OPENING REMARKS

This Report describes the current state of the San Francisco Bay-Sacramento-San Joaquin Delta Estuary's environment — waters, wetlands, wildlife, watersheds, and the aquatic ecosystem. It also highlights new restoration research, explores outstanding science questions, and offers take home notes for those working to protect California's water supplies and endangered species.

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 early the 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 20 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 nearly half 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.

This 2004 State of the Estuary Report summarizes restoration and rehabilitation recommendations drawn from the 43 presentations and 129 posters of the October 2003 State of the Estuary Conference and on 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 six 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 ecosystem in the Bay-Delta watershed.

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EXECUTIVE SUMMARY

Reprint of a December 2003 ESTUARY Newsletter article.

Though the words "changes and challenges" dominated the banners and brochures of October's State of the Estuary conference, another "C" word kept springing to the lips of its speakers: choices. The 800-plus crowd gathered at the Henry J. Kaiser Convention Center in Oakland heard experts talk about difficult choices ahead, as we try to reach ambitious restoration goals for huge areas of our watershed without bringing on more pollution, mosquitoes, invasions, or clashes over which city or island or bird or fish gets what water. "We are entering an era of choices, and they won't be easy ones," announced one of the first speakers, CALFED's Sam Luoma.

Tackling tough choices will require science, education, and especially leadership, according to keynote speaker Leon Panetta. Too often it is not these things, but a crisis that drives environmental policy said the 16-year congressman from Monterey, who served as White House Chief of Staff from 1995 to 1997. Panetta pointed to the collapse of Monterey Bay's valuable sardine fishery as an example of shortsighted stewardship and called for a national commitment to protecting our oceans and estuaries on the order of Roosevelt's early commitment to our national parks. "We need to decide what kind of quality of life we want to pass on to the next generation," he said.

Many of the decisions that loom ahead involve birds. The last few generations of Bay shorebirds have greatly benefited from the large constellation of salt ponds in the South Bay, but they may need to make way for other avians unless careful choices are made about what the U.S. Environmental Protection Agency's Mike Monroe called the largest single habitat restoration project ever envisioned for the Estuary. We must decide how and where to maximize habitat potential for the many different species of birds that currently use the ponds, continued the Point Reyes Bird Observatory's Nils Warnock. There will be tradeoffs in transforming the ponds to tidal marsh, with dabbling ducks benefiting the most, he said.

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>
> SAM LUOMA
> CALIFORNIA
> BAY-DELTA AUTHORITY

Tidal marsh restoration could displace the threatened snowy plovers that nest in and around the salt ponds and levees in the South Bay and that need to be handled with kid gloves. According to U.S. Fish & Wildlife's Joy Albertson, the Bay supports 100-150 breeding plovers, about 10% of the entire U.S. population of the Pacific Coast Western Snowy Plover. The birds nest in shallow scrapes on salt pond levees or flat open areas within 100 meters of water, lining their nests with pebbles and salt crystals. But California gulls—which also roost on dry salt ponds and levees—prey on plover nests and chicks. Like gulls, ravens and crows are thriving as the Bay Area continues to urbanize. They "hang out" in the landfills built next to the wetlands years ago, and also eat plover eggs and chicks. Choosing where to locate and restore salt pans and ponds will be critical to the plover's future, said Albertson, along with deciding how to manage water levels, salinities, and predators.

Ravens and crows are not the only interlopers on sensitive bird turf. The hum of mountain bikes or the drum of hiking boots can also disrupt shoreline birds and mammals, but regulators and scientists are still trying to figure out just how much is too much. The S.F. Bay Commission's Caitlin Sweeney told the crowd that two field studies along the Bay Trail show differing results—one that humans have an adverse effect; the other that there is no correlation between bird use and human use of trails. "We still have a lot to learn about the relationship between frequency and intensity of human use and effects on wildlife," admitted Sweeney.

Because the South Bay ponds are located in such a heavily populated urban area, said the Coastal Conservancy's Amy Hutzel, resource managers will need to decide how to balance many competing interests, among them endangered species, birds, flood management, and wildlife-oriented public access and recreation. Planners are applying what has been learned about restoring salt ponds in the North Bay, but the South Bay is a different animal, said Hutzel, who explained that the Conservancy and its partners are working on a phase-out and stewardship plan that will deal with such issues as formulating a long-term water circulation plan for the ponds, and minimizing mercury methylation, introduced species, and mosquitoes. Said Hutzel, "We hope to compress the 10 years of work done in the North Bay to five years in the South Bay."

But how will we pay for long-term maintenance and operations of the restored South Bay ponds? That was the question posed by the Bay Institute's Marc Holmes in his talk the second day. The Bay lacks a distinctive identity 3,000 miles away in Washington, D.C., said Holmes, which makes it challenging to get federal funding. It doesn't have the poetic "River of Grass" image of the Everglades, or the strong, multi-state constituency of Chesapeake Bay, said

Holmes, and "historic diked baylands" don't necessarily inspire East Coast politicians. "When people think of San Francisco Bay, they think about the Golden Gate Bridge and the Transamerica Pyramid building," he said. The Bay needs not only a strong identity that will resonate in Washington (Holmes suggested John Hart and David Sanger's "Hollow Lands"), but also a planned funding strategy to finance restoration, operations, and maintenance—not merely acquisition.

Once we have the money we need for restoration (and ongoing maintenance), we will need to decide where we will get the best return on investment, to use the banking-based terminology common in several talks. We tend to put restoration money into highly visible projects, like tidal wetlands and urban streams, said Jeff Haltiner of Phil Williams & Associates, but we also need to develop stewardship around mudflats, upper watersheds, and grazing lands—to take a broader look at the Bay. And in doing restoration, we need to better train the next generation. We are practicing by "learning on the patient," said Haltiner, who also pointed out that while we have regional goals for wetland restoration, we have nothing comparable for fluvial systems.

In fact, riparian restoration is the "poor cousin" of marsh restoration, according to the S.F. Regional Board's Ann Riley, despite enormous citizen interest and the fact that riparian restoration has evolved from city-block-long-sized projects to mile-long projects, an evolution due in part to opportunities to rehab old flood-control projects. One of the myths about restoring urban streams, said Riley, is that you cannot have a healthy ecological system in a city. If project designers get the length and width of the active channel right, she said, a fully functional channel is possible. Working with nature is a part of the new restoration paradigm, she added. "The era of planting streams with container stock from nurseries—to 'pretty up' an ugly engineering project—is over. Plants are our new engineering materials." Soil bioengineering techniques similar to those used in urban stream restoration—creating willow fascines and bundles to trap sediment—are also being used in the Delta, said Lauren Hastings in her overview of Delta restoration projects, the idea being to work with nature instead of trying to control it with hard structures. Working with nature—the tides—was also the U.S. Geological Survey's Jon Burau's focus, who described recent experiments at Frank's Tract. By synchronizing water project operations with tidal ebbs and flows, said Burau, we can control salinity and improve water quality.

Riparian restoration may not receive the attention marsh restoration does, but new science indicates that it should. Lester McKee pointed out that recent research by the S.F. Estuary Institute on sediment loads from small tributaries shows that they may be having a greater impact on the Bay than the larger rivers that flow to the Estuary. Why? Because there is proportionately more sediment in less volume of water, explained McKee, and particles are more likely to be deposited along channel banks and bottoms. These same small waterways are also large contributors of mercury and PCBs—at least equal to inputs from Central Valley rivers, according to McKee. Part of the problem is that many of these small tributaries historically entered the Bay in sloughs or seasonal wetlands, but now discharge their water—and contaminants—directly into the Bay in flood-control channels or pipes without first being filtered by wetlands.

Restoring the mouths of creeks is one choice we could make to see multiple benefits from our restoration dollars, as such projects would help filter sediment and pollutants while creating habitat. Meanwhile, other pollutants lurking at the bottom of the Bay will be harder to get rid of, said several speakers. For some pollutants, our only choice may be to do nothing—or try to reduce their loads, which is not always possible. The Estuary Institute's Mike Conner mentioned mercury, PCBs, DDT, dieldrin, and chlordane as problem pollutants in the Bay, which he christened "the Big Muddy" because sediments—and contaminants from the bottom—become resuspended with every tide. Conner's colleague, Jay Davis, described the efforts the Institute has undertaken over the past few years as part of the Regional Monitoring Program (RMP) to model the long-term fate of persistent organic pollutants in the Bay. The degree of contamination is most severe for PCBs, said Davis, which continue to "load" the Bay as bottom sediments are resuspended and recirculated, and contaminated sediments are eroded from the watershed. According to the Institute's model, if all these loads could be eliminated, we could reduce PCBs in the Bay by 90%, but it would take about 70 years. PAHs are another problem, and are at the threshold for concern, said Davis. When it comes to a relatively new pollutant, the flame retardant PBDEs, we don't know enough about the threshold for concern, said Davis. We do know that concentrations of PBDEs are increasing exponentially and that we are "loading up our sediments." The partial ban on PBDEs signed by former Governor Davis will help address the problem, but overall, the Bay is slow to respond to a

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>
> **LESTER MCKEE**
> **SFEI**

decrease in loadings of persistent chemicals, said Davis. "Even small loads of persistent chemicals can have significant consequences, and contamination of the watershed will prolong recovery."

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>
> ANN RILEY
> S.F. BAY REGIONAL WATER QUALITY CONTROL BOARD

Emerging pollutants—PBDEs and endocrine disruptors—were the focus of a trio of speakers during the first day's afternoon session. Tom McDonald with the Office of Environmental Health Hazard Assessment described health concerns related to PBDEs, which are now ubiquitous in our environment: Even house dust may be a pathway into the human body. Kim Hooper characterized humans as the proverbial canaries in a coalmine, making the case for measuring body burdens of contaminants like PBDEs. We measure chemicals in air, soil, water, and animals, said Hooper, but not in people. Yet body burden data—particularly from human breast milk—is very useful for analyzing risks associated with neurodevelopment, said Hooper. The bottom line is that persistent organic pollutants are "not a good idea." PBDE levels in humans and biota in the Bay are now among the highest in the world. One concern about PBDEs is that they may be endocrine disruptors, the focus of NOAA Fisheries' Tracy Collier's talk. Endocrine disruptors mimic or block hormones or alter hormonal balance in humans and other creatures, such as fish, explained Collier, who has studied the effects of PAHs (another problem Bay pollutant and endocrine disruptor) on zebra fish and found that they suffer from arrhythmia and loss of cardiovascular function.

So what can be done? Some solutions are simple, said the S.F. Regional Board's Keith Lichten, who described how post-construction stormwater management measures, such as swales, ponds, wetlands, media filters, green roofs, and even something as simple as narrower streets, can filter and improve what runs off to the Bay. Those measures can have other benefits too, like controlling floods and giving people a sense of place. "As people see runoff flow across the landscape, they better understand their connection to the Bay and how their actions affect it," said Lichten. "The Bay becomes more than something they just drive over." Another regulatory approach to cleaning up the Bay is through TMDLs, or standards that limit the maximum amount allowable from all dischargers on a daily basis. Lichten's colleague Dyan Whyte explained that regulators are continuing to define and refine water quality standards for the Bay. Whyte told the audience to "stay tuned" for a TMDL for PCBs in the Bay, an urban creek pesticide toxicity TMDL, a report on Napa River sediment and pathogens, sediment reports for San Francisquito and Sonoma creeks, and an amendment to the S.F. Basin Plan for mercury, which remains one of the Bay's most problematic contaminants and was one of the conference's most popular topics.

Mercury—in the form of methylmercury, which bioaccumulates in birds and their eggs—was chronicled by Steve Schwarzbach of the U.S. Geological Survey, who found that clapper rails are particularly vulnerable due to their tidal wetland foraging patterns in and along the edges of primary sloughs, and their endangered status. Schwarzbach found that slough channel order influences methyl mercury concentrations, with greater methylation taking place in primary—or smaller, more dendritic—channels. One of the most timely questions that needs to be addressed, said Schwarzbach, is whether wetland restoration will increase or decrease mercury levels—and whether the benefits of restoration outweigh any associated problems.

Another potential risk associated with wetland restoration is West Nile Virus, which is headed for the Bay Area in 2004, according to the Contra Costa Mosquito and Vector Control District's Karl Malamud-Roam. Some wetlands will present more trouble than others, said Malamud-Roam. High-risk wetlands include seasonal wetlands, wetlands with dense vegetation (in which mosquitoes can hide from fish), wetlands with no plumbing or operations and maintenance budget, and small, dispersed wetlands (for which it is harder to track down landowners about maintenance concerns). Good tidal flushing helps prevent mosquitoes, explained Malamud-Roam, because most juvenile mosquitoes need three-plus days of standing water in order to breed. "Wetland restoration is possible and compatible with mosquito control, but it has to be done right," Malamud-Roam concluded.

Regardless of fears about West Nile Virus, wetlands restoration efforts continue to burgeon around the Bay. Wetlands and Water Resources' Stuart Siegel gave a bird's eye tour of planned and in-progress projects, while Keith Merkel of Merkel & Associates showed us where the few remaining eelgrass beds are located and described the efforts being undertaken to map them, in order to better understand where to try to restore them. Currently, only 0.1% of the Bay's bottom supports eelgrass, compared to 11% in San Diego Bay and 55% in Mission Bay, for example, although there is more eelgrass in the Bay now than in the late 1980s. What is thriving in and around the Bay are weeds, such as invasive spartina, pepperweed, and other troublemakers, according to coastal plant ecologist Peter Baye. Restoration will affect the spread of all plants, including invasive species, warned Baye, who suggested that Heron's Head Marsh in San Francisco could be used as a model for other tidal marsh restoration projects. There, Atlantic cordgrass was removed prior to restoration and nearby colonies controlled to minimize reinfestation.

Phil Williams took the long-range view in discussing wetlands restoration, attempting to predict the future of Bay habitats. "We need to recognize that the Estuary as a geomorphic system is dynamic and evolving whether or not humans are on its periphery," said Williams. He cautioned that the time to do restoration is sooner rather than later. "The Estuary is still a drowning river valley that has not achieved equilibrium between sediment deposition and erosion yet," said Williams. Because we are faced with a diminishing sediment supply in the Estuary and accelerated sea level rise, we will get a vegetated marsh more quickly in restoring subsided sites now than if we wait until later, he explained. Phyllis Faber, of Phyllis M. Faber & Associates, has monitored several wetland restoration projects over the years, comparing Warm Springs in the South Bay, and Muzzi Marsh and Sonoma Baylands in the North Bay, to China Camp, a "control" site. Plants will establish themselves naturally where elevations and soil conditions are appropriate, said Faber. But a mature pickleweed marsh can take 30 to 40 years to develop, and she stressed that restorationists need to cultivate patience. Visiting scientist Denise Reed from the University of New Orleans echoed Faber, suggesting that we shouldn't "mess with stuff" too much, but rely on nature and time instead. We also need to consider how the Bay's wetlands are influenced by water management decisions, said Reed.

Such considerations were the focus of the conference's third day. The Resources Agency's Tim Ramirez kicked things off by reminding us that Southern California is tied to the Klamath, and the Bay to the Colorado River by virtue of our plumbing and political systems. CALFED's Patrick Wright agreed, emphasizing that our old approach to meeting water needs—by expanding existing projects—is "out the door," and suggesting that new approaches need to be regionally and partnership-based. "It's not an accident that in an area like the Klamath, conflict is more prevalent than in areas where we have a process," said Wright. The S.F. Regional Board's Loretta Barsamian stressed the importance her agency has placed on building partnerships with businesses, environmental groups, and dischargers in resolving Bay-related conflicts. Analyzing conflicts on the Klamath River was also the focus of U.C. Davis' Jeff Mount, who shared his perspective as a member of the National Research Council team convened to investigate last year's fish kill. The Council concluded that while the primary cause of the die-off was disease, resource managers in the Klamath Basin are not taking full advantage of the tools available to them under the Endangered Species Act. "The Klamath Basin lacks an ecosystem-based approach," said Mount, who felt that an important lesson to apply to the Bay-Delta is that single-species management is "destined to fail."

Managing for multiple species is part of what we need to do in figuring out whether we can pump more water south and still protect the Estuary, the hot topic of the third day's late morning session. If you are a small fish near the pumps, said Cal Fish & Game's Diana Jacobs, you will be drawn into the central and south Delta. "Will flow changes add to cumulative impacts or be barely perceptible?" asked Jacobs. "The stakes are high for people and ecosystems." The Metropolitan Water District's Tim Quinn presented Southern California's perspective, Kern County Water Agency's Brent Walthall described ag's point of view, and Steve McAuley covered that of the California Urban Water Agencies. Environmental Defense's Spreck Rosekrans offered his critique of the Environmental Water Account (EWA). The Department of Water Resources's Jerry Johns said that the EWA is working, calling it the "glue that put CALFED together," guaranteeing water supply reliability and fish recovery. "There have been two dry years and one above-normal water year," said Johns. "And no big fights. The fish have benefited, and the water supply is stable." But DWR's Kamyar Guivetchi predicted that by 2030, California will have "half as many new people as today," and pointed out that "because California agriculture is producing 50% more today than 20 years ago, we cannot afford to keep taking water away from ag to meet our urban water needs." He suggested that perhaps cotton and rice should be phased out. "We need to subsidize crops that can be used to promote things that will have statewide benefits."

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>
> PHIL WILLIAMS
> PHILIP WILLIAMS AND ASSOCIATES

In the afternoon, Senator Mike Machado said that while we have the tools to manage our water, we need to better choose how to use them. Assemblymember Joe Canciamilla agreed, but went one step further, saying that the state "is at a pivotal point in resolving water issues, all of which have a direct and indirect effect on the Bay-Delta." The challenge to public agencies, said Canciamilla, is "whether the CALFED

ROD will be followed. What's being proposed now is 'trust me.'" We can consider increased pumping, said Canciamilla, but we need to take care of the Delta in the process."

