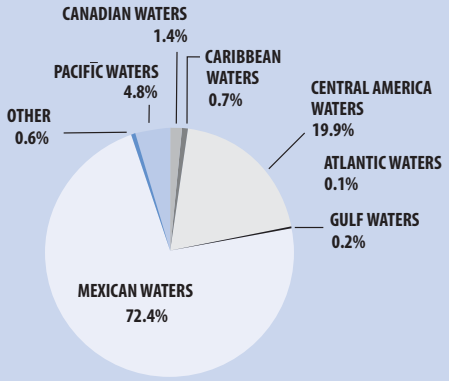
MORE INFO? **falknem@slc.ca.gov**

MARINE INVASIVE SPECIES PROGRAM MONITORING COMPLIANCE

REPORTED BALLAST WATER MANAGEMENT - 2004



SOURCES OF NONCOMPLIANT BALLAST WATER - 2004



TAKE HOME POINTS

- **The potential for expanding invasions is high.**
- **We are particularly concerned about voyages within the Pacific Coast region because of the potential for spread of the Chinese mitten crab, the chameleon goby, the Asian clam, and the striped barnacle.**
- **Looking to the future, we hope to improve compliance, improve performance standards, focus on non-ballast water ship-mediated vectors, and continue research into treatment technologies.**

THE MARINE INVASIVE SPECIES ACT OF 2003

"The purpose of the Act is to move the state expeditiously toward the elimination of the discharge of nonindigenous species into the waters of the state or into waters that may impact the waters of the state, based on the best available technology economically achievable."

Are We Preventing the Introduction of Exotic Species?

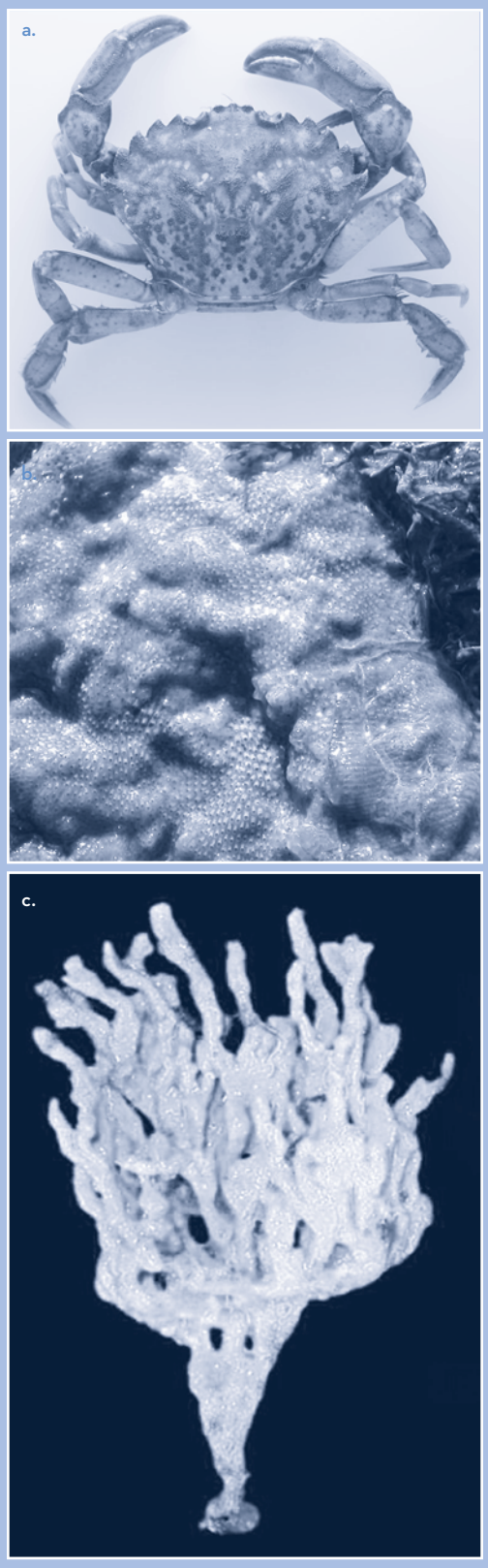
ANDREW COHEN
SAN FRANCISCO ESTUARY INSTITUTE

Exotic species have altered the species composition, habitats, food webs, population dynamics, and other aspects of the San Francisco Estuary. Exotics comprise most of the species, individuals, and biomass across many habitats, making this one of the most invaded estuaries in the world. A 1995 review found that hull fouling, ballast water discharges, aquaculture activities, and fisheries releases were the most important mechanisms introducing exotic species to the Estuary, with lesser contributions from bait imports, biocontrol releases, restoration activities, and others.

Studies have also shown that in recent decades, exotic species have been arriving and becoming established in the Estuary at an increasing rate, with ballast water discharges responsible for an increasing share of the introductions. Have our efforts to implement mechanisms for preventing the introduction of exotic species into the Estuary worked? Has significant progress been made? While the reports are reassuring, if you read the fine print, many ships are exempted from the new ballast water exchange laws. There is no good method of testing a ship's ballast water at the end of a voyage. At best, we may be removing 70 to 85 percent of the organisms in the ballast water, but a true figure might be closer to 25 to 50 percent. Hull fouling is another big problem. In one study, a large tuna fishing ship from Africa that came through the Panama Canal was covered from stem to stern with hundreds of species of hydroids. We have not begun to tackle this enormous problem. Aquaculture is also good at moving diseases, parasites, and pests. Decisions about how to manage aquaculture should not be left to the industry; we need to involve more effective stakeholders.

On the positive side, because we have made such little progress in controlling invasives, there is a lot we can still do. There has been agreement for a long time that exotics were a big problem—but not agreement in a forum where decisions are made about what to do.

MORE INFO? acohen@sfei.org; www.exoticsguide.org



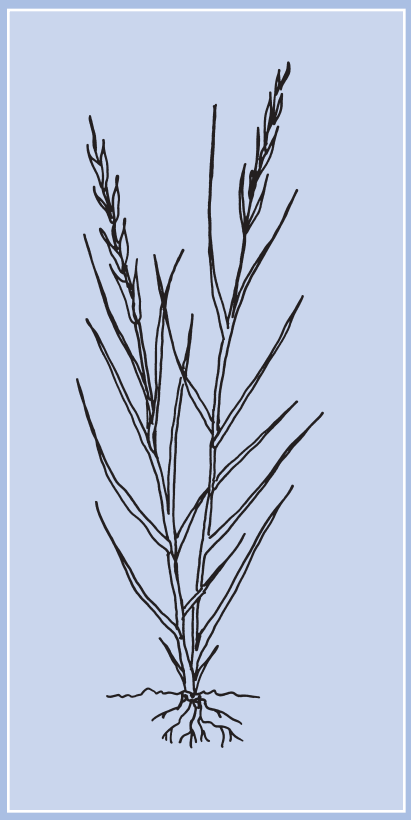
a) Green Crab, *Carcinus maenas*
b) Bryozoan, *Cryptosula pallasiana*,
c) Red Beard Sponge, *Clathria prolifera*

Non-native Spartina Control in the Estuary

ERIK GRIJALVA
SAN FRANCISCO ESTUARY
INVASIVE SPARTINA PROJECT

Introduced in the 1970s to control erosion, Atlantic cordgrass (*Spartina alterniflora*) spread rapidly throughout the Estuary, hybridized with Pacific cordgrass (*Spartina foliosa*), and today threatens thousands of acres of tidal marshes and restoration projects around the Bay. At the outset of the 2005 *Spartina* control season in the San Francisco Estuary, the Invasive Spartina Project (ISP) mapped and delineated 132 individual areas of varying sizes infested with non-native *Spartina*. In sum, over 1,200 net acres of *Spartina* were targeted for control, spread over roughly 11,000 acres of tidal marshland. At least 32 of these infested sites are restored marshlands, and many of the other sites are remnant or historic marshes that are assumed to serve as native propagule sources for planned restoration efforts in the Bay.

Building upon the knowledge gained through the successes and setbacks of the 2004 Spartina control season, the 3rd International Spartina Conference held in San Francisco in November 2004, the ISP's 2003 Spartina Monitoring Report, and work to date in other *Spartina*-infested areas worldwide, the ISP determined that aggressive targeting of all Spartina-infested areas within the Estuary in 2005 was warranted. This control effort was preceded by a comprehensive survey of the infested habitats for populations of endangered California clapper rails and an analysis of the potential impacts of the various proposed treatment methods on each individual site. The results of this work informed the timing and strategy of treatment planning efforts, while providing pre-treatment baseline information as a comparison for post-treatment effects on the systems involved.



Lisa Krieshok

In the 2005-2006 treatment season, the ISP switched to imazapyr (Habitat), recently registered for use in California. A recent report from Leson and Associates that summarizes laboratory and field studies describes imazapyr as both more effective and less hazardous than glyphosate. Among the report's findings: imazapyr degrades rapidly in water and inundated soil, leaving no detectable residue after two months; maximum planned application rates are not toxic to mammals, birds, or bottom-dwelling organisms; and exposure risks to workers applying the herbicide and to the general public are minimal.

The downside: accidental spraying of non-target plants carries a higher likelihood of damage than with glyphosate. Laboratory tests also indicated a slight risk to fish at highest concentrations. But based on the rates at which it will be used in an application, it is extremely unlikely that there is a risk to fish. Despite imazapyr's promise, cordgrass may still be a tough adversary, however. Some weed species, including perennial ryegrass and rigid ryegrass, have evolved resistance to the terrestrial version of the chemical, marketed as Arsenal and Chopper.

MORE INFO? ekgrijalva@spartina.org

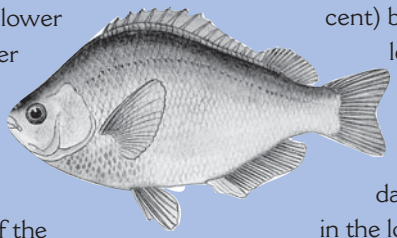
TAKE HOME POINTS

- **In 2004 surveys, we saw a 250 percent increase in non-native spartina from 2001-2003. The invasion consisted mostly of hybrids with varied and diverse genoytopes that can colonize anywhere.**
- **The greatest threats are to mudflats and restored tidal marsh.**
- **We have a chance to do something right now—to control it—before the invasion becomes even worse.**

Alien and Native Fish in the Lower San Joaquin River Watershed

LARRY BROWN
U.S. GEOLOGICAL SURVEY

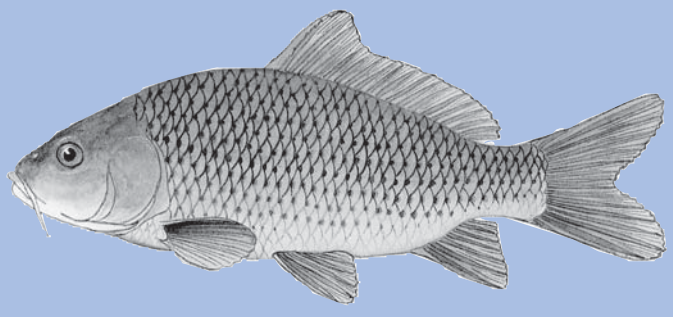
Changes in land and water use in the San Joaquin River watershed, as well as the deliberate and accidental introductions of alien species beginning in the mid-1800s, profoundly changed the aquatic flora and fauna in this region of California. Studies over the last decade in the lower mainstem San Joaquin River and its tributaries have provided much useful information on the fish assemblages of the region and have identified some of the environmental factors associated with their distribution and abundance. Those studies provide a basis for assessing possible outcomes of rehabilitation efforts.



Tule Perch
Illustration: Bill Crary

In a comparison of 20 major rivers across the United States, the lower San Joaquin River had the highest percentage of alien fish species (70 percent) and the highest percentage of alien fish captured (over 90 percent) based on data collected from 1993 to 1995. Detailed analysis of a comprehensive data set from 20 sites in the lower San Joaquin River watershed sampled during the same time period indicates the presence of four major fish assemblages, with native fishes most abundant in the reaches of tributary rivers just below the large foothill dams. Environmental conditions below the dams were more similar to conditions in the streams favored by many of the native fishes, compared to environmental conditions in downstream reaches. Analysis of annual monitoring data collected from 1987 to 1997 from eight sites on the lower Tuolumne River indicated that the abundances of native and alien fishes captured at a site were associated with springtime flow conditions and distance from the San Joaquin River. Alien fishes accounted for a greater percentage of the catch when flows in the previous year were relatively low and at sites closer to the San Joaquin River. In contrast to the lower San Joaquin River watershed, the lower Sacramento River watershed still supports relatively large populations of native fishes, possibly because the river channels are used as throughput water delivery systems, thus maintaining higher, cooler flows than in the San Joaquin River watershed, where water is diverted from river channels for off-channel uses. These studies suggest some level of predictability in the response of fish assemblages to environmental change. However, there are likely unknown interactions between alien and native fishes, between fishes and non-fish species, and between fishes and environmental conditions that make predictions regarding rehabilitating native fish populations uncertain.

Sacramento Sucker, Illustration: Bill Crary



Carp, Illustration: Bill Crary

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TAKE HOME POINTS

- **The lower San Joaquin River watershed is highly invaded—both compared to other rivers throughout the United States and throughout California.**
- **Native species persist below the dams.**
- **The success of invasive species is related to a number of environmental factors, including flow, temperature, and land use.**
- **The potential for increasing native fish populations seems high, but there is also a high potential for unexpected outcomes because of unanticipated interactions between native and alien species.**

What Do The Next Forty Years Hold For The Estuary?

JOE BODOVITZ
CALIFORNIA ENVIRONMENTAL TRUST

The state of the Estuary is, literally, the state of California. San Francisco Bay and its twin, the Delta, both lie within one state jurisdiction. But they are by no means identical twins, and we have not treated them as if they were.

We have made greater progress with the Bay than with the Delta. In 2005 we marked the fortieth anniversary of the beginning of the San Francisco Bay Conservation and Development Commission. And we note the work of the CALFED Bay-Delta program to resolve some of the most difficult issues in California—how to protect and restore the Delta while simultaneously providing water for agriculture and for the expanding population of urban California.

CALFED needs the same broad public support and understanding that the Save San Francisco Bay Association brought to the campaign to stop the uncoordinated filling of San Francisco Bay in the 1950s and early 1960s. Most residents of the Bay Area now understand the importance and value of the Bay. Unfortunately, most residents of California do not have the same understanding of the Delta.

Nobody can look forty years ahead and tell us what to expect. But we can already see the shapes of some things to come: the possible effects of global climate change; the possible effects of rising sea levels; the continuing struggles over water supply and water quality; and the need for better governance of the common resources of the Delta.

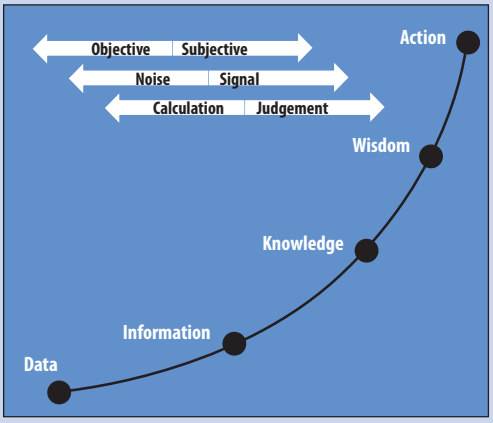
Stewards and Scientists: the Imperative for Collaboration

JERRY SCHUBEL
AQUARIUM OF THE PACIFIC

For most of my professional career I have attempted to identify, develop, and apply strategies to facilitate the collaboration of scientists with the decision-makers and stakeholders who are so critical to environmental sustainability. The investments of hundreds of millions of dollars in major coastal clean-up and restoration initiatives too often have failed to meet stated goals and stakeholders' expectations. It is clear that new institutional mechanisms are needed. There is a better way—one successful model that has emerged over my more than three decades as a student and practitioner is an "environmental decision value chain" that has the following elements:

- Proper valuation of the resources at risk
- A regional approach to finding solutions, that is:
  - Scalable to fit the issues
  - Inclusive and transparent
  - Futuristic in its orientation
- Functional institutional mechanisms at the regional level, and
- An informed, involved, concerned public.