One way to make sure we have enough water to meet multiple needs is to increase our use of recycled water. DWR's Fawzi Karajeh said his agency sees possibilities for using more recycled water in agriculture and landscape irrigation. At the top of the list of the state's recycled water task force are public safety and the environment, said Karajeh. If we can assure the public that recycled water is safe, 1.5 MAF of it could contribute 1.2 MAF of "new" water supply. Gary Wolff, of the Pacific Institute for Studies in Development, Environment, and Security, told the audience that California's economy can continue to grow without taking more water from the environment. Cost-effective conservation techniques for homes and businesses are available now, said Wolff, who summarized some findings from the Institute's new publication, *Waste Not, Want Not*.

Water saved by urban users could benefit both human quality of life and fish, said Wolff. But flows may not be all fish need, according to the University of Washington's Jim Anderson, who has found that temperature is more important, at least to fish in the Columbia River. U.C. Davis' Bill Bennett wondered if we can truly separate human impacts from natural influences on fish populations, concluding that the issue needs to be researched further. Human and natural influences may be co-occurring and interacting in complex ways, causing population declines, said Bennett. "It's not just pumps and pollution, but effects at local and regional scales. We can measure these things." Another human impact that remains a puzzle is the genotoxic effects of agricultural runoff in the San Joaquin River, said Susan Anderson, also from U.C. Davis. While Anderson saw elevated DNA strand breaks in fish exposed to the San Joaquin River, it wasn't clear which pesticides might be causing the problem. In the future, said Anderson, genotoxins, such as captan, ziram, carbaryl, malathion, methyl bromide, and trifluralin, should be studied.

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BAY-DELTA AUTHORITY

With all these chemicals in our waters, can we ever hope to restore our fisheries? Gordon Becker from the Center for Ecosystem Management and Restoration added water supply issues, flood control, and fish migration barriers to the list of challenges facing steelhead in Bay tributaries. While historical abundance will never be attained, said Becker, we should focus on improving passage and flows and on habitat improvements based on natural channel processes. "Restoration should focus on priority watersheds," said Becker, who believes that too few resources are being expended to restore Bay Area streams. "We should integrate steelhead restoration into watershed management efforts underway." Becker concluded on an optimistic note, citing great public support for restoring fish in Walnut, Alameda, and Coyote creeks, among other Bay Area streams.

Other speakers, too, were optimistic, despite the challenges and choices ahead. As a result of the RMP, the S.F. Bay-Delta is unique among U.S. estuaries in the accuracy and amount of temporal data collected, said Russ Flegal of U.C. Santa Cruz, making it possible to quantify current metal contaminants in the Bay. Other reasons for hope include increased public awareness about the Bay. Save the Bay's David Lewis pointed out that, under supervision of his organization alone, over 12,000 people have removed 20,000 pounds of invasive species and planted more than 20,000 native plants on several sites around the Bay. John Wise (retired, EPA), said he is optimistic about public engagement in Bay issues, citing a "continuous agenda of public involvement" as the driving force behind public policy over the past 40 years. We will need to continue making an effort to involve the public, said Wise, and the public is eager for a way to measure the success of restoration and adaptive management. "What gets measured gets done," said Wise. The Bay Institute's Report Card is one important step in that direction. The S.F. Estuary Institute's Bruce Thompson and the Bay Institute's Anitra Pawley presented the results of the S.F. Bay Index published in October 2003. Several speakers mentioned that the only way the public will fully support restoration is through good science. "Science has never been more important," said CALFED's Sam Luoma. "The Bay is a constantly changing place, and we are still learning better ways of operating our existing systems and how to work with Mother Nature." But most importantly, said Luoma, the public needs to understand that we are living in an era of choice. "We need to examine the gravity of the changes we've wrought as we've made ourselves comfortable and prosperous living along the Bay."

PROTECTING OUR RESOURCES — THE CHALLENGE OF STEWARDSHIP

FROM THE KEYNOTE ADDRESS BY
THE HONORABLE
LEON PANETTA
THE PANETTA INSTITUTE AND
PEW OCEANS COMMISSION

The San Francisco Bay Estuary is one of the greatest ecosystems of the world. It is a meeting place for waters, weather, tides, salmon, sturgeon, for migratory birds, for visitors from throughout the world, a meeting place for the eight million people who live along its coastlines. But a tremendous challenge faces us in trying to protect that fine, fragile cycle of life, that balance between life on land and life beneath the sea.

The challenge we have is also the challenge of what we pass on to our children. I think what drives us and should drive us is passing on to our children the opportunity to enjoy a better quality of life. For quality of life is related to protecting the most important resources we have. To those of us in California, that means places like the Big Sur coast, the Mendocino coast, the Farallones, the life, the wonderful life and habitats we have in our oceans, our coastlines. In Monterey it's not only the bay; it's Elkhorn Slough. And here obviously, it's not only the wonder of the coast but also this wonderful Estuary.

As a boy I grew up in Monterey, in a fishing village that was driven by the sardine industry. Families were there for that purpose; Cannery Row developed, and John Steinbeck wrote about it. But ultimately you know what happened. As a result of overfishing and poor stewardship, the sardines disappeared. The families and community that depended on the sardine industry were impacted, seriously. Because of poor stewardship, we lost a very important part of the legacy of that area. The question is, how many more Montereys will there be? How many more communities will suffer because of poor stewardship?

Too often we take our natural resources for granted. In the hearings we had on the Pew Commission it became obvious that the public generally takes our oceans for granted. They take our estuaries for granted, too: they see the estuary, but they don't see what goes on beneath the surface. So we take it for granted, and we pay a price for that. The question is whether we are going to protect the great natural splendors and resources that are so important not only to life itself, but also as the legacy we pass on to future generations.

> "Every eight months we have the equivalent of an Exxon Valdez oil spill — 10.8 billion gallons of oil — as runoff from streets and highways into our coastal waters."

We govern our democracy either through leadership or crisis. If leadership is there and is willing to take the risks of leadership, then we can take steps to avoid the consuming crisis that ultimately develops in every policy area. But if leadership is not there, crisis will drive policy. Too often today, we govern more by crisis than by leadership, whether in energy, health care, the budget, social security, Medicare, foreign policy, or indeed, too often, the natural environment. We wait for a crisis to happen in order to respond. And sometimes that can be too late. Our oceans and many of our estuaries are in crisis. The Pew Oceans Commission that I chaired engaged in three years of work and a journey of discovery to determine the state of our oceans and our estuaries and the steps needed to ensure that we protect them for the future. The report is titled *America's Living Oceans: Charting a Course for Sea Change*, and is a comprehensive look at the depths of our oceans and the impact of human behavior. And that's why I term the situation a crisis. Because many of the same stresses that you have identified here as impacting the Estuary are impacting our oceans.

We're looking at the equivalent of the last buffalo hunt when it comes to our fisheries. We have depleted our oceans of 90 percent of the large marine fish—the tuna, the marlin, and the swordfish. Populations of cod, haddock, yellow-tailed flounder, and rockfish have reached historic lows and in many cases are nearing the point where they will become extinct. Only 22 percent of fish stocks are fished sustainably. As you have found in the San Francisco Bay Estuary, pollution is an increasing problem, not only within our estuaries, but along our coastlines as well. Discharges of nitrogen have increased five-fold. And we expect that they could increase another 30 percent within the next few years. As a result, we have huge dead zones appearing off of our coastlines. A dead zone is exactly that: no life within that area. We have degraded about two-thirds of our estuaries and our bays as a result of pollution. Thirteen thousand beaches are closed or on pollution advisories. According to a study by the National Science Foundation, we have the equivalent of an Exxon Valdez oil spill—10.8 billion gallons of oil—as runoff from streets and highways into our coastal waters every eight months. In addition, invasive species are crowding out our native species and altering habitats. In San Francisco Bay, you have identified about 175 invasive, introduced species.

Coastal development is another stress we found to be significant. Here in California, 54 percent of our population lives on 17 percent of our land. And we estimate that 25-27 billion more people will move to our coastlines in the next 15 years. We've lost 20,000—and continue to lose 20,000—acres of wetlands each year in this country. California alone has lost 95 percent of its historic wetlands. So all of this tells us that we have a problem that has to be confronted. But the good news, to a large extent confirmed by the work that you have done here, is that it is not too late to reverse what has happened, to repair the damage, to restore these great resources.

The problem is, we can't deal with this kind of challenge on a hit-and-miss basis. We can't just address it with court orders. We can't just deal with it by simply waiting for crisis to drive policy. This kind of challenge requires leadership—not just by elected leaders but by all of us. The biggest challenge we face is how to change the laws and attitudes of the past so that they can meet the realities of the present. Our ocean laws—the laws that deal with our coastline waters—date back to an era when our primary concern was preventing other nations from stealing our ocean resources before we got to them. It was not about sustainability; it was not about good management. It was about protecting the resource from others who might try to seize it. And so what developed is a conglomeration of laws that oftentimes do not work together. Governance may be one of the biggest problems we face when it comes to dealing with our oceans crisis. There are 60 committees in Congress that deal with our oceans and estuaries; there are 140 laws; there are 30-40 agencies. There is a lack of science to look at these problems. As a result, there is very little coordination, and there is conflicting guidance by various agencies at different levels, whether federal or local. And so what oftentimes happens is that issues have to be taken to court to have a federal judge decide them.

"Too often today, we govern more by crisis than by leadership…we wait for a crisis to happen in order to respond."

So we govern much more by crisis than by leadership. Some of the primary recommendations of the Pew Commission were that we need to reform ocean management, that we need greater coordination of ocean policy at the federal level, that we need to have an ocean agency responsible for dealing with these agencies, that we need to develop ecosystem councils that manage ecosystems on land and in water. The Chesapeake Bay Plan was one of best models we saw—it involved several states plus the federal government, plus the local government, which came together to set goals to try to restore life in Chesapeake Bay. And it worked because everybody was committed; everybody was sitting at the same table. Those kinds of ecosystem councils need to be established for other major ecosystem areas such as the one you're dealing with here. It is also important to develop and reform fisheries policies in a way that advocates sustainability and gets away from single species management.

We need to protect coastlines, marshes, and wetlands from development and identify areas that need to be protected. We need to clean our waters, particularly of non-point source pollution. We've done a pretty good job on direct pollution but haven't done enough on non-point sources. The Clean Water Act needs to be amended to do that. But first, Congress and the President must make a commitment to protecting our oceans and our estuaries. We have recommended that Congress pass a national ocean policy act that clearly expresses the commitment of the nation to protecting these areas as a public trust. Very little will be accomplished unless there is a fundamental commitment recognizing that these areas must be protected the same way we protected Yellowstone or Yosemite.

One hundred years ago, Teddy Roosevelt made a national commitment to protect our land; today, 100 years later, this President and this Congress—all of us—need to make the same kind of commitment when it comes to protecting our oceans and our estuaries. It will not just happen on its own. It requires a call to action. As John Wise pointed out, it demands that people come together with clear goals. We live in a time when we're confronting crisis on a number of fronts—whether Iraq, North Korea, or the Middle East. Problems of the economy, deficits—all of these things consume us. The challenge is to point out to citizens that when it comes to problems involving estuaries and oceans, these are issues that relate to life itself—to our health, nutrition, the quality of air we breathe, to our climate, to the fisheries that are important to our communities, to our economies, to our recreational enjoyment, and to our very souls. That's the case we have to make. It is vital to the future and to that American dream my father talked about, that we pass on a better quality of life to our children when it comes to our oceans and our estuaries. And that will require a tremendous commitment by all of us. It will require fighting for what we believe in. If we're willing to fight I think we can establish such an important national commitment, that this is a national trust that all the people care about, that this great resource—the oceans and estuaries—belong not just to us but to our children as well.

vital statistics

2002-2004

"Organisms constantly adapt to their environment. So must policies. And so must policymakers. Learning from small failures is often more important than celebrating huge successes. Adaptive management is implicit in how we currently seek to manage the Estuary. We need to bring adaptive management — based on the goals and indicators being formulated, such as those the Bay Institute has presented — explicitly into the realm of public engagement."

JOHN WISE
U.S. ENVIRONMENTAL PROTECTION AGENCY (RETIRED)

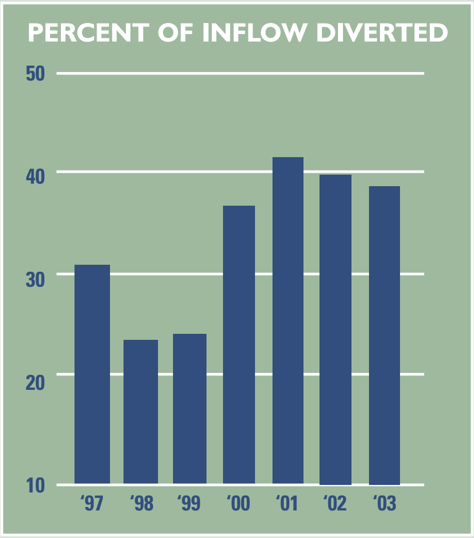
Flows

Recent Inflows

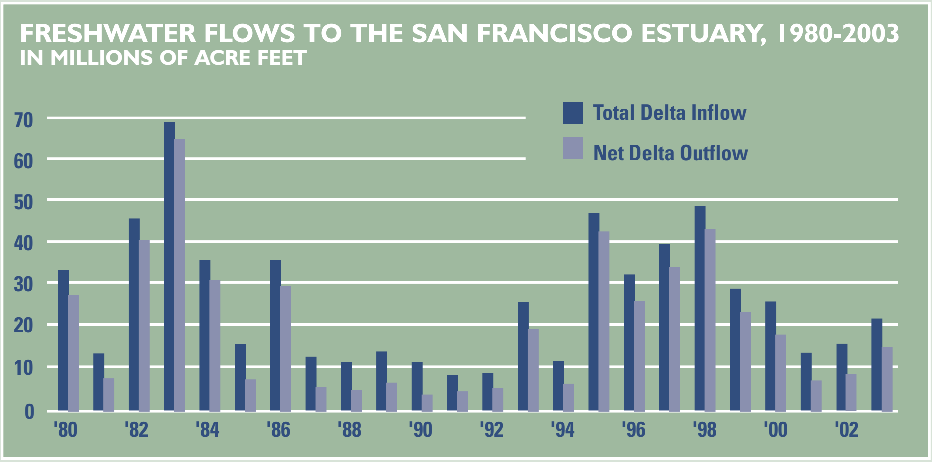
Normal or above normal rainfall has meant improved Delta inflows in recent years. Inflows to the Delta and Estuary were 15.4 million acre-feet (MAF) in water-year 2002 (October 1, 2001 - September 30, 2002) and 21 million acre-feet (MAF) in water-year 2003 (October 1, 2002 - September 30, 2003). Delta outflows were 9 MAF in 2002 and 14 MAF in 2003 (Interagency Ecological Program, 2004).

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 percent of Delta inflow diverted can vary widely from year to year. In water-year 2002, 5.5 MAF were diverted, and in 2003, 6.3 MAF. The average percentages of total Delta inflows diverted were 39.9 in 2002 and 38.3 in 2003 (Interagency Ecological Program, 2004).



Source: DWR, Exports TOT



Source: DWR, , Dayflow QTOT

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. From 2001-2003, CALFED's water use efficiency program provided $39 million in grants to more than 100 different local water conservation and recycling projects statewide. Prop. 50 provides an additional $180 million over the next three years to fund portions of the program. Prop. 13 also provided funding for water recycling projects. 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 af/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 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. The project's initial phase is now under construction, and first recycled water deliveries are expected in summer 2005.

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, with first deliveries expected after mid-2005. 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.

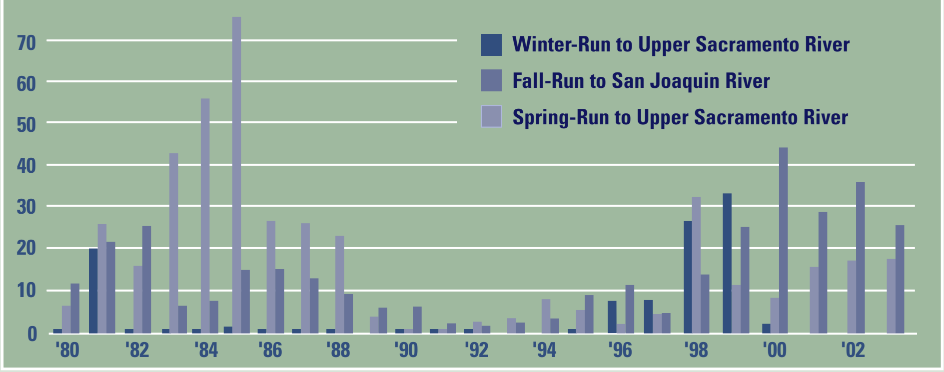
MORE INFO ? http://calwater.ca.gov/ or www.ebmud.com

Fish & Aquatic Organisms

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" was put into place recently. 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 off-spring 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 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.

SALMON RUNS OF CONCERN
IN THOUSANDS OF ADULT FISH RETURNING TO SPAWN



New counting methods for winter run implemented after 2000 shown in chart below. Source: CDFG

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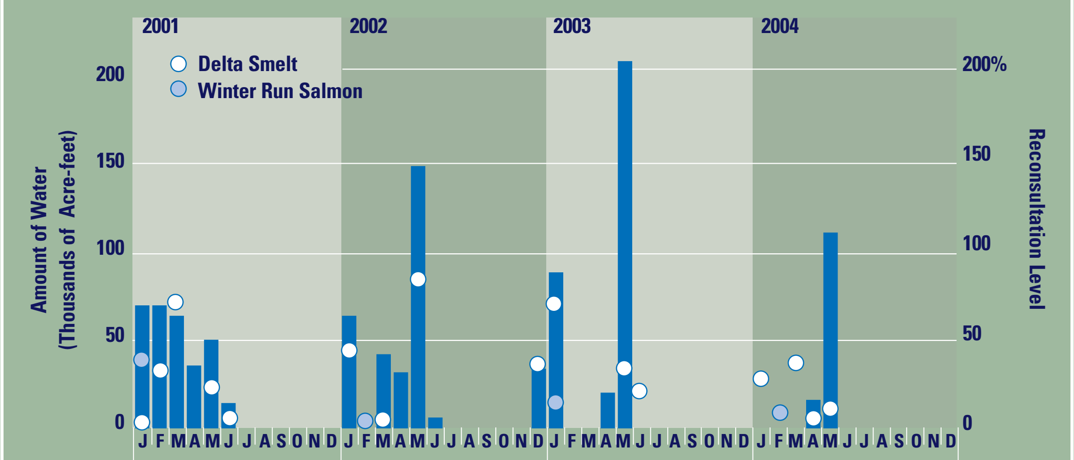
Delta Smelt

The Delta smelt, a 55-70 mm long translucent fish once common in the S.F. Estuary, was listed as a federal and state threatened species in 1993. Delta smelt are considered environmentally sensitive because of their primarily annual lifecycle, limited diet, low fecundity, and restricted distribution within the Estuary. Possible reasons for the Delta smelt's decline include reductions in Delta outflow, extreme high outflows (which displaces them away from suitable rearing habitat), entrainment losses at major water diversions, prey item changes, competition, toxicants, disease, and predation.

After a dramatic decline in the 1980s, Delta smelt abundance generally increased throughout the 1990s. Scientists attribute this population increase to the above-normal outflow conditions, which aided in the transport of larval/juvenile fish from the Delta to their rearing grounds around the Suisun Bay area. More recently, abundance indices indicate another downward trend, starting in 2001. Most likely, lower outflow through the Delta in recent years has been a major factor in the decline. Cal Fish & Game monitors the relative abundance of Delta smelt through two long-term monitoring programs: the Summer Townet Survey (TNS) (since 1959) and the Fall Midwater Trawl Survey (MWT) (since 1967). The 2003 TNS index for Delta smelt is 1.6, a decrease from 2002 (4.7) and

ENVIRONMENTAL WATER ACCOUNT EXPENDITURES
JAN 2001 THRU SEPT 2004



EWA expenditures are used to take proactive measures (release water from reservoirs and/or ramp down Delta pumping plant rates) to AVOID the reconsultation levels (100%, or "red light) for delta smelt and winter run chinook salmon. In previous years - without the EWA - protective actions could not be taken UNTIL the reconsultation levels were reached. Note that a single EWA action often provides benefits to more than one listed species (including spring run chinook salmon and steelhead).

2001 (3.5). Meanwhile, the 2003 MWT index was 210, up slightly from 2002 (139), but well below the MWT 36-year average (556). To reduce the impact of Delta pumping operations on Delta smelt, CALFED developed the Environmental Water Account (2000), which has been used primarily to reduce Delta smelt take by reducing pumping. It is too soon to determine whether this effort will provide population-level benefits. (Mayfield, Pers. Comm., 2004)

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Longfin Smelt

Longfin smelt 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 2003, and so has the abundance of longfin smelt, as measured by Cal Fish & Game's Fall Midwater Trawl Survey. In 2002, the abundance index increased slightly from 247 in 2001 to 707, before declining to 191 in 2003. These represent some of the lowest abundance levels observed for longfin smelt, and probably reflect poor early survival conditions resulting from recent low outflow years and changes in food web dynamics brought about by the introduced Asian clam, *Potamocorbula amurensis* (Kimmerer 2002). On a positive note, Cal Fish & Game has continued to collect 115 -140 mm spawners (about three years old) in trawl sampling, which suggests that survival has increased from juvenile to adult (age two) and beyond. 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., 2004)

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Splittail

Young splittail production has been low in the past two years as a result of low river flow during the splittail spawning period in late February-May. Nonetheless, in September 2003, U.S. 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. Splittail are known to spawn on inundated terrestrial vegetation, and recruitment appears most strongly associated with the magnitude and duration of floodplain inundation during spawning period (Sommer et al. 1997, Moyle et al. (in press)). Floodplain inundation occurred only briefly prior to the splittail spawning period in 2002 and 2003, but a late season pulse in late April-early May 2003 resulted in some successful spawning. Upper Estuary trawl surveys collected few or no young of the year in 2002, and those captured by the Fish & Wildlife Seine Survey were mostly upstream of the Delta. In 2003, most surveys captured low numbers of young of the year. 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. (Baxter, Pers. Comm., 2004)

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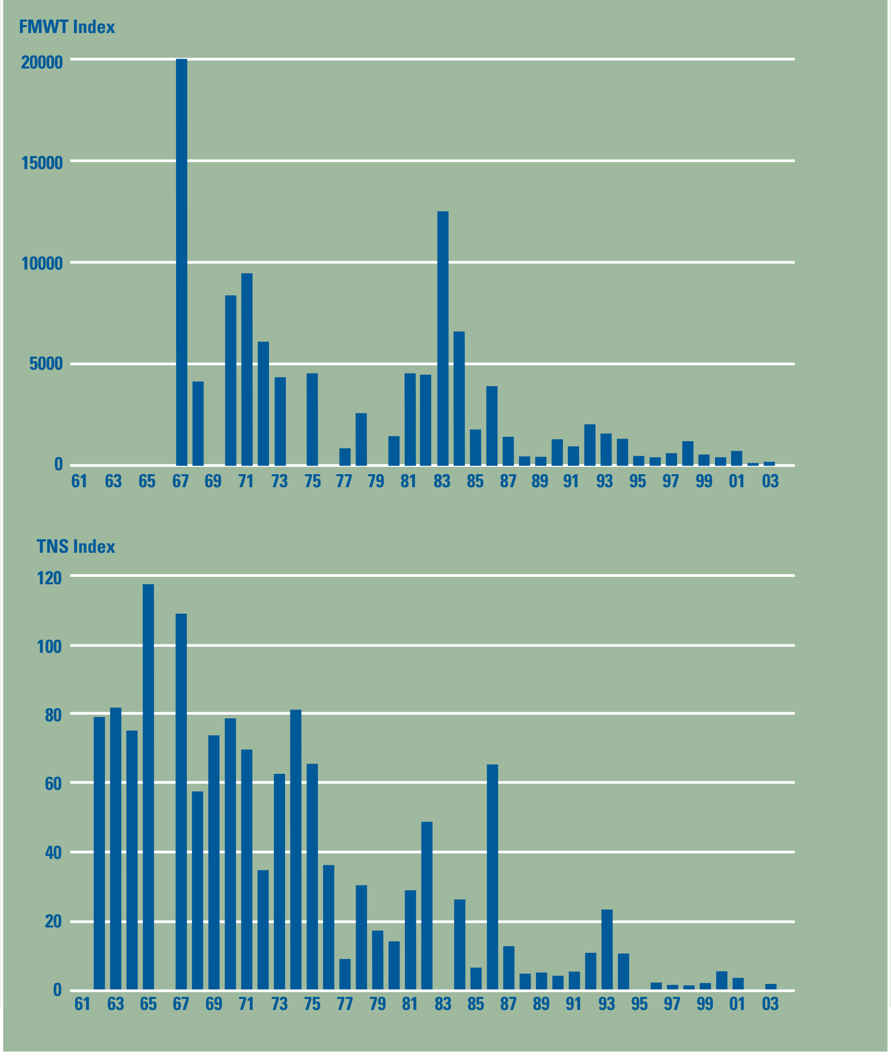
STRIPED BASS INDEX
1961-2003



Striped Bass

Adult striped bass numbers are increasing, while the abundance estimates of striped bass in their first year of life (young-of-the-year or YOY) remain at very low levels. Using data from an ongoing mark and recapture study, Cal Fish & Game reported a population increase of 70% from 1998 to 2000 (State of the Estuary 2002). However, abundance indices of YOY fish as indicated by Fish & Game's Midsummer Townet Survey (TNS) and Fall Midwater Trawl Survey (FMWT) are at or near their lowest levels.

In 2003, Fish & Game biologists investigated potential mechanisms that would explain how low numbers of YOY fish could result in large numbers of adult fish: 1) Was increasing water clarity leading to decreasing YOY striped bass catch? 2) Were YOY striped bass shifting toward the lower half of the water column where the oblique tow used by the TNS and FMWT would sample them for a shorter period of time? 3) Were higher proportions of YOY striped bass using shallow water (less then 4 feet) habitat? 4) Were abundance trends depicted by the TNS and FMWT representative of abundance in the upper Estuary? Results suggest that some other mechanism, such as increased survival after the first year of life, is responsible for the increasing numbers of adult striped bass.

Future lines of investigation include how spatial and temporal distributions of larval striped bass relate to survival, and a reassessment of the potential for density-dependent mortality to affect fall YOY abundance as suggested by Kimmerer, et. al. (2000).

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Commercial Fisheries

Since the 1997 El Niño, the spawning biomass of Pacific herring, 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, has 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 has not been finalized for 2002-2003). (Watters, Pers. Comm., 2004)

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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 make 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 candidate species list. Green sturgeon status will be reassessed within five years if warranted (NMFS 2003). 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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Invasive Species

Green Crabs

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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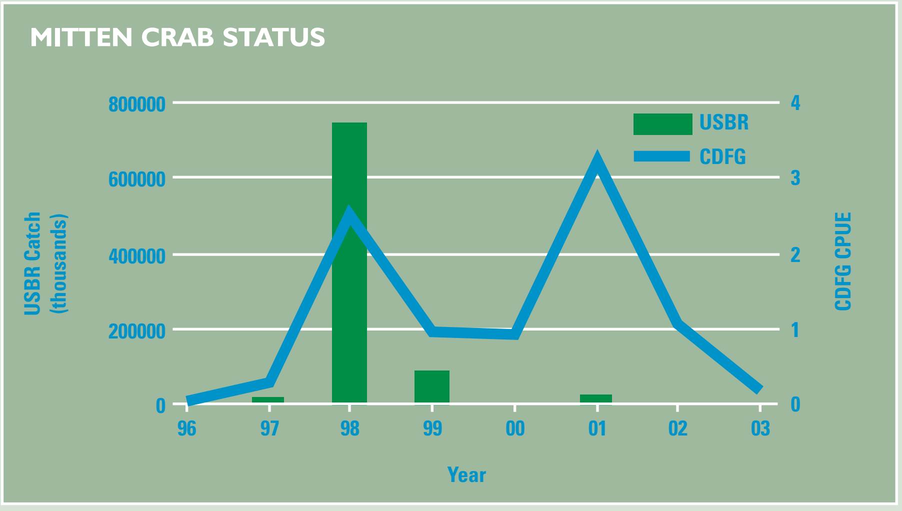
Chinese Mitten Crab

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 in 2002 and 2003. 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.



Total catch of adult mitten crabs at BurRec's fish facility (bars) and catch per tow (CPUE) of adult mitten crabs from Cal Fish & Game's S.F. Bay Study otter trawl survey (line), 1996-2003.

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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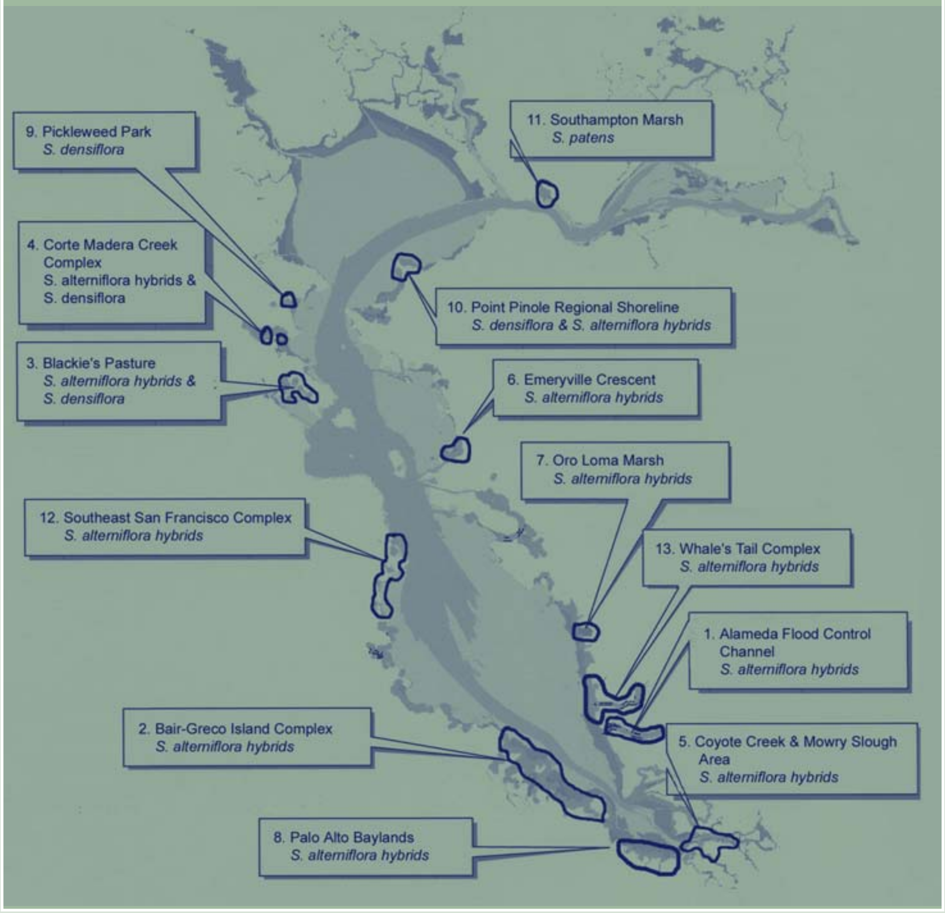
Pike

The voracious Northern pike, native to Canada and the Midwest, was illegally planted in the 85,000-acre-foot Lake Davis reservoir in the early 1990s. In 1997, Cal Fish & Game treated the lake with Rotenone to prevent pike from eating lake trout and escaping into and corrupting 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. Biologists have pulled approximately 38,000 pike from the lake since 1999, mainly from shallow areas such as Mosquito Slough, a weedy channel into the lake. In February 2000, a Lake Davis steering committee, comprised of Plumas County and Cal Fish & Game officials and local citizens, released a management plan recommending 13 "control-and-contain" measures, including several types of barrier nets, increased electro-fishing, underwater explosions, and fishing derbies. By the spring of 2003, those recommended activities were complete, and a three-year summary of those efforts was released (see http://www.dfg.ca. gov/ northernpike/ index.html). Despite the increased numbers of pike in the lake, they have not been found outside of Lake Davis, and the steering committee is assessing next steps.

SITES SELECTED BY THE INVASIVE SPARTINA PROJECT

FOR TREATMENT OF NON-NATIVE CORDGRASS IN 2004. NUMBERS CORRESPOND TO THE SPARTINA PROJECT'S "TREATMENT SITE NUMBER" FOR THAT LOCATION.



Asian Clams

The Asian clam (*Potamocorbula 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 northern bay for the last several years during early spring, when *Potamocorbula* biomass is at an annual minimum. These blooms have been earlier and shorter in duration than historic blooms. *Potamocorbula* 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 *Potamocorbula* filter-feeding. This is due to the seasonal cycle of *Potamocorbula* 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. (Thompson, Pers. Comm., 2004)

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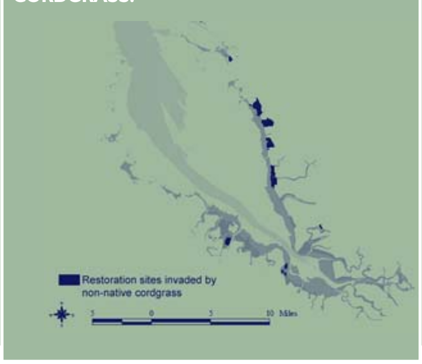
Cordgrass

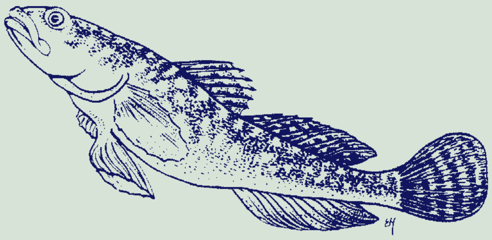
Species of *Spartina* (cordgrasses), introduced into the Estuary in the 1970s, have spread rapidly and pose a serious threat to the success of future tidal marsh restoration throughout the Estuary. The impacts associated with the spread of Atlantic cordgrass (*Spartina alterniflora*) include hybridization 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. Preliminary results from mapping at a limited number of infested sites in 2003 indicate that coverage increased three- to five-fold in approximately two years. If this holds true for the entire population of non-native cordgrass mapped in 2001 (469 acres), there are now between 1,400 and 2,300 acres of the invader. More detailed analysis of the 2003 monitoring data is currently underway, and full Bay-wide monitoring is planned for 2004. Meanwhile, the Coastal Conservancy and U.S. Fish & Wildlife completed the programmatic EIS/EIR for the S.F. Estuary Invasive Spartina Project. The Coastal Conservancy adopted the EIR, and Fish & Wildlife is preparing the ROD. The Spartina Project identified and prepared site-specific control plans for 13 priority sites encompassing more than 250 acres of non-native Spartina; more than $250,000 in CALFED-funded grants will allow seven local agencies to carry out these plans in 2004. With adequate funding, the Spartina Project expects to control the invasive *Spartina* by 2010, but a dedicated funding source for the effort has not yet been established.