ENVIRONMENTAL DECISION-MAKING VALUE CHAIN



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TAKE HOME POINTS

- **Restoration and conservation of the Bay-Delta are not limited by a lack of scientific understanding, but by a lack of a clear and compelling vision, and institutional mechanisms to exploit the data and knowledge we have.**
- **The evolution of our scientific understanding has outstripped our ability to apply it.**
- **We need a compelling vision, a proper valuation of resources, a regional approach that is futuristic, and appropriate institutional mechanisms.**
- **We need new approaches and new institutional mechanisms for harvesting what we know.**
- **We spend over $100 million a year telling the public why agriculture is important but less than 10 percent of that on why oceans and estuaries are important.**
- **Solutions to our current environmental problems depend on our ability to imagine and shape the future.**
- **Policies are experiments. We've made a lot of mistakes. We need to learn from them and move on.**

Where Are We Headed in the Next Ten Years?

NADINE HITCHCOCK
CALIFORNIA COASTAL CONSERVANCY

Thanks to the passage of several voter-approved state bond acts in recent years, public agencies have been able to work in partnership with non-governmental organizations, citizen groups, and private foundations to acquire over 30,000 acres of historic Baylands in the San Francisco Estuary. Planning and engineering is now well underway to determine how to restore these areas to provide habitat for endangered species, waterfowl, shorebirds, and other native wildlife, to improve water quality, and to provide wildlife-oriented recreational opportunities to the public. During the same period, much attention has been focused on the need to look up into the watersheds and out into the ocean to address water quality, species protection, flood management, hydrology, ocean conservation, and other issues if we are to meet restoration and protection goals for the Estuary. With the creation of the California Ocean Protection Council, the development of new incentives to integrate water resources management on a regional scale, and a greater interest in working collaboratively with new partners, we have an unprecedented opportunity to take a more seamless look at how to manage the Estuary, its watersheds, and the ocean resources to which it is connected.

How will we fund future restoration work estimated to cost over $300 million in the next decade alone when federal funding is on a downward projection? New bond acts and local/regional funding initiatives will be required. The Napa River/Rutherford benefit assessment district is a good example of such a local /regional initiative.

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LIKELY DELTA RESTORATION PROJECTS BY 2015 WITH NO NEW STATE BONDS

TAKE HOME POINTS

- **In the next 10 years, more significant historic tidelands will be restored and enhanced, but there will be minimal new acquisitions.**
- **There will be more desalination facilities built.**
- **There will be an increased focus on subtidal areas—efforts include the Subtidal Goals Project, new tools to battle aquatic invasives (ballast water exchange and treatment), eelgrass restoration, and native oyster restoration.**
- **Much more eelgrass habitat could be restored in the Bay. We could restore an estimated 22,000 acres; we now have only 2,600 acres. The Coastal Conservancy is funding several pilot restoration projects.**
- **A race is taking place around the Bay between people acquiring land for preservation and those acquiring it for development.**
- **The funding outlook for the next 10 years is grim. More needs are going to be completing for less funds. Politically, ecosystem restoration is often thought of as competing with traditional engineering projects, and there is increased support right now for funding levee repair and flood control projects due to earthquake predictions as well as the recent natural disasters such as Hurricane Katrina.**
- **Despite the poor funding outlook, we need to continue to do restoration projects in disadvantaged communities such as the restoration of Yosemite Slough in Hunter's Point, San Francisco.**
- **We need to develop a regional vision for the landscape that identifies local and regional funding sources.**
- **There is a general trend toward ocean ecosystem-based planning and management. The California Ocean Protection Council established in 2004 will have funding for "ocean" projects, including subtidal restoration in the Bay.**
- **Another general trend will be toward watershed ecosystem-based planning and management. The Bay Area Watershed Plan—www.bayareawatershedplan.net—will guide watershed restoration efforts.**

California Water Plan 2005: a Framework for Action

KAMYAR GUIVETCHI
CALIFORNIA DEPARTMENT OF WATER RESOURCES

The Department of Water Resources (DWR) has changed the process for preparing the California Water Plan and the information it contains. The Water Plan has become a strategic document that describes the role of state government and the growing role of California's regions in managing the state's water resources.

In preparing Update 2005, DWR sought the participation of California's water communities, responded to new state laws, and, by working with an advisory committee, developed a new approach to planning California's water future. DWR significantly expanded the public forum for updating the California Water Plan by establishing a 65-member advisory committee and a 350-person extended review forum, and seeking input from 2,000 other interested members of the public.

Water Plan 2005 provides California's water communities with a vision, mission, and goals for meeting challenges of sustainable water use through 2030 in the face of uncertainty. It has recommendations for decision-makers, resource managers, water suppliers, and water-users. And for the first time, the water plan includes a proposal for carrying out its recommendations. The plan provides a Framework for Action to stimulate progress now to ensure a sustainable and reliable water supply in 2030. This framework will focus and prioritize state government's water planning, oversight, and technical and financial assistance on several foundational actions and initiatives. The Framework for Action also identifies a number of essential support activities needed to accomplish its foundational actions and initiatives.

Water Plan 2005 contains water data, information, and studies used to develop the strategic plan. It outlines today's water challenges and evolving water management responses; it presents benefits and costs of 25 resource management strategies; it reports regional water conditions and activities; it considers multiple future scenarios and their water demands; and it describes an approach to improve data management and analytical tools for future plan updates.

Water Plan 2005 is summarized in the Highlights document and presented in five volumes: (1) Strategic Plan, (2) Resource Management Strategies, (3) Regional Reports, (4) Reference Guide, and (5) Technical Guide. The final California Water Plan Update 2005 was released in January 2006.

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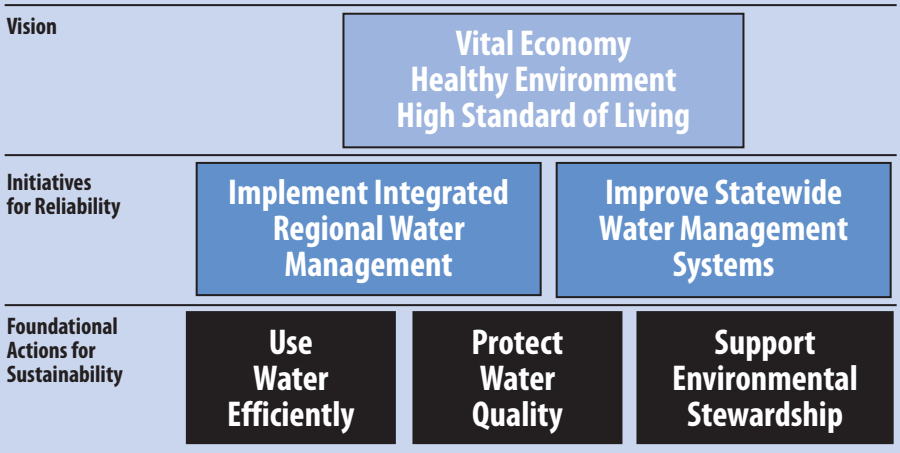
PLAN GOALS, STRATEGIES, AND ACTIONS



Linking Wetlands to Watersheds

JOSH COLLINS
SAN FRANCISCO ESTUARY INSTITUTE

Habitat stewards and scientists have been working together to achieve the Baylands habitat goals set in 1999. The size of Bayland restoration projects has increased, the fragmentation of habitats seems to be decreasing, the suite of target habitats has broadened, and the amount of collaboration on project design and assessment has grown.