MORE INFO? www.spartina.org

RESTORATION PROJECTS

(INCLUDING MITIGATION SITES) KNOWN TO BE INVADED BY NON-NATIVE CORDGRASS.





Gobies

Four species of non-native gobies (all of which were probably introduced via ballast water release) continue to inhabit Estuary waters. Cal Fish & Game S.F. Bay Study catch of the shimofuri goby (*Tridentiger bifasciatus*) has remained relatively stable over the past five years, whereas catch of the chameleon goby (*T. trigonocephalus*) has declined slightly. The yellowfin goby (*Acanthogobius flavimanus*) has historically been the most abundant and widespread of the introduced gobies. Yet in 2002 and 2003, Bay Study catch of shokihaze gobies (*T. barbatus*) exceeded the catch of yellowfin gobies. The impact of the shokihaze goby in the Estuary has not yet been determined. Within the Estuary, shokihaze gobies are found primarily in Suisun Bay and the lower Sacramento River, where they have the potential to harm native fishes (e.g., sculpin, Delta smelt, and longfin smelt) and shrimp and other invertebrates by competing for resources and through predation. Adult shokihaze gobies have been found in salinities ranging from 0.44 to 28.81 parts per thousand. In February 2002, the Bay Study caught two shokihaze gobies south of the Dumbarton Bridge. The potential exists for the shokihaze goby range to expand within the Estuary and also into other bodies of water within California.

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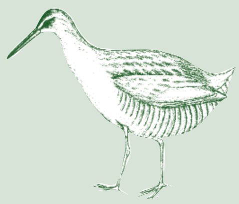
Wetlands & Wildlife

Wetlands

S.F. Bay Joint Venture partners completed several major acquisitions around the Bay, including the Cargill property (16,000 acres) and the Bahia wetlands (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, and West Stege Marsh. 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 S.F. 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. 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 recent 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. The S.F. 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.

MORE INFO?
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 S.F. Estuary Institute's Wetland Project Tracker (www.wrmp.org/projectsintro.html), S.F. Bay Joint Venture (www.sfbayjv.org/), and Central Valley Joint Venture (www.cvjv.org). For detailed information about CALFED's extensive activities and accomplishments, see the CALFED Bay-Delta Program Annual Report 2003 (http://calwater.ca.gov/). For information about restoration of the Cargill property, see www.southbayrestoration.org

California Clapper Rail



Current Bay-wide population estimates for the endangered California clapper rail (*Rallus longirostris obsoletus*) are not available, but surveys in the mid-1990s placed their numbers at about 1,200 (up from a low of 300-500 birds in 1991). While Central and South Bay populations continue to hold steady, there is some indication that North Bay populations are in precipitous decline, at least at some locales. Recent field studies suggest that rails in the more pristine North Bay marshes are faring less well than those in areas closer to residential and urban areas. The estimated 13 pairs present in Sonoma Creek in 1993 dropped to one to three pairs in 1998, and in 2001, no rails were found. Along the Napa River, an estimated 16 to 23 pairs surveyed in the 1990s dropped to four to seven pairs in 2001 and perhaps to as few as three pairs by 2004. Heavy rains in the winter of 1997-1998 may have caused some declines in the North Bay, as residual high water, particularly along the North San Pablo Bayshore, impacted nesting success (Albertson & Evens 1998), and there is concern that predation by non-native mammalian predators (primarily red fox) may be further impacting North Bay populations. The causes of the dynamism of clapper rail populations in S.F. Bay are poorly understood—a regionwide survey effort beginning in 2004 will attempt to clarify many questions. Early results of surveys underway indicate that some areas are still depressed (e.g., Sonoma Creek and White Slough), while other areas are supporting relatively high densities (San Pablo Bay shoreline from Gallinas Creek north to the lower Petaluma River). (Evens, Pers. Comm., 2004)

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Black Rails

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 Terns

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 low-flying helicopters, mammalian predators, 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 2001, fledgling estimates reached an all-time high of 320. In 2002, Alameda's fledglings represented between one-fourth (minimum) to one-half (maximum) of the state's total fledgling population.

Farther north, the number of terns at the Southern Power (formerly PG&E) cooling ponds in Pittsburgh decreased from 13 pairs in 2001 to 8 in 2003. 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. It hosted somewhere between 8-12 pairs in 2000 and 9 pairs in 2001; in 2002 and 2003, there were no nests. The East Bay Regional Park District recently established a least tern breeding site on the Hayward Regional Shoreline. Terns visited this site in 2003, but no nesting was observed. 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 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. More recent surveys by PRBO scientists are consistent with 2000 surveys. Salt marsh yellowthroats appear to respond to specific vegetation composition and are more abundant where there is a greater amount of *Scirpus maritimus* (alkali and bulrush) and peppergrass (a non-native herb). 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 Sparrows

Reproductive success of salt marsh song sparrows has been increasing slowly since 1998, which was the poorest year recorded to date; in particular, reproductive success levels in 2003 were, overall, higher than in any year since 1996. Despite the relative increase in reproductive success, the overall success observed at most marshes (usually between 15% and 20% of nesting attempts result in any fledged young at all) is 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. The greatest cause of nest failure is predation. Current efforts are being directed toward identifying predators (potentially mammals, snakes, and crows and jays). In addition, about 10% of nests fail each year due to flooding during the highest tides. Estimated numbers of breeding Alameda song sparrows (*Melospiza melodia pusillula*), restricted to Central and South S.F. bays, range from 12,000-18,000 individuals; of Suisun song sparrows (*Melospiza melodia maxillaris*), found in Suisun Bay, from 36,000-53,000; and of San Pablo or Samuel's song sparrows (*Melospiza melodia samuelis*), found in San Pablo Bay, from 65,000-85,000. 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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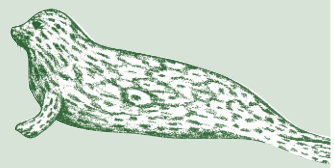
Riparian Brush Rabbit

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 into the refuge. 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*). 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, 194 young rabbits released into the refuge, and as many as 70 rabbits still in the pens. The rabbits in the pen 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.

MORE INFO? (916)414-6600 or (559)487-5139

Harbor Seals



S.F. Bay harbor seal (*Phoca vitulina*) numbers have remained fairly stable over the past decade. 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 heavily during the pupping (mid-March-May) and molting (June-mid-August) seasons. Since 2000, approximately 300 harbor seals and 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, seals are typically most plentiful at Yerba Buena Island, with 200-300 harbor seals using this site (1998-2002). Castro Rocks, a chain of rock clusters just south of the Richmond Bridge and the second-largest pupping site in the Bay, is used by approximately 150-250 seals year-round (2000-2003). Seismic retrofit work began on the Richmond Bridge in early 2001, and researchers from S.F. State University are monitoring what effect, if any, the construction is having on seal numbers and behavior.

To date, researchers have documented a shift in site use to rocks located farther from the bridge when construction is underway in the immediate area; overall seal numbers have not declined. (Green, Pers. Comm., 2004).

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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 three 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 mice populations are underway in the North Bay, and the South S.F. Bay Marsh Restoration Project has begun in the South Bay, but it will take years to decades for new marshes to be produced and hence increase mouse populations. (Shellhammer, Pers. Comm., 2004)

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Red-Legged Frogs

The once-abundant California red-legged frog (*Rana aurora draytonii*) federally listed as threatened, has disappeared from approximately 70% 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. Across the frog's range there are only four populations with 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 U.S. 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. More than two-thirds of the proposed habitat is privately owned. A draft economic analysis is expected in early 2005.

MORE INFO? (510)663-0616

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 150-200 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. 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 utilized Bay salt ponds during the breeding season, an increase from 2003. As of late June 2004, approximately 50 nests had been found and followed through to completion to determine hatching success. In addition, avian predator surveys were conducted to determine what predators may be posing the highest risk to plover success. The highest concentration of plovers was found in Eden Landing Nature Reserve. (Albertson, Pers. Comm., 2004; Strong Pers. Comm., 2004)

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Western Burrowing Owl

Western burrowing owls (*Athene cunicularia hypugaea*) were once common throughout the West, but they have declined precipitously in California in the last several decades—breeding owls have been eliminated from at least 8%-10% of their former range in the state and are trending toward extinction in another 25%. Currently, estimates are that more than 70% of California's breeding owls live in the margins of agricultural land in the Imperial Valley. Locally, burrowing owls declined 50% from the 1980s to the 1990s. The owl has been extirpated from San Francisco and Marin counties and from most of San Mateo and Sonoma counties. It can still be found in scattered spots in the East Bay, including the Berkeley Marina, and in Santa Clara County, where a census five years ago estimated 120-141 pairs. 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, Cal Fish & Game denied a petition that would have granted the owl endangered status.

MORE INFO? (408)252-3748

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, excessive 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. New studies are underway at Rush Ranch and other sites to further understand management factors influencing critical life stages of this endangered plant, and to test the plant's response to invasive species control options.

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Water & Sediments

Bay Contaminants

In the Bay, most contaminant guidelines are being met, but the level of contamination today is probably high enough to impair the health of the ecosystem (indications of impairment include the toxicity of water and sediment samples to lab organisms and the frequent presence of contaminant concentrations exceeding water, sediment, and fish guidelines). A relatively small number of problem contaminants makes it rare to find clean water or sediment in the Bay. Of all the contaminants measured by the Estuary's Regional Monitoring Program (RMP), results suggest that those of greatest concern are mercury and polychlorinated biphenyls (PCBs). While mercury concentrations remain unchanged, 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. Concentrations of chemicals currently in use, such as pyrethroid insecticides and polybrominated diphenyl ethers (PBDEs) may be increasing. Also of concern are copper, dioxins and polycyclic aromatic hydrocarbons (PAHs). Work outside the RMP suggests that selenium is also a concern. The S.F. Regional Board established a water quality attainment strategy (site-specific objectives and prevention-based action plans) for copper and nickel in South S.F. Bay (south of the Dumbarton Bridge) in May 2002; the strategy is currently being implemented. The Board will establish a mercury TMDL (total maximum daily load) for S.F. Bay in 2004 and expects to establish TMDLs for PCBs and for pesticides in urban creeks that drain to S.F. Bay in 2005. The Board is currently working with the Clean Estuary Partnership (the Bay Area municipal wastewater and urban runoff agencies) to establish TMDLs, water quality attainment strategies, or other appropriate response plans for legacy pesticides and selenium in S.F. Bay, and copper and nickel in S.F. Bay north of the Dumbarton Bridge.

MORE INFO? www.sfei.org; www.swrcb.ca.gov/rwqcb2/

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 is expected to consider amendments to its Basin Plan to address water quality problems in the Delta associated with elevated levels of diazinon, chlorpyrifos, and mercury, along with an amendment to begin control of low dissolved oxygen in the Stockton Deepwater Ship Channel. The Basin Plan amendments for each will include an implementation plan with a schedule and monitoring to assess compliance. Each plan will likely contain a reopener clause, probably after 5-10 years, to ensure that monitoring results and new scientific findings are incorporated into the revised implementation plans.

In the Sacramento basin, the Board passed a Basin Plan amendment to control diazinon and chlorpyrifos in the lower Feather and Sacramento rivers. In 2004, the Board will consider whether requirements for diazinon and chlorpyrifos control in Sacramento urban creeks adopted into the city's MS4 permit several years ago can be accepted in lieu of an actual Basin Plan amendment. The Board is expected to consider amendments for mercury control in Sulfur Creek, Harley Gulch, and Cache Creek in 2005.

In the San Joaquin basin, the Board will consider amendments for chlorpyrifos, diazinon, boron, and salt in 2004-2005. 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. Lower ambient pesticide concentrations make passage of the organophosphorus insecticides basin plan amendments less controversial. In contrast, controlling salt in the San Joaquin basin remains highly contentious.

Ensuring that all the recently adopted control actions are implemented is a concern, due to resource constraints. The recently approved agricultural waiver may help, but lawsuits by both agricultural and environmental interests are still pending. Nonetheless, agricultural coalition groups have submitted monitoring plans and watershed evaluation reports. Monitoring is scheduled to begin in summer 2004, and results will help track the concentration of contaminants of concern.

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

THE EXPLOSION OF NEW SCIENCE ABOUT THE BAY: IMPLICATIONS FOR MANAGEMENT

SAMUEL N. LUOMA
CALFED BAY-DELTA PROGRAM AND U.S. GEOLOGICAL SURVEY

In managing the Bay-Delta in the future, we will have to choose between difficult economic, social, and environmental issues. We are living in an era of choices. Many of these choices have a technical basis, and science has never been more important. Scientists need to better link to and communicate with the public. We need a much closer link between the scientific community and the community of people making policy.

As we began to understand the gravity of the changes we have brought to the Bay environment as we made our lives comfortable and prosperous, some powerful laws were passed that gave us tools to begin to change the direction of a downward environmental trend. Since the 1970s, the growth of our understanding of the Bay has exploded.

tamination; we've knocked the top off, and it will be expensive to do more. We need to understand that just as the Bay is constantly changing, our policies are constantly changing as well: the EPA's standard for copper in the South Bay, for example. The point is that the experiment continues. We're now trying to incorporate a little more flexibility into regulation, but it is very important that we follow the experiment through and don't go back to the conditions of the 1970s.

Probably the ultimate in choices is the CALFED Bay-Delta Program. It's a very complicated, ambitious program, but the multi-stakeholder approach is the only way to move forward, and the scientific community has a major role to play. We're talking about improving the situation for threatened species, improving water supply reliability, improving water quality, and maintaining a levee system so that we can maintain water supply for 22 million Californians, all while improving the environment.

> "We need a much closer link between the scientific community and the community of people making policy. It is our job as scientists now to engage in the process. We need to be at the policy table more than we have in the past."

We learned about the stressors; we learned that the whole Bay-Delta system is linked. Even the South Bay is linked to the rivers in the North Bay, which are linked to the coastal system. We've realized that if we're going to understand this system, we have to understand it all.

There is a lot left to do. We've taken the easy steps in terms of con-

There are lots of goals, and lots of contradictions. There is also a lot of money involved: The people of California have shown—by passing four different bond measures—that they are very interested in finding solutions to these problems.

We're talking about implementing ecosystem restoration projects, about improving urban water quality by

> "It is so important that the public understands that we are living in an era of choices, not in an era of black or white, an all or nothing situation."

reducing agricultural drainage, about making some major changes (these are proposals from the 2000 Record of Decision). We're talking about improving conveyance through the Delta more effectively, moving more Sacramento River water through the giant pumps to the Central Valley and Southern California, about evaluating the potential for storing water in the Delta, and improving flood protection. These are proposals, not decisions. As we start to learn about the Delta—and we've learned a lot since 1997—sometimes alternatives to the obvious engineering solutions appear. That is our role in the scientific community; that is what growing knowledge is all about. It is not just about pointing out problems (which we have to do), but it is also about recognizing that with problems come opportunities to learn and to propose creative solutions. We're learning that we need to work with Mother Nature instead of building engineering projects that are less flexible.

In the CALFED Bay-Delta program, we're interested in rehabilitating, re-engineering, re-naturalizing, or restoring our ecosystems—this is a challenge, but this is also the thing we hope will balance some of the other choices we have to make. We will also need to choose where we do restoration: some places respond quickly; some don't respond at all. Are we investing in the right places? Or does it just take some places a long time? There are conundrums: Peter Moyle has taught us that native fish benefit from variable salinity in the Delta. But variability is just what we don't want in our drinking water. How do we resolve this conundrum? Most of our salmon management policies assume that we want to keep salmon out of the Delta, but others have taught us that the Delta is a nursery for salmon. We built hatcheries for fish to make up for habitat loss above Shasta Dam so we could continue to have a fall run, but we now know that hatchery fish can threaten wild salmon. Even from an ecosystem restoration point of view: Do we restore whole ecosystem processes or do we focus on individual species like winter run salmon or Delta smelt? Do we focus on protecting endangered species? CALFED has chosen to walk down the middle, to try to do both.

We are entering an era of choices, of re-engineering and re-naturalization in an effort to improve the functioning of disturbed ecosystems while at same time providing stable and sustainable resource extraction. We cannot pretend that the stability of our lives and the economic prosperity of our society aren't linked to resources like water. How do we do both? One of the important components is understanding and respecting Mother Nature and working with her as best we can. We have to understand which tradeoffs are most effective, which we want to make, and which we don't want to make. This is why it is so important that the public understands that we are living in an era of choices, not in an era of black or white, an all or nothing situation.

This has begun to manifest itself in CALFED where the policy is that investments in environmental science should be commensurate with the stakes. Proposition 50 requires every large project to have a component that learns about its performance. We are not ready to move science to policy until we understand how a process works, and we cannot predict the rate of discovery. But there is always time for science. Those of us in the scientific community can be naïve about policy. It is our job as scientists now to engage in the process. We need to be at the policy table more than we have in the past.

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INDICATORS OF ESTUARINE HEALTH

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Like the Chesapeake Bay, the Great Lakes, and the Everglades, the San Francisco Bay-Delta watershed comprises one of the nation's great natural treasures. But unlike these systems, the San Francisco Bay has no agreed-upon, defined suite of indicators to guide and measure the effectiveness of the policy reforms and habitat restoration projects being proposed to improve its health.

Two projects seek to remedy this situation: the San Francisco Estuary Project's effort to identify Indicators of Estuary Condition, and The Bay Institute's Ecological Scorecard, a prototype suite of indicators for the Bay region. These efforts illustrate the iterative nature of and the challenges and complexity involved in developing compelling and easily understood indicators for the Estuary. Both efforts build on previous indicator identification efforts (i.e., Levy et al. 1996; Young et. al. 1998; Pawley et. al. 2000; Gunther and Jacobson 2002), and existing Bay region monitoring programs (i.e., Interagency Monitoring Program, USGS, Regional Monitoring Program).

The San Francisco Estuary Institute identified a draft set of assessment questions and indicators in collaboration with the Center for Ecosystem Management and The Bay Institute after holding workshops with a wide range of local scientists. The Bay Institute's Scorecard evolved over a three-year period with input from a panel of nationally recognized experts and many local scientists. The Bay Institute developed a conceptual framework and eight indexes composed of 39 indicators to provide a regional view of the Bay's condition. The indicators lists from the two projects are converging, testament to the progress made in developing indicators after numerous such efforts were attempted. We are currently aligning these projects to strengthen the way we evaluate the Bay, to provide a stronger funding base, and to unify the ways in which we describe the Estuary's health.

Discrete examples from the Scorecard show how these indicators can be developed from existing data sources and aggregated into multimetric indexes. The Scorecard used a tiered approach for presenting complex information to the public, managers, decision-makers, and scientists. Each index is supported by an overview of the index and score, a discussion of each of the component indicators, and supporting technical documentation. The unique but simple scoring system captured the attention of the media, policy-makers, and the public. Upon its release in October 2003, a wide array of newspaper and radio stations carried the story, many in front page and prime time spots.

So how is the Bay doing? In general, the Scorecard indexes provide a picture of regional ecosystem health that has declined dramatically over the long-term data record; however, recent trends are stable for most indexes and in limited cases, somewhat improving. For habitat and shellfish populations, there have been small but noticeable improvements. Although progress is slow, we have been acquiring a significant amount of habitat for wetland preservation and restoration; recent numbers are up for the Dungeness crab (the well-known symbol of San Francisco's Fishermen's Wharf); and several new protections designed to improve water quality have been adopted.

The Freshwater Inflow Index chronicles the increasing amounts of fresh water that have been diverted from the Bay since the 1940s: In 2002, fully half of all the water that would have flowed into the Bay naturally was used for irrigated agriculture in the Central Valley or exported to southern and coastal California cities. In 11 of the past 20 years, the Bay received the same amount of water it would typically see in a critically dry year, meaning that the Bay is experiencing a chronic drought. Many Bay fish depend on healthy inflows of freshwater during the spring—the near collapse of several species (e.g, longfin smelt), documented by the Bay Fish Index, coincided with record diversions of freshwater from the Bay during the 1987-1992 drought. Despite several wet years since then, and new inflow protections and restoration efforts tracked by the Stewardship Index, fish populations have not substantially recovered, a testament to both the challenges of the task ahead as well as the as yet limited implementation of habitat and flow restoration programs. There is bound to be a delay in ecosystem response to these improvements; however, newly established protections are already being eroded as new pressures are placed on the Bay's water resources.

Many of the indicators in the Bay Index consistently told us that the upstream portion of the Bay was in the most trouble. This is a critically important part of the Bay's estuary ecosystem, home to many species that are found nowhere else but San Francisco Bay. It is also the part of the Bay most affected by reduced freshwater inflows and, along with the South Bay, the most impacted by pollution from agricultural, industrial, and urban runoff. Of all areas of the Bay, Suisun Bay is the most heavily infested with alien species, both plant and animal. The invasion by the alien clam *Potamocorbula* is centered in Suisun Bay and it is directly related to the collapse of the pelagic food web there.

Also chronicled by the Scorecard are the improvements in water quality that were initiated 30 years ago as a result of the federal Clean Water Act. The open waters of the Bay are substantially cleaner that they were in the 1960s and 1970s. However, water quality standards designed to protect the health of aquatic organisms as well as people are regularly exceeded for several potent toxics, including mercury and PCBs, both of which still enter the Bay in non-point source runoff. Largely because of these two contaminants, most fish caught in the Bay are not safe to eat. More disturbing, improvements in water quality appear to have stalled—neither the Water Quality Index nor the Fishable indicator show any improvement during the past nine years, underscoring the need to make better progress with pollution reduction programs tracked in the Stewardship Index.

The Scorecard Index is now being used in outreach around the Bay. A desired outcome is that the public gain a greater depth of understanding about the complexity of the Estuary and its condition, a heightened awareness of the impacts of individual actions on the Estuary, and a broader understanding of the opportunities and threats that face the ecosystem. The public is clamoring for a concise and easy way to understand the Bay's health. Without this tool and others like it, we are not reaching the people who can help change the way we collectively impact the ecosystem and garner the support that is so urgently needed for programs that improve San Francisco Bay's health.

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SCORECARD: THE STATE OF THE ESTUARY ACCORDING TO THE BAY INSTITUTE

Grade	Indicator	Long-term	Short-term
D+ Score = 32	**Habitat** Bay habitat loss is slowly being reversed, but it could take nearly 200 years to reach the tidal marsh restoration goal.	↓	↑
D Score = 29	**Freshwater Inflow** Reduced inflows are still degrading the Bay ecosystem, and recent gains from wetter years and new standards are being eroded	↓	↓
C Score = 55	**Water Quality** Open waters are cleaner, but standards are not met in parts of the Bay. Toxic sediments and storm runoff are a major problem.	↑	↔
F Score = 10	**Food Web** Plankton levels in the upper Bay have crashed, reducing food sources for fish and birds. Alien species are locally dominant.	↓	↔
B- Score = 63	**Shellfish** Crab and shrimp numbers are increasing, but commercial harvest is still down from previous high levels.	↓	↑
C- Score = 39	**Fish** After a long decline, fish populations are stable at low levels, but some species are still endangered.	↓	↔
D+ Score = 31	**Fishable-Swimmable-Drinkable** Fish are harder to catch, and unsafe to eat. Beach closures are up, drinking water violations are down.	↓	↔
C- Score = 43	**Stewardship** Water conservation, pollution limits, monitoring, and restoration efforts are finally underway, but progress is slow.	↓	↔

REFLECTIONS OF A WRITER AND PHOTOGRAPHER

JOHN HART AND DAVID SANGER

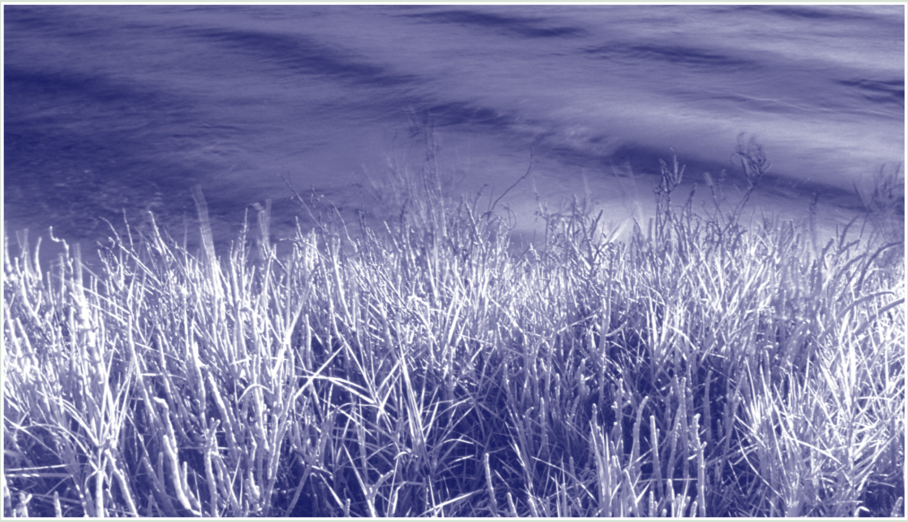

Photo: David Sanger

The water is expanding. After years of controversy about encroachments on the Bay and Delta, we have to ponder the effects of an estuary that is growing in volume and potentially in area. The nineteenth century "Sierra mudwave" is gone. Diked-off lands are subsiding and threatened with flooding. Sea level is rising. Maintaining the land area of the Delta is a challenge. In many places, the deliberate restoration of marginal wetlands only makes a virtue of necessity.

Restoration is a big, big deal. We are struck by the boldness, the promise, and the difficulty of the rehabilitation ("restoration") efforts now proposed. The most dramatic measure, tidal wetland restoration, is well defined but challenging. It will require lots of money, lots of knowledge, lots of mud to rebuild subsided lands, and lots of follow-through attention once begun. Other than wetland enhancement, further steps in restoration seem rather inchoate.

There's a huge amount yet to be learned. Despite years of excellent research, fundamental questions remain open. Are expanded wetlands going to be a major source of nutrients to open water, or not? Can the estuary be healthy on its reduced freshwater budget? What are the effects of the explosive rise of Potamocorbula? As one scientist told us, "The system changes faster than you can publish."

Transportation is the source of many pressures. If container vessels are approaching maximum practical size, channel dredging and port expansion may recedeg as issues. But ships remain polluters and vectors for exotic species. Plans for a bigger, faster ferry system raise hopes but also questions about impact. Most regional airports, not just San Francisco International, are sited on the estuary's margins and face pressure to expand.

Public understanding of the Estuary is growing—but slowly. People and even governments have a way to go in seeing the system as a single, regionally central. Increased contact, as through shoreline parks and ferry service, can help forge connections. Explicit educational efforts remain vital: courses, exhibits, youth programs, publications like our book, treatments in other media, and of course gatherings like the State of the Estuary conference.

John Hart and David Sanger spent three years researching, writing, and photographing the book San Francisco Bay: Portrait of an Estuary, University of California Press; www.sanfranciscobaybook.org.

Photo: David Sanger

MEETING OUR GOALS FOR THE BAY

MICHAEL W. MONROE
U.S. ENVIRONMENTAL PROTECTION AGENCY

The San Francisco Bay Area Wetlands Ecosystem Goals Project report, Baylands Ecosystem Habitat Goals, the culmination of three years' effort by nearly 100 scientists and resource managers, is one of the most widely-used government documents ever read. It recommends the kinds, amounts, and distribution of wetlands and related habitats needed to sustain diverse and healthy communities of fish and wildlife resources in the San Francisco Bay Area. These habitat goals were developed in response to the San Francisco Estuary Project's Comprehensive Conservation and Management Plan and represent several years of work by scientists and resource managers.

The Goals Project's geographic scope included the portion of the San Francisco Bay Estuary downstream of the Sacramento-San Joaquin Delta. Project participants focused their attention on the baylands—the lands within the historical and modern boundaries of the tides—and immediately adjacent areas.

The Goals report calls for restoring more than 60,000 acres of diked baylands to tidal salt marsh. It also stresses the need for other large-scale habitat improvements: managing large areas of shallow saline ponds for shorebirds and waterfowl and restoring and enhancing transitional habitats, riparian forests, and seasonal wetlands. In total, the report calls for improving habitats on more than 100,000 acres in and around the Bay.

Several thousand copies of the Goals report have been distributed, and many public and private entities have embraced the report's recommendations and begun to use them as guidance as they seek to improve habitats. Although the Goals Report includes recommendations ranging from conceptual to quite specific, it provides only the general template upon which additional, much more detailed planning is required for even the smallest of habitat projects.

Last year, as a follow-up to the Goals Project, the resource and regulatory agencies established the San Francisco Bay Area Wetlands Restoration Program. The purpose of that program is to encourage effective implementation of the Goals report recommendations and to improve interagency coordination involving habitat restoration. The Wetlands Restoration Program includes top-level agency managers, senior staff, and technical experts who work to address both policy and technical issues. One of the most exciting sub-groups within the program is the design review group, consisting of scientists and engineers, many of whom were involved in the Goals Project, whose role is to provide technical review and assistance to folks considering habitat projects or who are well into habitat projects. That group sets up review panels, and project sponsors come in and make presentations. The final product is a letter that sets forth concerns and suggestions for improving the projects, and most people have found it very helpful.

Bay Area habitat restoration started several decades ago with a few small projects. Today, projects ranging from a few acres to thousands of acres are being planned or implemented. Their success will depend largely on how well we apply the information in the Goals Report as well as the science presented at this conference.

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CELEBRATING THE CCMP

WILL TRAVIS
SAN FRANCISCO BAY CONSERVATION AND DEVELOPMENT COMMISSION

At this sixth biennial State of the Estuary Conference, we celebrate the tenth anniversary of the CCMP—the Comprehensive Conservation and Management Plan—created by the San Francisco Estuary Project in 1992.

The folks who put the CCMP together renewed the idea of developing public policy by talking with the people who would be impacted by the policies and basing the policies on the best science available at the time. This approach found traction in the 1990s and led to lots of other efforts: the San Francisco Estuary Institute's Regional Monitoring Program, the Bay-Delta Accord, the San Francisco Bay Joint Venture, CALFED, and the Baylands Ecosystems Habitat Goals publications—all based on the principles and approach embodied in the CCMP.

Many of the recommendations and policies in the CCMP are being achieved, not because the promised federal funding has finally come through, but because the people involved in formulating and carrying out the CCMP keep finding ways to advance the Estuary Project goals using whatever resources are available. Perhaps ironically, this has given the CCMP more durability than lots of federal funding would have.

As we look ahead to the next ten years, we can expect the San Francisco Estuary Project to continue to provide us with a forum in which we can address important Bay-Delta issues, ranging from non-point source pollution and watershed management to invasive species and massive wetland restoration projects.

pollutants

"The 1972 federal Clean Water Act called for 'best available treatment' for removing pollutants, and that approach has been largely successful. However, some pollutants are not removed by conventional treatment. There are three ways of dealing with this problem. One is to provide better-than-secondary treatment, typically nitrification and sand filtration. Data indicate that this approach reduces mercury in sewage treatment plant effluents by about 70 percent. A second approach is to seek legal or regulatory action to discontinue use of the offending pollutant. This has been effective for DDT, PCBs, mercury (for most of its former uses), and lead as a fuel additive. A third approach is water reclamation, in which water and the pollutants it contains are applied to plants and soils, where further pollution breakdown can occur without damage to natural waters."

LARRY KOLB
S.F. Bay Regional Water Quality Control Board

In 2002, SFEI identified five different phthalate compounds—polymers used to make plastics more flexible—in the Bay. "We still don't have a clear consensus on how much of a risk they pose."

MIKE CONNER
SFEI

Photo: Norah Rudin

THE LONG-TERM FATE OF PERSISTENT CHEMICALS IN SAN FRANCISCO BAY

JAY DAVIS, ET AL.
SAN FRANCISCO ESTUARY INSTITUTE

Some simple models developed by the San Francisco Estuary Institute (SFEI) over the past few years as part of the Regional Monitoring Program for Trace Substances in the San Francisco Estuary (RMP) can tell us a lot about the long term fate of persistent organic chemicals such as PCBs, PAHs, and legacy pesticides (DDT, chlordane, and dieldrin) in the Estuary. The models are useful in illustrating how choices made today will determine how clean the Bay will be in decades to come. They describe simple mass budgets for each chemical in the Estuary, based on estimates of masses entering the Bay, cycling and degradation within the Bay, and outputs from the Bay. The framework has also been used to provide preliminary assessments of dioxins and the flame retardant polybrominated diphenyl ethers (PBDEs).

Of these chemicals, the degree of contamination is most severe for PCBs, with median concentrations in the key indicator (white croaker muscle tissue) 10 times higher than the threshold for concern. In spite of restrictions on PCB use in place since 1979, concentrations have declined slowly in the past 20 years. Important features of the PCB budget that are thought to be responsible for the slow decline are the resistance of PCBs to degradation, limited pathways for loss from the Bay, and residual loading from erosion and remobilization of contaminated soils and sediments in the watershed. The model predicts that even if all loads could be eliminated, a 90% reduction would take about 70 years to achieve, and that continued loading of 10 to 20 kg per year would significantly delay recovery.

Other chemicals can be compared and contrasted with PCBs. Dioxin contamination is the next most severe, with concentrations in white croaker that are five times higher than the threshold for concern. Dioxins are quite similar to PCBs, with residual loading from the watershed probably comprising a large fraction of inputs, limited degradation, and limited pathways for loss from the Bay. PAH and legacy pesticide concentrations are right at thresholds for concern, so a lesser degree of improvement is needed to address these contaminants. PAH concentrations are remaining constant in the Bay in spite of large continued loadings, primarily due to their relatively high degradation rates. A reduction in PAH loads would quickly translate into reduced concentrations in the Bay. Legacy pesticide concentrations have been falling more rapidly than PCB concentrations in the past few decades, probably due to higher degradation rates. Legacy pesticide concentrations may generally fall below thresholds for concern, even if no action is taken. PBDE concentrations have risen rapidly in recent years. The thresholds for concern and degradation rates for these chemicals have not been established. The partial ban of PBDEs passed by former Governor Davis in August 2003 will help prevent the potential long term problem of PBDE accumulation in the Bay food web.

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CHOICES AND CONSEQUENCES

PCBs	• No action: Recovery in >100 years • Load reductions of 10 kg could have significantbenefit over the long-term
DDT	• No action or localized action may be a viable alternative • Load reductions would yield relatively quick reduction in concentrations
PAHs	• No action: Maintain present concentrations • Load reductions would yield relatively quick reduction in concentrations
PBDEs	• No action: Potentially create a long-term problem • Early detection and load reductions will minimize a potential long term problem

SCIENCE QUESTIONS

• Why are persistent organic pollutants (POPs) still contaminating Estuary fish decades after bans were implemented?