This collaboration has fostered new ideas about tracking wetland health and restoration progress. Multi-disciplinary teams of technicians and managers are more likely than before to give advice on and review the conceptual designs and monitoring plans for restoration projects. This is expected to improve project performance. A three-tiered approach to comprehensive wetland assessment is emerging to support project design and tracking. Regional habitat inventories comprise level one. Cost-effective rapid assessments of ambient condition and selected projects comprise level two. Standardized intensive monitoring to address critical concerns and test specific hypotheses comprises level three. Public information management that enables data sharing among regional centers is also envisioned. The ongoing State Wetland Inventory, the California Rapid Assessment Method, the growing number of intensive monitoring protocols adopted by the Bay Area Wetland Monitoring Group, and the continuing development of the Wetland Tracker for coastal watersheds indicate significant progress toward implementing the assessment framework.

This approach to regional habitat assessment—setting shared goals and developing a tiered approach to tracking progress toward the goals—is being adopted in other regions, including Elkhorn Slough, Humboldt Bay, and the Great Salt Lake Ecosystem. It is also being used to begin integrating the assessments of Baylands and watersheds in the Bay Area. Through the Napa Watershed demonstration project, habitat inventories, probabilistic surveys of ambient condition, and intensive assessments of restoration performance are being integrated into a single report of overall wetland health at the watershed scale.

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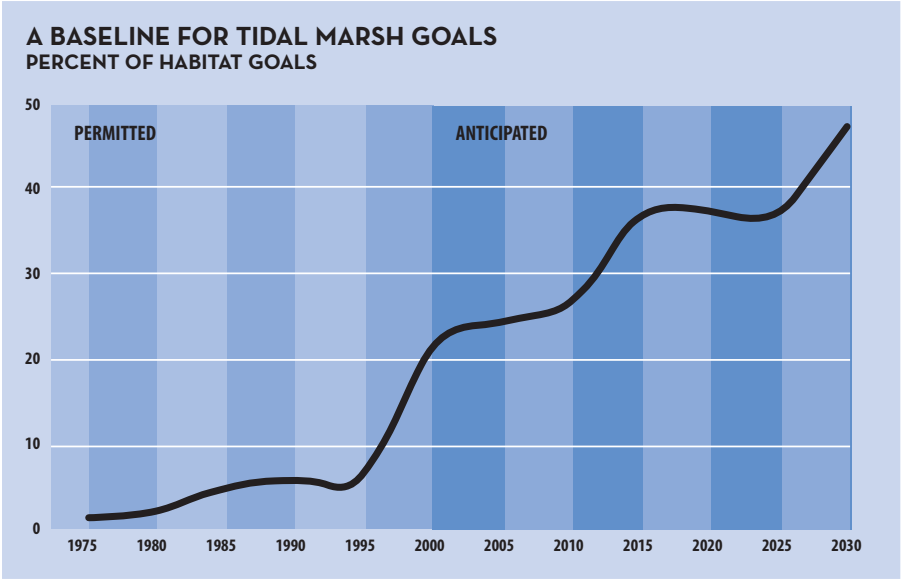


TAKE HOME POINTS

- **We need to embrace the idea that the Baylands really are the edge of the Bay (right now they are a kind of "no man's land"): they have fallen between watershed science and Bay science.**
- **The future of the Bay depends on watershed processes.**
- **Sediment storage and transport are very important. Off-channel wet meadows once played a large role in sediment storage and transport, but we have lost most of them.**
- **The natural functions of alluvial fans and off-channel wetlands may need to be restored.**
- **Our challenge is to put the Bay, Baylands, and watersheds back together again. Efforts to restore each part will otherwise fail expensively.**
- **We need to set goals for restoring riparian habitat just like we did for wetlands — a "Riparian Habitat Goals" project.**
- **Setting riparian goals could serve to integrate the science and policy of watersheds, wetlands, and estuarine protection.**
- **Understanding the interactions between fluvial and tidal processes will be increasingly important.**
- **The interaction of fluvial and tidal processes affects creek erosion, flooding, sediment delivery to the Baylands and the Bay, dredging, fish passage, and the biodiversity of the system as a whole.**
- **Watershed restoration will need to focus on sources, transport, and storage of sediment as well as water.**
- **We need to reconnect our watersheds with the Bay.**

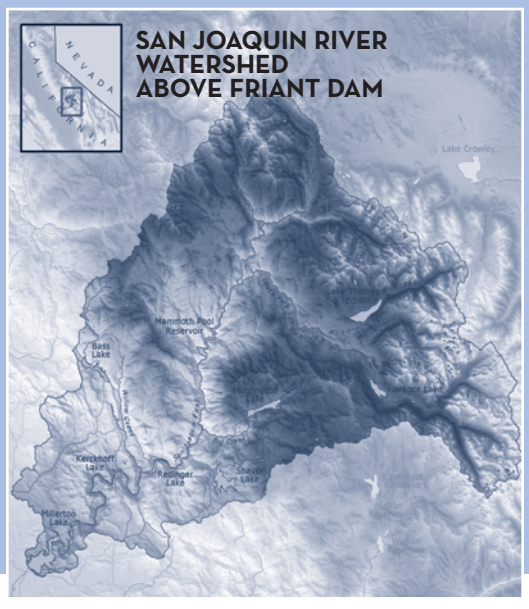
San Joaquin River Restoration Challenges

RON JACOBSMA
FRIANT WATER USERS AUTHORITY

The San Joaquin River between Friant Dam and the confluence of the Merced River can be broken up into five sections, each with unique challenges for restoration. There is a live river for 37 miles below Friant Dam. You hear that water users divert 98 percent of the water, but that's not the case. On average 15 to 20 percent of the water is released below the dam, much of it during flood flow years. Non-flood flow releases average approximately 116,000 acre feet per year out of an average run-off of approximately 1,700,000 acre feet per year. Flood flows average in excess of 200,000 acre feet per year. In late summer and early fall, more water is released from Friant Dam than would occur in nature.

Reach 1, the live river, has been impacted by gravel mining operations; there are temperature, sedimentation, and predator issues. Reach 2, a very porous area, dries up; most of the water flows through a bypass during flood events. A fish ladder would have to be put in at Mendota Dam to restore that reach. Reach 3 looks like a river, but replacement water from the Delta comes in there to meet the exchange agreement with the historical San Joaquin River water users, the Exchange Contractors. Parts of Reach 4 are basically an overgrown ditch with some agricultural drainage water coming in. Reach 5 has floodplain habitat opportunities, but again there are temperature issues—it's a flat-gradient system in the hottest part of the Valley.

The economy is a big concern to our area, having relied on that water supply for so long. Twenty-eight districts in the Central Valley Project contract for Friant water. We serve about one million acres, 15,000 small family farms in the top three agricultural counties of the nation. Forty percent of the city of Fresno's water supply comes from the Friant diversion, and smaller cities like Orange Cove and Lindsay are even more dependent. We deliver about 1.4 million acre feet per year to our contractors, leaving 100,000 acre feet to that 37 miles of river. Class 1 districts along the foothills with little or no groundwater have a firm supply; Class 2 districts further down the valley have active conjunctive use programs.



Friant is not the only dam on the system; there are eight others, most built earlier. The upper reservoirs are maintained by Southern California Edison, the bottom two by PG&E. Friant came into being after groundwater levels dropped drastically and tens of thousands of acres of fertile farmland were taken out of production. Friant was a cornerstone of the California Water Plan, which ended up being built and structured with federal assistance. By the time Friant Dam was to be built, in the early 1940s, salmon counts were down to 3,000-5,000 per year. Friant's first long-term contract, in 1949, was a 40-year commitment to make water available for irrigation. There was conscious recognition that there would be sections of dry river and that salmon would be extirpated from the upper San Joaquin. This was reaffirmed by a State Water Board decision in 1959 as being in the public interest. The California Department of Fish and Game revisited the issue in the 1970s and recommended focusing resources on improving existing salmon runs elsewhere instead of the upper San Joaquin.

There are no easy answers to the tensions on the San Joaquin River. NRDC's lawsuit began in 1988. We worked with the plaintiffs for four years to find a way to restore the river without adversely impacting Friant water supplies. We had some pilot projects but did not reach a settlement. A back-of-the-envelope analysis projected that around $650 million would be needed for river improvements, even before developing alternate water supplies. One option would be on-stream storage upstream of the dam. Our concerns are a loss of 20 to 50 percent of our water supply and water development costs potentially in excess of $1 billion.

Without getting into the lawsuit, Friant is engaged in a lot of activities, including a possible water quality exchange program with Metropolitan. We want to work with river groups to improve the water quality on the lower San Joaquin River. We want to look at upper San Joaquin River storage basins. And we are very much interested in restoration opportunities that won't devastate our regional economy.

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Low Dissolved Oxygen in the Tidal San Joaquin River

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UNIVERSITY OF CALIFORNIA, DAVIS

The Stockton Deep Water Ship Channel, a stretch of the tidal San Joaquin River, is frequently subject to low dissolved oxygen conditions and annually violates regional water quality objectives. Hypoxia is most common during June through September immediately downstream of where the river enters the ship channel. Underlying mechanisms are examined here using the long-term water quality data, and the efficacy of possible solutions using time-series regression models.

At the annual scale, ammonium loading from the Regional Wastewater Control Facility has the largest identifiable effect on year-to-year variability. The longer-term upward trend in ammonium loads, which have been increasing over 10 percent per year, also corresponds to a longer-term downward trend in dissolved oxygen during summer. At the monthly scale, river flow, loading of wastewater ammonium, river phytoplankton, ship channel temperature, and ship channel phytoplankton are all significant in determining hypoxia. Over the recent historical range (1983–2003), wastewater ammonium and river phytoplankton have played a similar role in the monthly variability of the dissolved oxygen deficit, but river discharge has the strongest effect.

Model scenarios imply that control of either river phytoplankton or wastewater ammonium load alone would be insufficient to eliminate hypoxia. Both must be strongly reduced, or reduction of one must be combined with increases in net discharge to the ship channel. Model scenarios also imply that decreasing the impact of exports on San Joaquin flow into the ship channel—for example, by preventing discharge down Old River with a barrier or by using an isolated conveyance facility to supply the water projects—markedly reduces hypoxia in the ship channel.

Upgrades to the Regional Wastewater Control Facility, to be completed in 2006, will not eliminate the impact of wastewater loading but should significantly reduce the incidence of low dissolved oxygen. Although activities are also underway to identify and manage nonpoint sources of nutrients fueling algal growth in the San Joaquin River, very challenging levels of reduction will be required to have an impact on summer-fall hypoxia in the ship channel.

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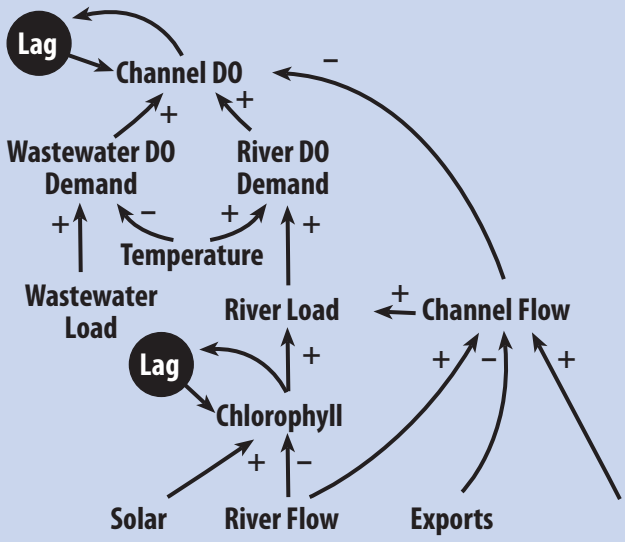
MAIN MECHANISMS CONTROLLING STOCKTON SHIP CHANNEL DISSOLVED O_2 IN TIME SERIES MODEL



Managing Water Quality in the San Joaquin River Basin

NIGEL QUINN AND TRYG LUNDQUIST
BERKELEY NATIONAL LABORATORY

Adaptive real-time water quality management is a strategy for improving water quality conditions in an impaired water body by providing real-time (immediate) access to flow and water data, disseminating river assimilative capacity forecasts using computer-based simulation models and implementing control strategies. The technique is particularly relevant to the San Joaquin River Basin where water quality objectives and regulatory constraints on flow and contaminant loads are often in conflict and lead to sub-optimal utilization of river assimilative capacity. In the case of contaminants such as dissolved solids, boron, and selenium these inefficiencies have led to frequent violation of Regional Water Quality Control Board objectives, especially during dry and critically dry years.

We have conducted several experiments over the past decade using adaptive real time water quality management. These experiments have been interagency collaborations that have clearly demonstrated that improved cooperation and coordination of agricultural, municipal, and wetland drainage return flows with east-side reservoir releases has unrealized potential for improving river water quality. As the Water Quality Subcommittee of the San Joaquin River Management Program, we conducted the first phase of experimentation, which concentrated on the main stem of the San Joaquin River and its major tributaries, and continued for a period of five years. During this period a number of supplemental projects were initiated that focused on major contributing watersheds among the west-side tributaries to the San Joaquin River. Those included selenium-affected agricultural land as part of the Grassland Bypass Project and seasonal wetland drainage in CALFED-sponsored projects located in the Grassland Water District and San Luis National Wildlife Refuge. The latest implementation of the adaptive real-time water quality management strategy is contained in the Stockton Dissolved Oxygen TMDL and CALFED Directed Action Project. These projects have, for the first time, created an opportunity for basin-wide water quality modeling and forecasting to minimize real-time excursions of the dissolved oxygen concentration in the Stockton Deep Water Ship Channel. The long-term goal of this effort is to replace the piecemeal and conflicted TMDL approach to water quality management

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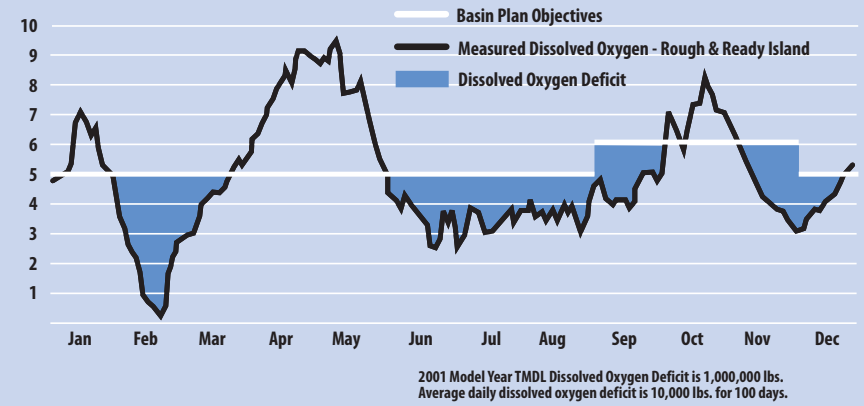
STOCKTON DEEP WATER SHIP CHANNEL O2 DEFICIT



2001 Model Year TMDL Dissolved Oxygen Deficit is 1,000,000 lbs.
Average daily dissolved oxygen deficit is 10,000 lbs. for 100 days.

TAKE HOME POINTS

- **When given an incentive, agricultural districts can decrease their pollutant loads.**
- **One way to do this is to temporarily store contaminant loads, releasing these contaminants during higher flow when there is adequate river assimilative capacity.**
- **Forecasts of river water quality are necessary for real-time water quality management to be practiced – this can help to guide real-time remedial actions.**
- **Agricultural districts implementing real-time water quality management should collaborate with regulatory entities to develop interim targets and load objectives—creating a transition period during which the districts can adapt to the new program.**
- **We need additional monitoring stations, more timely and accurate information from local managers, a decision support coordinator for the watershed, and agreements that recognize the experimental and cooperative spirit of a real time water quality management system.**
- **Current real-time management projects may be the model for future basin water quality management.**

Climate Change Impacts on the San Joaquin River Basin

SEBASTIAN VICUNA AND JOHN DRACUP
UNIVERSITY OF CALIFORNIA BERKELEY

Climate change has the potential to impact hydrology and water resources throughout the world—and California. Some regions in California, like the Sierra Nevada mountains, are especially vulnerable to these impacts due to their dependence on snow accumulation and snowmelt, two processes especially susceptible to changes in temperature. This potential risk looks even more relevant if we consider changes in the timing of streamflow that are already happening in the Sierra Nevada as suggested by various studies.