Mass budget models suggest several key factors are responsible:

- Ongoing inputs of POPs: PCBs and legacy pesticides enter the Estuary, as contaminated sediments throughout the Estuary watershed continue to erode. The primary sources of PAHs are continuing emissions from cars and trucks.
- The long residence time of sediments in the Estuary ecosystem: POPs generally become tightly bound to sediment particles in the Estuary. While the waters of the Estuary pass through to the ocean in a matter of months, sediments become trapped in the ecosystem for decades.
- Degradation rates of some POPs are slow (e.g., DDTs) or very slow (e.g., PCBs): These characteristics of the Estuary and POPs highlight the need to prevent the entry of persistent pollutants into the ecosystem.

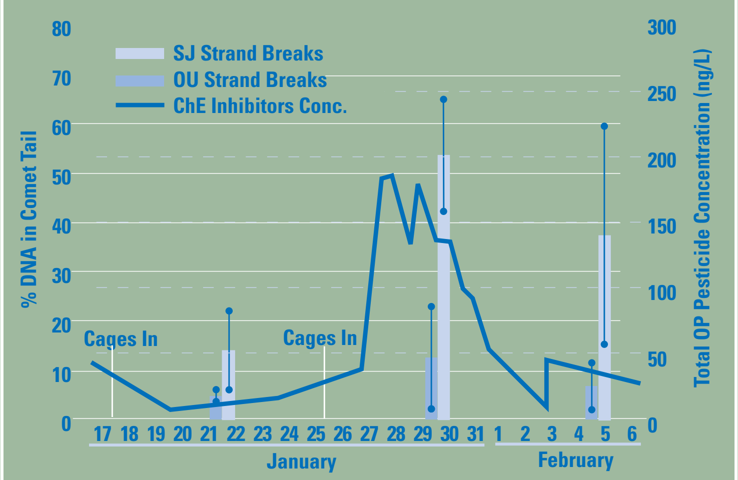
TRACKING PESTICIDE EFFECTS ON NATIVE FISH USING BIOMARKERS

SUSAN ANDERSON, ET AL.
DAVIS BODEGA MARINE LABORATORY

Agricultural pesticides contaminate waters of the Sacramento and San Joaquin watersheds at concentrations toxic to test invertebrates, yet effects on resident native fish species have not been examined in much detail. We performed experiments in the field and lab to test whether pesticide exposures are correlated with genetic biomarker responses in the Sacramento sucker (*Catostomus occidentalis*).

Experiments were timed to coincide with the first rainstorm event after dormant-season application of organophosphate (OP) pesticides to orchards. DNA strand breaks (Comet Assay), acetylcholinesterase (AChE) activities and pesticide concentrations were measured. Data from these experiments indicated that concentrations of dormant season pesticides during 2000 and 2001 were much lower than in previous years and did not induce AchE enzyme inhibition in exposed fish in the field or lab. However, DNA strand breaks were significantly elevated in fish exposed to San Joaquin River water (38.8%, 28.4%, and 53.6% DNA strand breakage in 2000 field, 2000 lab, and 2001 field exposures, respectively) compared to a nearby reference site (15.4%, 8.7%, and 12.6% in 2000 field, 2000 lab, and 2001 field exposures, respectively). DNA strand break induction was not correlated with OP pesticide concentrations. In 2001, the Ames mutagenicity assay was applied to field-collected water and indicated that San Joaquin River water was significantly more mutagenic than the reference site. Further studies should investigate the cause of genotoxicity observed. (Anderson, SOE, 2002)

DNA STRAND BREAKS IN SAN JOAQUIN RIVER SUCKERS



MORE INFO? susanderson@ucdavis.edu

TAKE HOME NOTES

- Since DNA strand breaks did not appear to be correlated with OP pesticide concentrations, we recommend that other genotoxic pesticides be analyzed for, including captan, ziram, carbaryl, malathion, methyl bromide, and trifluralin.

MONITORING WORKS

A. RUSSELL FLEGAL
UNIVERSITY OF CALIFORNIA
SANTA CRUZ

In contrast to many estuaries in the United States, the San Francisco Bay-Delta Estuary has been monitored for trace metal contaminants since 1989. Now performed under the Regional Monitoring program, those systematic measurements have yielded insights on the temporal, as well as spatial, variations of trace metal concentrations throughout the Bay. Initial results showed pronounced seasonal variability in some metal concentrations in the South Bay, associated with temporal gradients in the system's hydraulic regime: metal concentrations increased as flushing rates decreased. Subsequent surveys corroborated that seasonal variability but also highlighted the importance of episodic events on the biogeochemical cycles of metals in the Estuary. For example, floods that release water from the Yolo Bypass markedly alter chromium's concentration and speciation in the Bay. While that seasonal and episodic variability has complicated assessments of longer term variations in metal concentrations in the Estuary, recent studies using stable lead isotopic composition analyses and time series models have provided the first measure of decadal changes in metal contamination in the Estuary. This level of resolution, which is unique to San Francisco Bay, is only possible because of the continuance of the Regional Monitoring Program over the past decade.

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TAKE HOME NOTES

- Our research suggests that the sediment budget for the Estuary is changing. Our best estimates suggest that about 60% of the suspended sediment entering the Estuary annually comes from the Sacramento/San Joaquin River system and the other 40% from the small tributaries draining the nine Bay Area Counties (Marin, Sonoma, Napa, Solano, Contra Costa, Alameda, Santa Clara, San Mateo, San Francisco). This has the following management implications:
- Since sediment is the main vector for transport of Hg, PCBs and OC pesticides, a downward trend in sediment load from the Sacramento/ San Joaquin River system suggests that the contribution of Hg, PCBs and OC pesticide loads derived from the Central Valley may also be decreasing over time.
- A downward trend in sediment load from the Sacramento/ San Joaquin River system suggests that there may be less sediment available for future wetlands restoration projects.
- This shift in our understanding of the proportion of Hg, PCBs and OC pesticide loads derived from each pathway suggests that continued improvements in stormwater quality in urban areas surrounding the Estuary can help improve water quality in the Estuary.

SMALL TRIBUTARY STORMWATER CONTAMINATION OF SAN FRANCISCO BAY

LESTER MCKEE
SAN FRANCISCO ESTUARY INSTITUTE

Small tributaries that flow into San Francisco Bay may be having more of an impact on water quality than previously thought. Recent studies by SFEI and its partners suggest that sediment loads entering the Estuary from the Central Valley are decreasing over time and currently reflect magnitudes estimated for the pre-mining period (circa 1850). Studies also suggest that approximately 40% of total sediment loads to the Estuary (~2 Mt) comes from local urbanized and agricultural watersheds that comprise less than 5% of the total watershed area and provide only 4% of the annual average runoff that enters the Estuary.

Stormwater runoff has been identified as a significant source of pollution to San Francisco Bay, and new TMDLs are likely to call for substantial, quantifiable reductions in these loads. Contaminants of current TMDL focus, such as mercury (Hg), polychlorinated biphenyls (PCBs), and organochlorine (OC) pesticides, are transported into the Estuary primarily via suspended particles. An improved understanding of sediment processes in the Estuary and its tributaries provides an important framework for understanding contaminant processes.

Research carried out by SFEI on historical and contemporary sediment transport processes supports the hypothesis that sediment loads from small tributaries may have increased over time. For example, many of the small tributaries that once discharged to slough systems or ended as distributaries in seasonal wetlands now have flood conveyance channels near the Estuary margin that efficiently transmit suspended sediments to the Estuary. Geomorphic studies have shown that changes in land use and management have increased non-point sediment supply to streams. Large-scale hydromodification has caused many streams to incise, increasing sediment transport and reducing access to natural floodplains. We know that annually averaged exports of suspended sediments from Bay Area streams vary spatially by two orders of magnitude, and suspended sediment loads from a single watershed can vary inter-annually by up to four orders of magnitude. Available data also suggest that during about one year in every seven, sediment loads from local tributaries are greater than those from the Central Valley. It appears that the average load of suspended sediment from local tributaries may form an increasingly important contribution to the sediment budget of the Estuary.

SFEI, in conjunction with the Regional Monitoring Program and the Clean Estuary Partnership, is conduct-

SCIENCE QUESTIONS

- Is there a trend in the sediment loads entering the Estuary from the small tributaries within the nine Bay Area counties?
- Are the PCB data collected in the Guadalupe River watershed indicative of other urban watersheds in the Bay Area?
- Are concentrations of Hg in stormwater in the urbanized drainages of the Bay Area typical of other urban areas in the U.S. or does mercury in rocks and soils of the Coast Ranges naturally elevate mercury concentrations and loadings?
- Is the trend of decreasing sediment loads from the Central Valley responsible for the observed erosion in some areas of San Francisco Bay?
- What influence does the Yolo Bypass have on annual mercury loadings from the Central Valley into the Estuary?

ing studies on sediment and contaminant loading at the confluence of the Sacramento and San Joaquin Rivers (Hg, PCBs, OC pesticides and polyaromatic hydrocarbons (PAHs)) and on the lower Guadalupe River (Hg, other trace metals, PCBs, and OC pesticides). Preliminary results suggest that previous Hg load estimates from the Central Valley were over-estimated by a factor of 2 to 3 and loads of Hg from the Guadalupe River were underestimated by a factor of 2. It now appears that the loads of Hg from local tributaries are at least equal, if not greater, in magnitude than those coming from the Central Valley. Preliminary results on PCBs suggest that local tributaries may supply a significant portion of the external inputs to the Estuary, perhaps about equal to the Central Valley loads.

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THE BIG MUDDY

MIKE CONNER
EXECUTIVE DIRECTOR
SAN FRANCISCO ESTUARY INSTITUTE

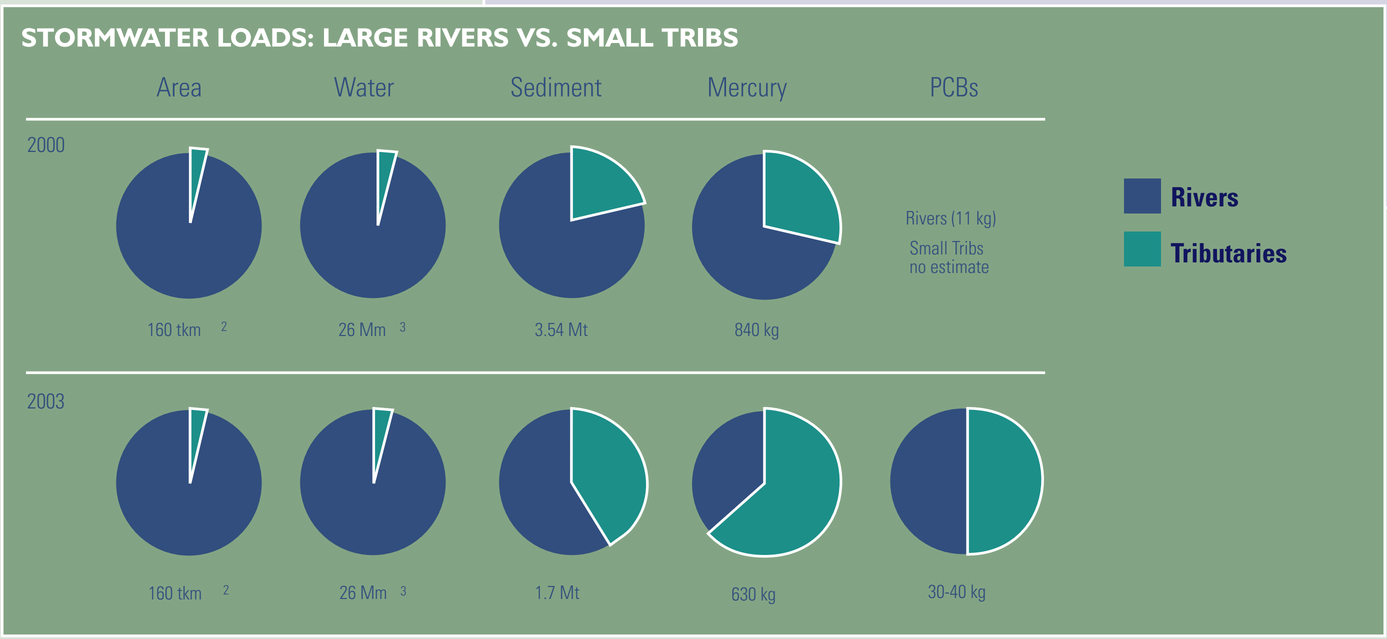
San Francisco Bay is "the Big Muddy;" it's a very muddy estuary; the muds are resuspended with every tide. They absorb most of the contaminants we're worried about; they take them down into the sediments and prevent them from being washed out of the Bay. That's the long-term problem we're dealing with. The question is, instead of dealing with these things contaminant by contaminant, should we start thinking about a sediment strategy for the Bay? That also figures into restoration issues—do we have enough sediment for restoration?

Six obvious questions to ask are

- What are the contaminants of concern?
- What problems are they causing?
- How can we control them?
- Are our control methods working?
- Are we focusing on the right issues, and what else could we be doing?
- If you make the Bay safe for people, are you going to make it safe for everything else?

Bigger policy questions that need to be debated and discussed include

- How much energy do we want to spend on legacy pollutants versus emerging contaminants like the brominated flame retardants—where will we get the most bang for our buck?



This chart compares source and magnitude of water, suspended sediment, mercury, and PCBs entering the Bay from the Central Valley (Sacramento and San Joaquin Rivers) and small local tributaries (entering the Bay from the nine Bay Area counties). Over the past three years, San Francisco Estuary Institute and its partners have carried out a number of desktop evaluations, literature reviews, and empirical field studies. The results of these efforts have changed our understanding of the sediment budget of the Bay, the average loads of contaminants entering the Bay annually, the variation of sediment and contaminant loads entering the Bay between years, and the relative proportion of sediment and contaminants entering the Bay from a variety of pathways. Management measures designed to improve water quality of the Bay will need to be adaptive as new empirical data continues to improve our understanding of Bay processes.

STORMWATER CONTAMINATION: SIMPLE THINGS THAT WORK

KEITH H. LICHTEN
SAN FRANCISCO BAY REGIONAL WATER QUALITY CONTROL BOARD

Revised stormwater permits requiring municipalities and developers to clean up pollutants in urban runoff from new development and significant redevelopment projects have caused concern and confusion. What exactly is required, and how can those requirements be incorporated into project designs? Is it possible to build controls that really work into projects, and can they be maintained? In fact, a wide variety of practices and controls can be incorporated into projects at a reasonable cost. Such measures can reduce urban runoff pollution while increasing property values, reducing downstream erosion and costs to taxpayers for flood control maintenance, and creating attractive public spaces.

Congress created the National Pollutant Discharge Elimination System (NPDES) Program in 1970 as part of the federal Clean Water Act, to reach the goal of making the nation's waters fishable, swimmable, and drinkable. In the 1970s, NPDES did substantially reduce pollution from "big pipe" dischargers, such as wastewater treatment plants, refineries, and large manufacturing plants. However, the nation's waters remained significantly impaired by non-point source pollutants, including those in urban stormwater runoff, one of the most significant remaining single sources of pollutant loading to waters. As a result, in 1987, Congress expanded the NPDES permit program to include urban stormwater runoff. In the Bay Area, each large municipality is covered by an NPDES stormwater permit that requires the municipality to act to reduce pollutants to the maximum extent practicable.

Examples of actions include stenciling storm drain inlets with "No Dumping – Drains to Bay" messages, sweeping streets on a regular basis, and inspecting industrial and commercial facilities. Federal law also recognizes that new development and significant re-development projects are significant sources of pollutants. Over the last two years, existing municipal NPDES storm water permit performance standards for new and re-development projects in the Bay Area and the state have been significantly revised.

Examples of simple measures that can help meet NPDES requirements include trash enclosures, water quality ponds, vegetated swales, bioretention areas, skinny streets, and more. Geographical examples can be found from the Bay Area to the Pacific Northwest, Washington D.C., and Europe. Frederick Law Olmsted's 1879 Back Bay Fens in Boston provide an excellent example of how elegant engineering and landscape architecture can be used to achieve multiple goals, including improving water quality.

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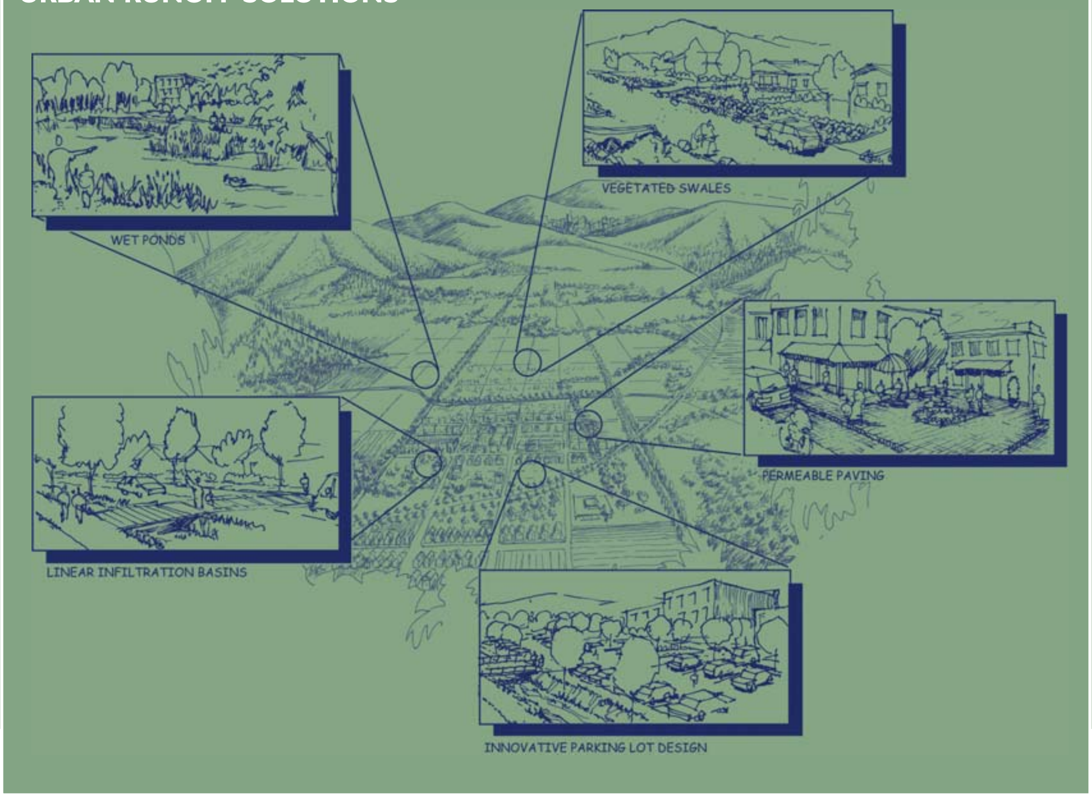
www.scvurppp.org
www.cabmphandbooks.org

TAKE HOME NOTES

- New development and significant redevelopment projects must now clearly incorporate a combination of :
  - Source controls to prevent the discharge of pollutants;
  - Design measures to reduce the amount of directly connected impervious surface; and,
  - Treatment controls to remove pollutants from runoff prior to discharge to receiving waters.

URBAN RUNOFF SOLUTIONS



TMDLS: WATER QUALITY SOLUTIONS FOR THE BAY

DYAN C. WHYTE
S.F. BAY REGIONAL WATER QUALITY CONTROL BOARD

The S.F. Bay Regional Water Quality Control Board (Board) is committed to using a collaborative approach to develop scientifically sound and effective Total Maximum Daily Loads (TMDLs) to restore and protect the beneficial uses of San Francisco Bay. San Francisco Bay is listed as impaired by mercury, PCBs, pesticide toxicity, legacy pesticides (i.e., DDT), selenium, dioxins/furans, and exotic species. TMDLs for these pollutants will identify sources, define how much of a pollutant the Bay can assimilate, allocate responsibility for reducing pollutant loads, and include reasonable and feasible implementation plans.

Through cooperative efforts such as the Clean Estuary Partnership, the San Francisco Bay Regional Monitoring Program, and local stakeholder groups, our collective challenge is to develop implementation plans that result in tangible water quality benefits. Adaptive implementation plans can address concerns regarding limitations in our knowledge of pollutant fate, transport, and effects, while promoting immediate actions to remedy the problem. Adaptive management is founded on the premise that implementing actions and observing the Bay's response will provide the dual optimum benefit of defining source control effectiveness and improving our understanding of the Bay.

In order to be truly adaptive, TMDL implementation plans should include pollutant load reduction actions commensurate with our understanding of the problem; a monitoring program to assess the effectiveness of control actions and progress towards achieving TMDL targets; a list of outstanding management questions and a framework for addressing such questions; and a clearly defined process for reviewing and modifying the TMDL.

Successful TMDL implementation will require continuous dialogue and trust, both in the process and amongst stakeholders and regulators.

The Board will soon consider adopting a mercury TMDL for San Francisco Bay, which we hope will exemplify how one of San Francisco Bay's most challenging water quality problems was jointly solved using adaptive management.

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TAKE HOME NOTES

- Urban runoff pollutant loads are a significant concern. Additional work is needed to determine how to effectively and efficiently remove (or prevent pollutants from entering) urban stormwater runoff.
- While we need to reduce mercury loads to the Bay, studies are urgently needed to determine how we can minimize methyl mercury production in both newly constructed and existing wetlands.
- If control measures are put in place now, it will still take the Bay over 100 years to recover from past discharges of PCBs and mercury.
- Prevention is still the best approach and we need to take this lesson to heart when it comes to managing pollutants such as PBDEs.

DEFINING THE DESIRED CONDITION OF A WATERBODY BY REFINING WATER QUALITY STANDARDS

Numeric TMDL targets more directly reflect the condition of the beneficial use.

METHYLMERCURY IN ESTUARINE BIRDS

STEVEN SCHWARZBACH, ET AL.
WESTERN ECOLOGICAL RESEARCH CENTER, USGS BRD
SACRAMENTO FISH AND WILDLIFE OFFICE, USFWS

Because mercury is efficiently transformed to methylmercury in wetland sediments, and methylmercury strongly bioaccumulates in aquatic foodwebs, we speculated that widespread mercury contamination of the Bay/Delta from historic mining in the Coast Range, and the use of a significant fraction of this mined mercury in extracting gold from stream sediments and placer deposits in the Sierra Nevada, could be posing a health threat to piscivorous wildlife.

To assess our hypothesis, we conducted a systematic survey of mercury exposure in aquatic birds in both San Francisco Bay and the Sacramento/San Joaquin Delta, as part of the CalFed mercury project in 2000 and 2001. Avian mercury exposure was documented by sampling 321 eggs from 15 species and analyzing total and methylmercury concentrations in their contents. We found that nearly all the mercury in wild bird eggs was methylmercury.

Significant differences in mercury bioaccumulation were found in species and locations within both the Delta and the Bay. Slough channel order appears to influence methyl mercury concentrations, with greater methylation taking place in primary—or smaller, more dendritic—channels. Mercury concentrations among all eggs assessed varied by two orders of magnitude, from less than 0.02 to 3.33 ppm on a fresh wet weight basis. The lowest concentrations were found in the eggs of California and western gulls in the Bay. Three species had location means above the currently accepted Lowest Observed Adverse Effect Concentration (LOAEC) of 0.8 ppm in avian eggs. These were Caspian terns, which had location means ranging from 0.7 to 1.2 ppm, Forster's terns, which had location means between 0.5 and 1.63 ppm, and California clapper rails, which had a mean of 0.82. The highest tern egg mercury came from South Bay locations. Two other species, the snowy plover and black-necked stilt, had a location mean concentration just below 0.5, but some had eggs between 0.5 and 0.8.

A companion study by Dr. Gary Heinz of USGS's Patuxent Wildlife Research Center using egg injection techniques seemed to indicate the cormorant is less sensitive than the mallard, the species upon which the LOAEC is based, so the threshold exceedance in this species at Suisun Bay in 2000 was probably not indicative of a mercury problem for cormorant hatchability. The Heinz work also indicated that clapper rails were likely much more sensitive than the mallard, and that therefore, even concentrations below the 0.8 mallard number could still be toxicologically significant. We concluded that mercury concentrations found in clapper rail eggs that failed to hatch from Wildcat Marsh were likely embryotoxic. Hatchability of clapper rail eggs has been demonstrated to be below normal in previous studies in both the South and North Bay. The sensitivity of clapper rail embryos to methylmercury, their elevated exposures to methylmercury resulting from their tidal wetland foraging patterns along the edges of primary sloughs, and their endangered population status may make them the avian species most vulnerable to methylmercury contamination in the Bay Delta system.

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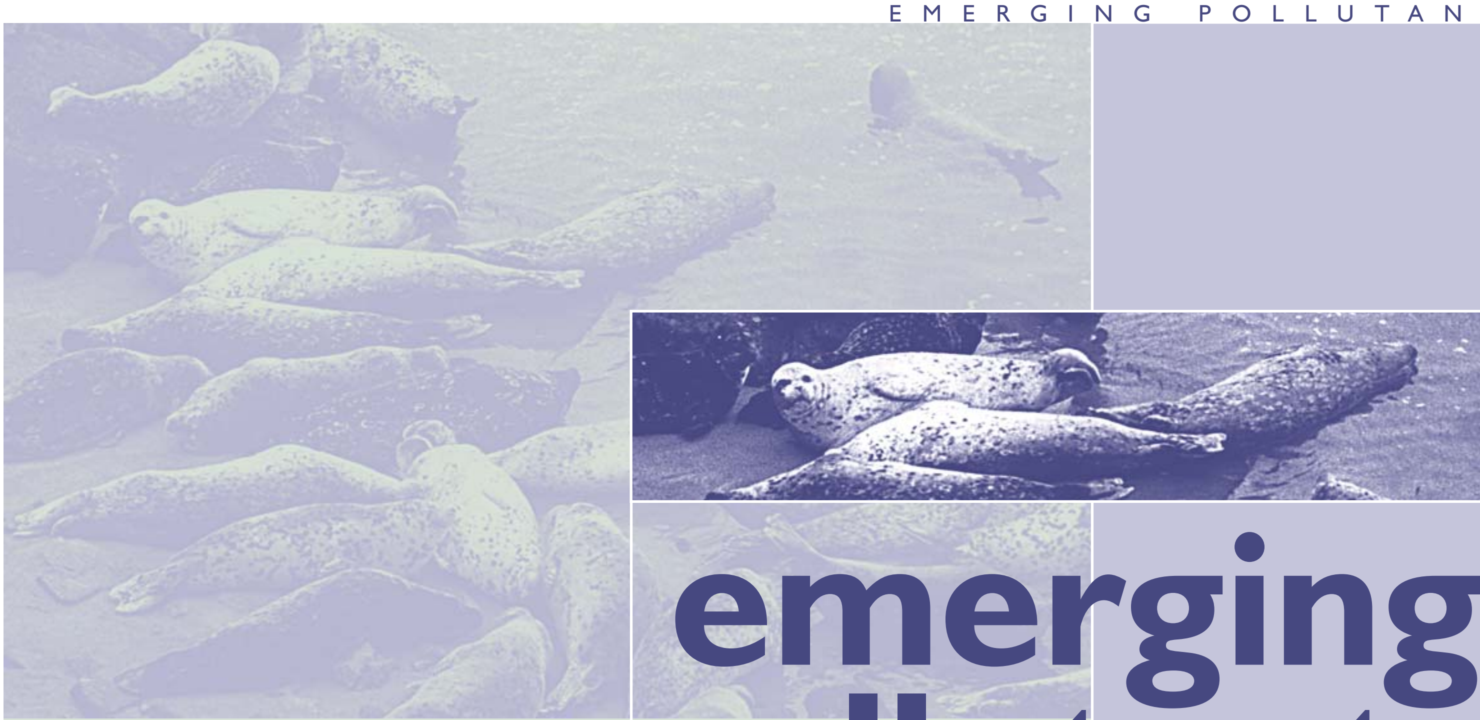
SCIENCE QUESTIONS

- Is bioaccumulation of mercury having reproductive effects on other species, such as terns?
- Does methylmercury affect migratory birds?
- What is the effect of elevated mercury levels in the livers of diving ducks?
- Do other non-fish-eating species have mercury-induced problems?
- What dietary pathways lead to the greatest risk of bioaccumulating mercury?
- Will wetland restoration increase or decrease mercury levels? Do the benefits of restoration outweigh the problems?

TAKE HOME NOTES

- Mercury does occur at potentially embryotoxic concentrations in some species of aquatic birds within the Bay/Delta ecosystem, but concentrations were highly variable (0.02 to 3.33 ppm on a fresh wet weight basis) and dependent upon species foraging patterns and geographic location of nests.
- In the Delta, great blue herons nesting along the Sacramento River had higher mercury concentrations than great blue herons nesting along the San Joaquin River, and mercury concentrations in eggs of herons were correlated with mercury concentrations in silversides, a common prey fish found throughout the Delta.
- The highest mercury concentrations in bird eggs were found in birds nesting in the Bay rather than the Delta. Birds foraging in the margins of the Bay generally had greater mercury bioaccumulation risk than did birds foraging at similar trophic levels in the Central Bay. Terns, for example, have greater egg mercury concentrations than double-crested cormorants.

INTERTIDAL MARSH STRUCTURE
PRIMARY SLOUGHS ARE SMALLEST



emerging pollutants

"Concentrations of polybrominated diphenol ethers (PBDEs) in fish, marine mammals, and people from the San Francisco Bay region are among the highest in the world.

Five years ago, I had never heard of this class of compounds nor had most of the folks at my agency. In five years, they have gone from being completely off the radar screen of most U.S. environmental scientists until the point that in 2003 the State of California signed legislation to ban them."

TOM MCDONALD
OFFICE OF ENVIRONMENTAL HEALTH HAZARD ASSESSMENT
CALIFORNIA ENVIRONMENTAL PROTECTION AGENCY

TAKE HOME NOTES

- PBDEs are persistent and bioaccumulative toxicants, whose levels are increasing in humans and biota in North America.
- Children's health is our greatest concern, since early exposure to PBDEs results in altered development of the brain and reproductive organs in animals.
- The current margin of safety is low: tissue concentrations in some U.S. residents are approaching tissue levels in animals associated with developmental effects.
- PBDEs and PCBs, of which we are all co-exposed, may work together to alter development of the brain and reproductive organs.

SCIENCE QUESTIONS

- Now that the bioaccumulative forms of PBDEs have been banned, how long will it take for tissue levels in the U.S. to start to decline? That is, how long of a lag time is there between the use of a persistent, bioaccumulative chemical and when it reaches the top of the food chain?
- Risk estimates from PCB exposures are usually based on the cancer endpoint, since it is thought to be the most sensitive toxic endpoint. Some regulatory programs currently regulate PCB exposure based only on the PCB congeners that behave like dioxin, using their "dioxin-like equivalents" to predict risk. However, many ortho-substituted (non-dioxin-like) PCBs, which are present by far in the greatest concentrations in fish and people, are neurotoxic to the developing organism. PBDEs also harm the growing brain, and recent data indicate that some PCBs and PBDEs work additively to alter brain development in mice. Some recent estimates of the risk of neurodevelopmental effects from PCBs are very close to the risk estimates derived for cancer effects. With the high (and increasing) levels of PBDEs in people, will developmental health effects (from co-exposures to PCBs and PBDEs) become the most sensitive endpoint for regulatory control of these pollutants?

THE RISK POSED BY FLAME RETARDANTS

THOMAS A. MCDONALD
CALIFORNIA ENVIRONMENTAL PROTECTION AGENCY

Concentrations of polybrominated diphenol ethers (PBDEs) in fish, marine mammals, and people from the San Francisco Bay region are among the highest in the world, and these levels appear to be increasing each year. Approximately 75 million pounds of PBDEs are used each year in the U.S., added as flame retardants to plastics in computers, televisions, appliances, building materials, and vehicle parts, and to foams used in furniture. PBDEs migrate out of these products and into the environment, where they bioaccumulate. PBDEs are now ubiquitous in the environment and have been measured in indoor and outdoor air, house dust, food, streams and lakes, terrestrial and aquatic biota, and human body tissues. Although not well understood, the primary sources of exposure appear to stem from ingestion of foods, especially fish and breastmilk, and possibly from inhalation of dust containing PBDEs in homes and offices.

California and the European Union have banned two of the three commercial mixtures of the PBDEs, and firms in Japan have voluntarily stopped using PBDEs.

Based on multiple studies in animals, the greatest health problems associated with human environmental exposure to PBDEs are disruption of thyroid hormones and harm to the developing brain. PBDE levels in people are approaching the levels in animals that have been shown to cause adverse effects on learning, memory, and behavior. New research suggests that PBDEs and PCBs (which are also present in people) may work together to alter learning and behavior following exposure early in life.

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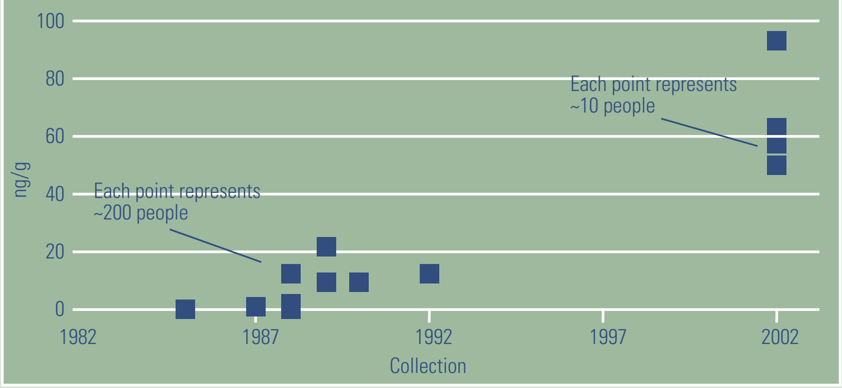
PBDE LEVELS ARE RISING IN U.S. PEOPLE



PBDE levels have been rising in the North American environment as evident by many time-trend studies in fish, birds, and other wildlife. Recently, researchers have also confirmed that PBDE levels in people in the U.S. have increased over time. Sjodin and colleagues from the U.S. Centers for Disease Control (Sjodin et al., 2003, Organohalogen Compounds 61:1-4) took archived serum samples from various regions in the U.S. covering the years 1985 to 2002. For time points before 1992, pooled blood from 9 separate groups of U.S. residents, each representing about 200 individuals per each group, was analyzed. Additionally, serum collected from 5 groups of U.S. residents in 2002, each representing about 10 individuals per group, were analyzed. Seven of the most commonly found PBDE congeners in people and wildlife, as well as a polybrominated biphenyl congener and a polychlorinated biphenyl congener, were assayed using gas chromatography, high-resolution mass spectrometry. This figure shows that total PBDE levels in North Americans have increased substantially over the past 20 years.

HUMAN CANARIES*

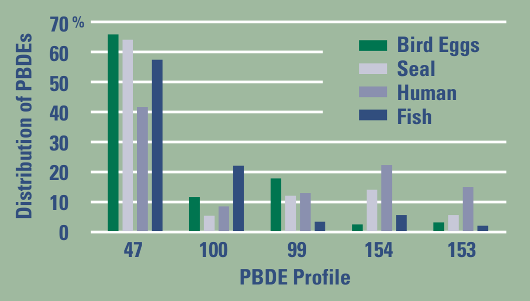
KIM HOOPER
CALIFORNIA ENVIRONMENTAL PROTECTION AGENCY

During the past 25 years, tens of thousands of new chemicals (seven per day) have been introduced into commerce after being evaluated by the U.S. EPA. But few (200-300) of the 85,000 chemicals presently in commerce are regulated, despite the fact that many of them may adversely affect human health and ecosystems such as San Francisco Bay.