The prediction of future climate change impacts on California hydrology and water resources is based primarily on the use of General Circulation Models (GCMs), which predict future changes in temperature, precipitation, and other climatic variables based on the interactions between the land, atmosphere, and oceans. Hydrologic models then use these changes to predict climate change impacts on natural runoff. Finally, water resources models are used to transfer these changes in natural runoff into changes in water deliveries and impacts to the water resources systems. There have been a vast number of research activities in the last 20 years that have attempted to assess the impacts of climate change on California's hydrology and water resources systems. These studies have used different GCMs and hydrologic or water resources models at various levels of complexity, but all of them consistently predict a change in timing in streamflow runoff due to a consistent increase in temperature. However, changes in the winter runoff are still uncertain, mainly due to uncertainties in precipitation predictions. The message taken from these studies is simple: there will be more water when we don't need it and less when we need it.

When comparing the relative impacts of climate change for different regions in California, most of these studies have shown that the impacts will be higher in the northern (e.g. American River) than in the southern (e.g. Merced River) Sierra Nevada. This is a result consistent with measured historical streamflow trends and relates to the relative altitude of the basins located in these two regions (the high altitude basins in the southern Sierra Nevada being less affected by increases in temperature). However, recent modeling results suggest that an opposite effect might happen: i.e., impacts could be much higher in the southern as compared to northern Sierra Nevada. The reasons behind these contradictory results are higher temperature predictions by the latest GCM runs and almost neutral changes in precipitation.

Using these latest GCMs results to run a hydrologic model (VIC) and a water resources model (CalSim) for California, we conclude that these changes will potentially affect the performance of the infrastructure in the San Joaquin River basin, limiting its availability to meet all water resources objectives, like water deliveries, energy generation, and environmental services in the Bay Delta and San Joaquin River.

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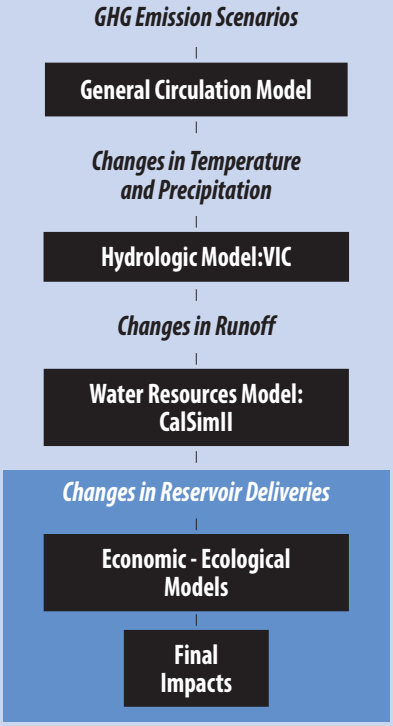
ASSESSING CLIMATE CHANGE IMPACTS IN WATER RESOURCES



TAKE HOME POINTS

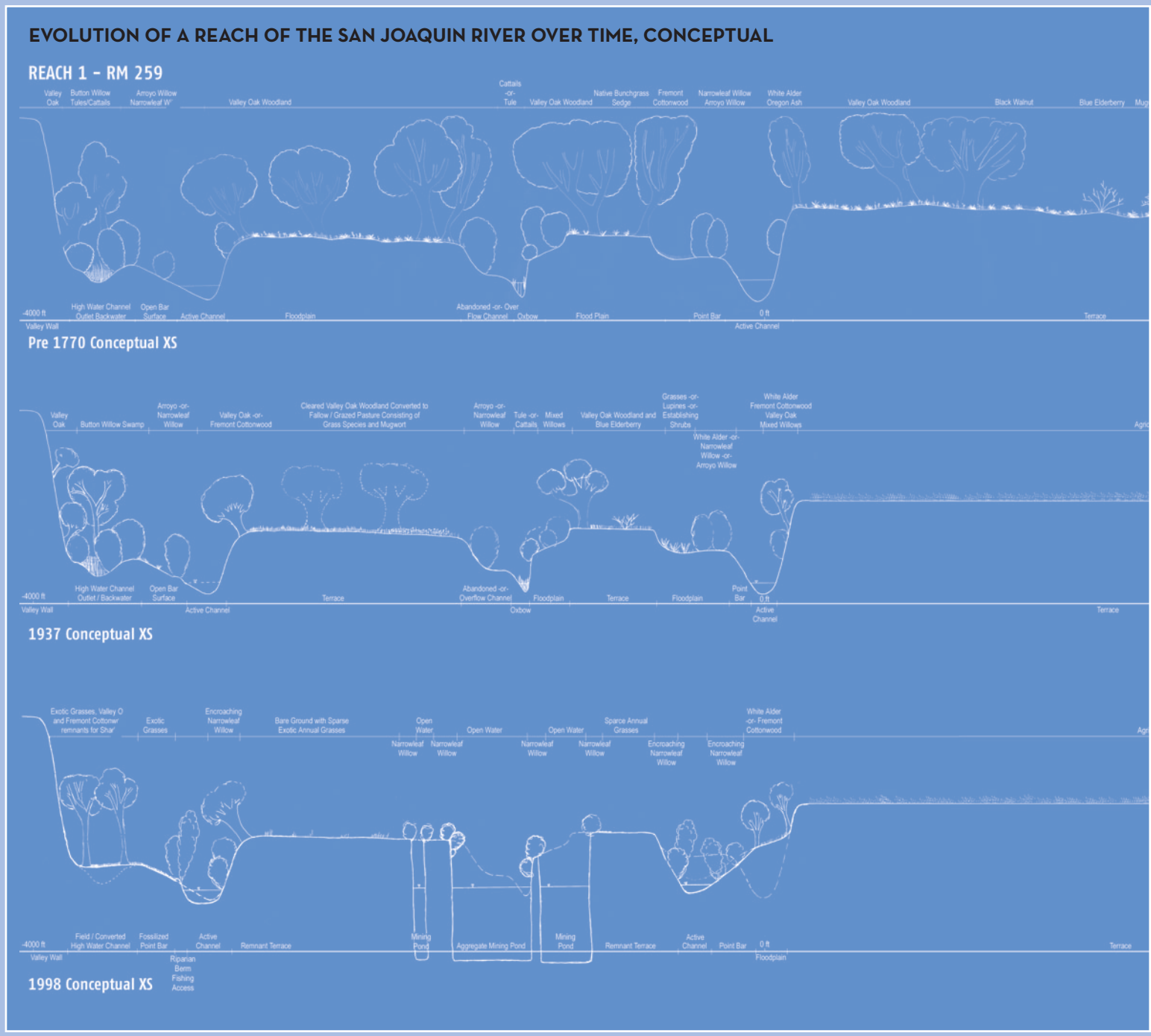
- **Climate change is already happening, as trends in hydrological conditions in the West show.**
- **The latest general circulation model output shows greater negative impacts on California hydrology and water resources than in previous assessments.**
- **Impacts will be higher by the end of the century and in the southern Central Valley.**
- **It is important to consider not just average results but also impacts during extreme conditions.**
- **Models show that we may have more water when we don't want it — early in the Spring —and less later on when we need it more.**
- **We need to take climate change into account in future management of the Estuary.**

Can We Restore Healthy River Functions to the San Joaquin?

SCOTT McBAIN
McBAIN AND TRUSH

Can the mainstem San Joaquin River downstream of Friant Dam, the southern Central Valley's complement to the Sacramento River, be restored to support a species assemblage that includes anadromous salmonids? It is a challenging task for a river that has experienced dramatic physical and hydrologic changes since the 1850s, because the cumulative effects of dams, diversions, and land use on the San Joaquin River have been more severe than on other Sierra Nevada rivers.

The snowmelt-dominated hydrograph characteristic of larger Sierra Nevada rivers once supported spring- and fall-run Chinook salmon, and likely other anadromous fish species. While floods still occur on



occasion under regulated conditions, most of the other natural hydrograph components have been eliminated, and in some reaches the aquifer has been severely depleted, water quality is poor, channel capacity reduced, and several reaches of the river are perennially dry. Sediment supply from the upper watershed has been eliminated, and the channel has been mined, confined, and bypassed. In one reach, the channel is indistinguishable from old sloughs, agricultural canals, and drains.

Anadromous salmonids can return, although the challenges will be considerable. Furthermore, improving healthy river function and the biota supported by that function faces many scientific and technical uncertainties. How do we reestablish under highly regulated conditions a cold water anadromous fishery that must migrate through a complex system of diversions, pumps, and flood bypasses? How do we rehabilitate geomorphic processes in a system with lower than average channel slope and sediment supply compared to other Sierra Nevada rivers? Answers to these questions will require additional predictive modeling, yet will also require more experimental releases and adaptive management. To provide the physical forces needed to restore natural processes, and consequently anadromous salmonid habitat, high flow releases will need to be re-operated. Solutions will also need to incorporate creative water operations, channel reconstruction, and other mechanical solutions.

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TAKE HOME POINTS

- **The restoration plan (developed as part of settlement negotiations in 2001-2003) was developed to "expeditiously evaluate instream and related measures that will restore natural ecological functions and hydrologic and geomorphic processes of the San Joaquin River below Friant Dam to a level that restores and maintains fish populations in good condition, including but not limited to naturally reproducing, self-sustaining populations of Chinook salmon."**
- **Rehabilitation of a riparian floodway has been done on other Central Valley streams; therefore, it can also be done on the San Joaquin River.**
- **Slope is a significant constraint to restoring geomorphic processes on the San Joaquin River in the gravel bedded reach immediately downstream of Friant Dam. Levees, land use, and changes to the groundwater table are significant constraints to restoring geomorphic processes in the sand-bedded reaches.**
- **Other scientific uncertainties include temperature modeling results and salmonid thermal tolerances, how to re-establish and route extirpated fish species, ecologically significant restoration scale (e.g., what size and shape does the riparian corridor need to be ecologically meaningful to key indicator species), and others.**

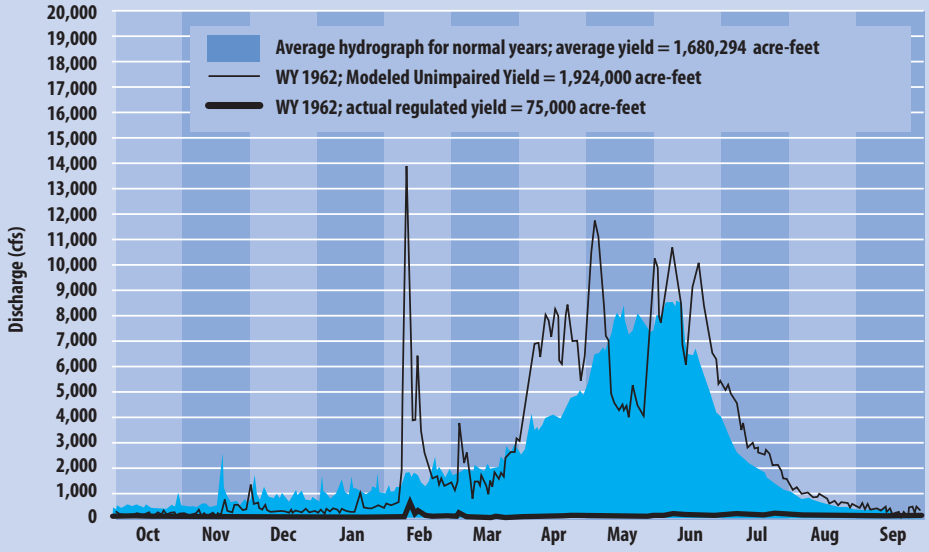
When, Not If

GARY BOBKER
THE BAY INSTITUTE

There was a time when the San Joaquin River dominated the southern half of the San Joaquin Valley and was a major contributor of inflow to the Delta. It is now a pale shadow of its former glory. Historically the main stem San Joaquin was a snowmelt driven system supporting some of the biggest salmon runs on the West Coast, up to 500,000 spring run spawners and 100,000 fall run spawners. Healthy runs persisted as late as the 1940s when Friant Dam was built. Both runs were extirpated in 1948 with the closure of the dam gates. After 1948, flow in a representative year dropped from 1.9 million acre feet to 75,000 acre feet of regulated yield. Below the confluence with the Merced, most of the water in the San Joaquin is agricultural drainage. The river's loss of assimilative capacity aggravates water quality issues—salt, boron, and dissolved oxygen.

In 1988, the Natural Resources Defense Council, the Bay Institute, and other groups filed suit to restore the San Joaquin salmon runs, citing Fish and Game Code language requiring sufficient water passing over, around, or through a dam to maintain fish populations below the dam. The courts have rejected claims that the state's liability to meet the Code requirements has been extinguished. After the US Supreme Court declined to hear the case, the plaintiffs entered settlement talks with Friant. These ended without agreement and the parties returned to court. Subsequent rulings held that the operation of Friant Dam violates the state Fish and Game Code and the Endangered Species Act. As this report went to press, the Judge was deciding whether to adopt a settlement or proceed to trial.

SAN JOAQUIN RIVER FLOWS WERE FLATLINED



Peter Moyle at UC Davis and Matt Kondolf at UC Berkeley have made a set of recommendations for restoring the San Joaquin that recognize that pristine conditions will not be reestablished and consumptive use of most of the river's water will continue. These include base flows of 350 cubic feet per second for most of the year with higher spring and fall pulses. The result, 15-20 percent of unimpaired runoff, would be comparable to current flows on the Merced, Tuolomne, and Stanislaus. Impact on Friant's customers could be addressed through groundwater banking and other strategies. Moyle and Kondolf also recommend some modifications to channels, levees, and fish ladders.

We're not going to get the old river back. But we're at a tipping point, and the thinking has changed. If the river is wet, fish will want to recolonize it. We are going to have people fishing, hiking, and canoeing on a restored San Joaquin.

MORE INFO? **bobker@bay.org**

TAKE HOME POINTS

Strategies for replacing some of the water now diverted from the river include:

- **Implementing groundwater banking and conjunctive use**
- **Re-operating Friant and other reservoirs**
- **Using market transfers, including long-term, dry year options**
- **Increasing water use efficiency**
- **Recapturing water downstream of Friant Dam**
- **Expanding existing surface storage**
- **Building new surface storage**

Re-inventing the Delta: a Call for a New Vision

MARCI COGLIANESE
FORMER MAYOR OF RIO VISTA

Only five years after the CALFED Record of Decision was signed, key stakeholders in the water and environmental communities are calling for another new vision for the Delta, one that will endure. Assuming that it is possible to design and implement a long-term plan for an ecosystem as complex and dynamic as the Delta's, how shall we arrive at a durable new vision for the future?

Water, agriculture, recreation, and the environment, traditionally identified as key Delta interests, are well-represented in the statewide debate about the Delta's future and would all be expected to be a critical part of the new vision. But where do the dozens of Delta-area special districts, cities, and counties, along with local landowners, fit into the process? Not traditionally engaged as stakeholders, Delta-area local governments in six counties are making land use decisions without a common vision and without recognition of the potential impact to unique resources of statewide importance.

The Secondary Zone of the Delta, as defined in the 1992 Delta Protection Act, is urbanizing in response to the same growth and development pressures being experienced throughout the state. At one time largely undeveloped, it has served as the buffer between urban development and the essential resources of the Delta's Primary Zone. But since 1993, local governments have approved development on over 44,000 acres in the Secondary Zone, resulting in 94,000 new residential units (including thousands of new houses behind levees), and thousands of square feet of industrial, commercial, and retail space. Between 1990 and 2002 an additional 12,000 acres of Secondary Zone farmland (including 8,000 acres designated "prime") were converted to an urban land use designation.

When all currently approved development is built out, urban land uses in the Secondary Zone will have doubled, expanding from one-quarter of the zone's total acreage in 1993 to one-half. With the diminishing ability of the Secondary Zone to serve as a buffer, the Primary Zone will experience increasing "edge" conflicts along its ag-habitat-urban fringes, further threatening the delicate balances of a fragile ecosystem and impacting the continued viability of Delta agriculture.

Science has an important role to play in researching and illuminating the impacts of urban development upon Delta resources. Without scientific data, the politically charged issue of land use in and around the Delta cannot be successfully addressed nor can a durable new vision for the future be achieved. Delta local governments are necessary stakeholders in the visioning process.

MORE INFO?
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TAKE HOME POINTS

- **The Delta is no longer the remote, sparsely populated backwater it was 10 years ago when CALFED began. Urbanization is accelerating, fed by the need to house the state's burgeoning population.**
- **The Delta is a critical crossroads between the Bay Area and the Central Valley.**
- **Every day a "Tower of Babel" of government agencies influences the Delta without a shared vision or understanding of the Delta's problems.**
- **The time is ripe for a broader examination of all state policies affecting the Delta.**
- **We need a serious discussion of state and local growth policies such as permitting development behind levees and on floodplains.**
- **The fundamental problem with the Delta is that state government is not supplying the leadership needed to deal with hard problems. The six counties in the Delta have fallen through the cracks.**
- **The Delta needs a unifying force to bring us together. It is a region without a leader, without leadership.**
- **As the governor tries to refocus CALFED, I urge him to think broadly and bring local governments, state legislators, and scientists together with water interests.**
- **Solutions cannot be imposed on the Delta. They must be supported from within to be sustainable.**

Where Do We Go from Here?

WILL TRAVIS
SAN FRANCISCO BAY CONSERVATION AND DEVELOPMENT COMMISSION

Despite our progress in saving and restoring the Bay, we need to make a renewed commitment to continue these efforts in a language most people understand—economics. At a recent dinner I attended of the Bay Area Council—a coalition of the biggest employers in the region—there was no mention of the word "environment" except in the context of the "business environment." Nor was there any mention of the word "Bay"—except as in "Bay Area."

I wondered how the folks at the dinner could just ignore the Bay. Then I realized that it isn't so much that they have forgotten the Bay; it is that we spend all our time talking to ourselves. We insist in speaking in science—a language few people understand. As a result, we are marginalizing ourselves out of the regional political debate. It is inevitable that our region's population will grow by about a million people over the next 15 years. Those of us who are concerned about the Bay need to fully engage in the political process of deciding where these one million new residents will live and work, how to build housing they can afford, and how our new neighbors can travel from home to work to school without spending most of their lives in traffic jams. And in this political debate, we need to better explain, in economic terms, why protecting the natural environment is important to solving these other problems. Our job is to become the evangelists who put the environmental ethic into the economic equation.

Economically, the Bay is our region's most valuable resource. It is the highway for the ferries that can lace our waterfront communities together. The Bay is essential to our flourishing maritime industry. The Bay is the equivalent of a national park in our front yard where we can sail, swim, fish, kayak, and play. And it is essential to our tourist industry.

> "The decision to save the Bay in 1965 laid the foundation for the economic prosperity our region has enjoyed over the past four decades. The Bay is probably the best fringe benefit Bay Area employers can offer—the equivalent of a national park in our front yards where we can sail, swim, fish, kayak, and play."

The Bay is the heart, soul, and visual icon that gives our region its name, its unique quality, and its identity as a truly special place. The decision to save the Bay in 1965 laid the foundation for the economic prosperity our region has enjoyed over the past four decades. The Bay Area depends on bright, well-educated, innovative workers to make our economy hum. In competing with other regions for these workers our employers don't pay appreciably higher salaries even though the workers face outrageous housing costs, have to endure terrible traffic congestion, and have to tolerate so-so public schools.

Yet the workers continue to move here and stay here because it is a terrific place to live. It has a sensational quality of life, a lot of which comes from the abundant, beautiful, and healthy natural resources we environmentalists work so hard to protect. We are providing the best fringe benefit Bay Area employers can offer. We may not be able to charge them for it. But we can remind them how much it is worth.

TAKE HOME POINTS

- **We need to fully engage in the political process and explain how protecting the Bay-Delta environment is critical in making decisions about where new California residents will live, and how they will commute. We need to join groups like the Greenbelt Alliance in advocating for infill development and drawing the line on places where we simply cannot develop.**
- **We need to better explain, in economic terms, why protecting the natural environment is important to solving problems like traffic and housing. Otherwise, those concerned purely with economic issues are more likely to advance their campaigns than we are.**

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ACRONYM KEY

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BCDC: (San Francisco) Bay Conservation and Development Commission
CALFED: CALFED Bay-Delta Program
CANOD: California Aquatic Non-native Organism Database
CEMAR: Center for Ecosystem Management and Restoration
CEQA: California Environmental Quality Act
CVP: Central Valley Project
DIP: Delta Improvement Package
DFG: California Department of Fish and Game
DHS: California Department of Health Services
DWR: California Department of Water Resources
ESU: Evolutionarily Significant Unit
GCM: General Circulation Model
GGNRA: Golden Gate National Recreation Area
IEP: Interagency Ecological Program
IRWM: Integrated Regional Wetland Monitoring Program
ISP: Invasive Spartina Project
MLML: Moss Landing Marine Lab
MWD: Metropolitan Water District of Southern California
NEPA: National Environmental Policy Act
NMFS: National Marine Fisheries Service
NOAA: National Oceanic and Atmospheric Administration
NOS: National Ocean Service
OEHHA: California Office of Environmental Health Hazard Assessment
PBDE: Polybrominated Diphenyl Ether
PEEIR: Pacific Estuarine Ecosystem Indicator Research
PRBO: PRBO Conservation Science, formerly Point Reyes Bird Observatory
PWA: Philip Williams & Associates
RCD: Resource Conservation District
SBSP: South Bay Salt Pond Restoration Project
SFBBO: San Francisco Bay Bird Observatory
SFBCDC: San Francisco Bay Conservation and Development Commission
SFBJV: San Francisco Bay Joint Venture
SFBRWQCB: San Francisco Bay Regional Water Quality Control Board
SFEI: San Francisco Estuary Institute
SFEP: San Francisco Estuary Project
SFSU: San Francisco State University
STRAW: Students and Teachers Restoring a Watershed
SWP: State Water Project
SWRQB: State Water Resources Control Board
TBI: The Bay Institute
TMDL: Total Maximum Daily Load
UC: University of California
USF: University of San Francisco
USACOE: United States Army Corps of Engineers
USBR: United States Bureau of Reclamation
USDA: United States Department of Agriculture
USEPA: United States Environmental Protection Agency
USFWS: United States Fish and Wildlife Service
USGS: United States Geological Survey

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**Titles within the Presentations and Posters sections based on abstracts submitted prior to the conference. Some details may have changed since then. For Cochrane presentation, see Lotta and Lee abstracts.*

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A Note to State of the Estuary Conference Participants

This report includes a mixture of original unpublished and published research presented at the October 2005 State of the Estuary (SOE) conference.

Thank you to all those who responded to our call for updated abstracts after the conference. The Estuary Project appreciates your extra work in helping us put together this report. Due to budget and space constraints, information from some posters and presentations could not be included in this report, especially if not submitted in digital form as requested soon after the conference. Apologies to any of those we were not able to include. Information from all posters and presentations can still be found in the original conference abstract book.