The persistent organic pollutants (POPs) are a group of fat-loving, stable, polyhalogenated industrial chemicals (e.g., organochlorine pesticides, PCBs, polychlorinated –dioxins and -furans, and polybrominated diphenyl ethers (PBDEs)) that contaminate the estuaries, sediments, and wildlife of San Francisco Bay. A number of these POPs are neurotoxic to developing organisms, interfering with the normal development of the nervous system in test animals, wildlife, and humans. Unfortunately, the placenta is transparent to these chemicals, so unprotected fetuses receive the same exposures to POPs as their mothers. Consequently, neurotoxic fetal contaminants, such as the POPs, pose significant environmental health hazards to wildlife and humans.

A relatively new group of POP chemicals of concern are the PBDEs, a family of persistent brominated flame retardants whose levels have been increasing exponentially over the past 20 years in humans and biota throughout the world. Levels of PBDEs in humans and wildlife from the San Francisco Bay area are among the highest in the world. The PBDEs, like their structural "cousins," the PCBs, are neurodevelopmental toxicants, and easily pass through the placenta to contaminate the fetus.

PBDE PROFILES IN SF BAY RESIDENTS



POP contaminants in the fetus like PBDEs, can be most easily monitored by measuring levels in samples of the mother's breast milk collected shortly after birth. The concentrations of POPs in breast milk, maternal blood, or cord blood are the same when expressed on a fat-weight basis (e.g., pg POP/g fat) because POP levels equilibrate in the fat of these three compartments. Thus, breast milk provides us with a convenient window into the fetus, through which we can measure chemical levels and identify new chemicals of concern.

The comparative ease and convenience of collecting breast milk is an advantage. Because breast milk can be collected by mothers and communities, these groups can design their studies and have easy access to the lab measurements.

We are using breast milk samples to measure adult and fetal "body burdens" of chemicals in human populations, and to flag chemicals that may impact fetal development and reproductive success in wildlife populations. The health and environmental advantages of breast milk are several: to promote breastfeeding; to monitor "body burdens"; to identify fetal contaminants; to describe family, community, and wildlife exposures; to highlight new chemicals of concern; to permit community-initiated studies; and, in tandem with environmental measurements, to provide information on chemical levels in wildlife and human populations so that local communities can take appropriate actions to reduce their exposures.

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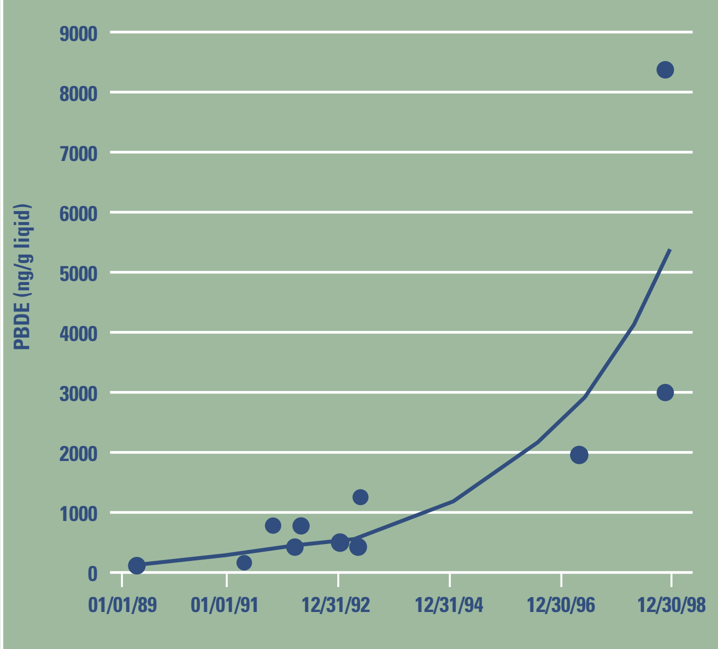
** The views and opinions expressed by the author are not necessarily those of the Department or of Cal/EPA.*

PBDEs IN CALIFORNIA SEAL BLUBBER



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PAHs: A THREAT TO ESTUARINE FISH

TRACY K. COLLIER
NORTHWEST FISHERIES SCIENCE CENTER, NOAA FISHERIES

Research from our laboratories indicates that juvenile and adult fish exposed to PAHs—polycyclic aromatic hydrocarbons—show increased cancer risk, reduced reproductive output, and immune system suppression.

PAHs are environmental contaminants that can be derived from a wide range of human activities, most notably the use of fossil fuels. Levels of PAHs, in contrast to many other contaminants of concern, do not show demonstrable decreases in the past few decades, and in many cases levels of these compounds are increasing in freshwater, estuarine, and marine ecosystems.

Recently, technologies have been developed which allow aquatic toxicologists to conduct sensitive developmental toxicology studies in fish species, and we have been using these methods to address the issue of developmental toxicity of PAHs. Our findings (in studies largely conducted by Drs. John Incardona and Nat Scholz) suggest that PAHs have distinct and specific toxicities in early life history stages of fish. Studies with 3-ring PAHs (phenanthrene and dibenzothiophene) indicate that PAH-induced impairment of cardiac conduction occurs first, with other common developmental defects (such as craniofacial malformation, neural tube alterations, bent spine, and kidney malformation) being secondary to cardiac effects. Our results also show that PAH-exposed fish can exhibit subtle changes in cardiac morphology, which may be associated with reduced fitness. Because estuaries provide important habitat for early life history stages of many fish species, these findings strongly suggest that strategies for reducing inputs of PAHs to estuaries are needed.

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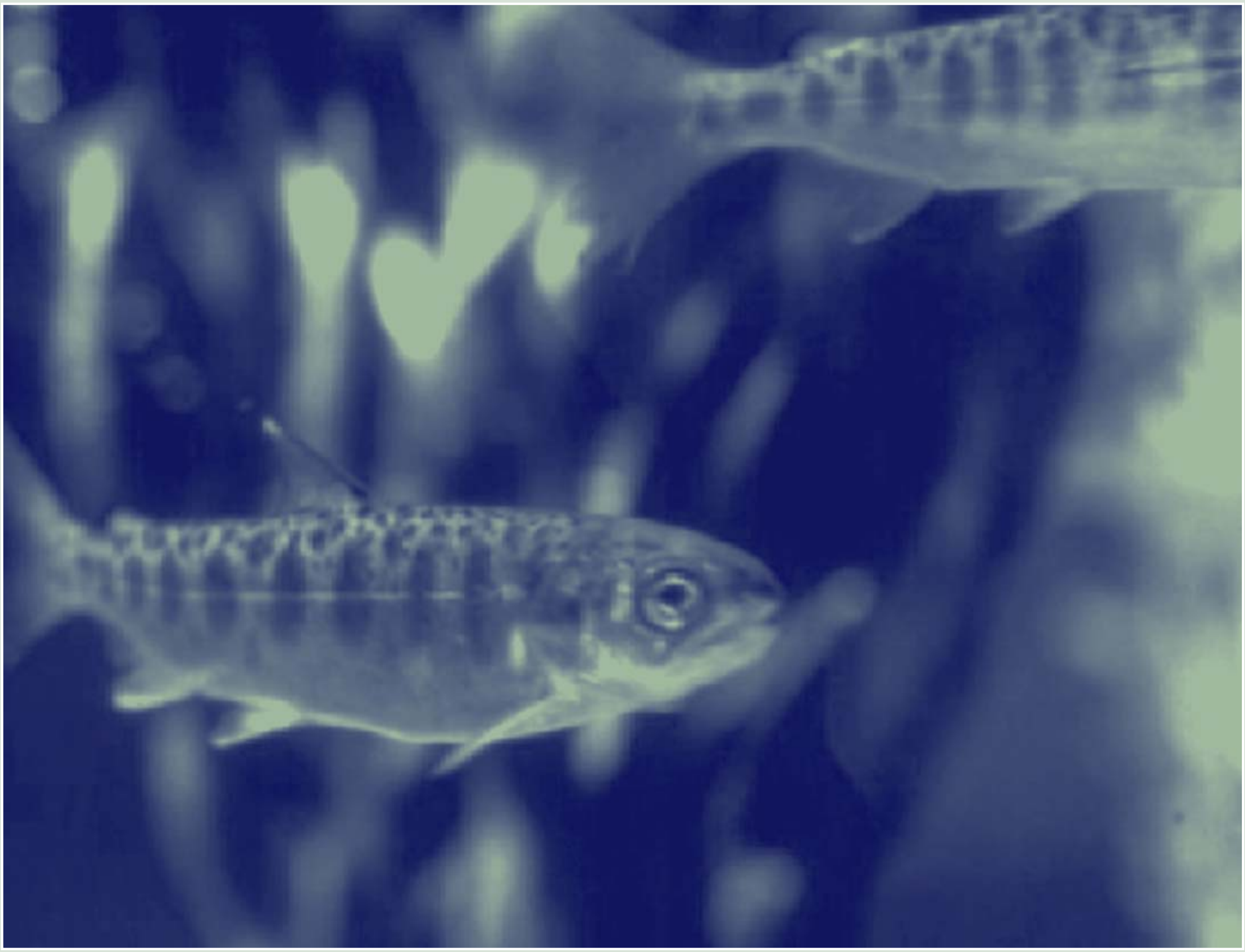


restoring
the estuary

watershed

"We need to act sooner rather than later."

PHIL WILLIAMS
PHILIP WILLIAMS & ASSOCIATES, LTD.

"Don't mess with stuff too much."

DENISE REED
UNIVERSITY OF NEW ORLEANS

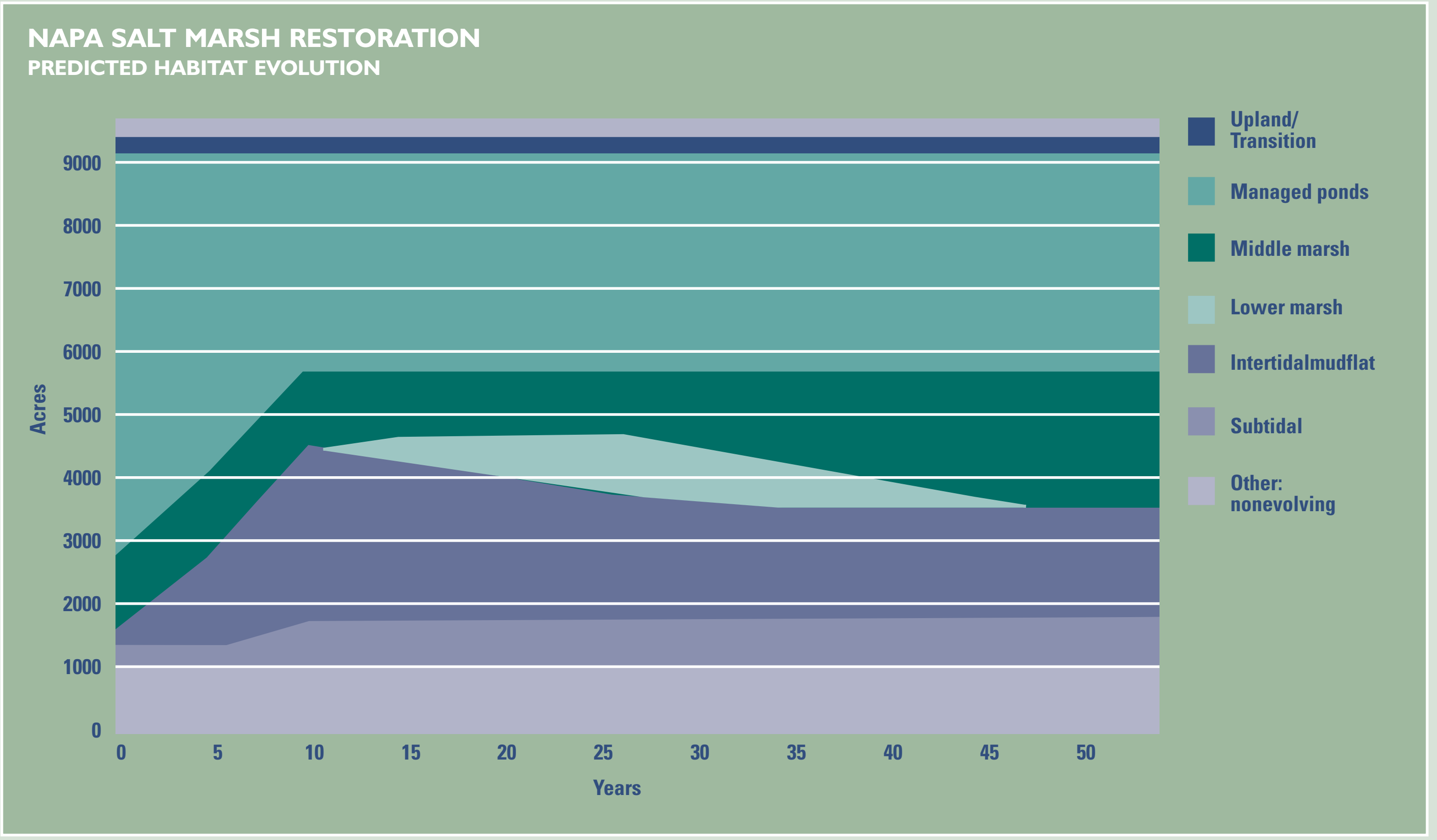
Wildcat Creek, Richmond, CA
Photo: Norah Rudin

FROM THE HILLS TO THE BAY: THE STATE OF RESTORATION

JEFFREY HALTINER
PHILIP WILLIAMS AND ASSOCIATES, LTD.

Restoration of aquatic habitats (tidal and fluvial) in the San Francisco Bay region is now in its fourth decade. During that time, restoration has evolved from the construction of a few small, localized projects with minimal budgets to a major element of many larger land use planning processes, with involvement from numerous agencies, consulting firms, nonprofit organizations, and other stakeholders. Changes have occurred on the following scales:

- Spatial: Early tidal wetland work focused on single locations, while more recent projects have expanded to hundreds of acres. Current projects in the design stage will restore sites of thousands of acres, with the largest projects (in the planning stages) on the order of tens of thousands of acres. While fluvial restoration projects have increased in scope, their spatial scale and complexity are not as extensive as that of tidal systems.
- Temporal: Monitoring programs and success criteria were initially based on site characteristics in the initial three to five years. We now recognize that sites will continue to evolve for decades and longer. Part of the shift to a longer planning horizon is that people are being more realistic in their predictions of site evolution. The types of sites being restored now are more challenging (the easy ones have already been restored), and the more challenging sites may take longer to mature. They include larger or more deeply subsided sites such as Napa and Hamilton. In fluvial systems the time for geomorphic evolution and development of a mature riparian canopy will be even longer than for tidal wetlands.
- Planning: Project goals were initially established on a local basis, guided by a limited group of project stakeholders. The Goals Project provided a regional context for wetland restoration within the zone of Bay influence. A similar level of planning has not been developed for fluvial systems. However, some regional planning is occurring as a result of watershed scale initiatives (particularly for water quality) and also in response to endangered species issues (especially steelhead). Fluvial restoration would benefit from a regional goals project to characterize historic changes and guide types and extent of restoration at the county and landscape scale.



Predicting restored marsh habitats over a multi-decade time scale, as illustrated here for the Napa River Salt Marsh restoration, helps project proponents set realistic expections about the length of time required for habitats to evolve, identify interim habitat benefits/losses, and make decisions about when to implement successive phases of multi-phase projects.

- Regulatory: The regulatory role of various government agencies has played a significant role in shaping some projects, especially those based on mitigation requirements. Initially, the key role was the U.S. Army Corps of Engineers' authority over wetlands under Section 404/Section 10 of the Clean Water Act. More recently, application of endangered species laws has played a major role. The broader authority of the S.F. Bay RWQCB is currently a major influence as well, incorporating water quality considerations through the TMDL process.

Despite our progress in restoring tidal marshes and urban streams, two components of the "hilltop to Bay" ecosystems have been neglected: the upper watershed zones, mostly remaining as agricultural lands, and, at the bottom of the system, intertidal mudflats. Many upper watershed zones have been degraded by 200 years of grazing; often, they include eroding streams that are supplying excessive sediment to downstream systems. Meanwhile, the mudflats fronting the shoreline play a key role in the regional sediment budget, in dissipating energy along the shore, and providing valuable habitat. Acknowledgement of their role and function—and restoration of these areas—has lagged behind that of the more visible tidal marshes. Other habitats that historically occurred more commonly around the Bay have been reduced or eliminated as well, including beaches and salt flats along the east shore, and high groundwater/saturated soils in uplands around the Bay.

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Alkali Heath

TAKE HOME NOTES

- Opportunities to identify, expand, and recreate forgotten and neglected habitats—upper watershed zones, intertidal mudflats, beaches and salt flats, and adjacent uplands—should be pursued.

- The S. F. Bay Habitat Goals project (and other similar documents) provided a regional perspective and guidance for restoring tidal systems. We need a comparable regional streams/watershed goals project. Such a project should include a comprehensive review of historic conditions and functions provided by streams and watersheds in the nine Bay counties, a characterization of existing conditions, and a vision for the future. While the project would not specify detailed goals for very individual channel system, it would identify the types of habitats needed most and where they could be recreated, and would provide examples of successful restoration projects to date. It could also identify specific watersheds most likely to provide suitable opportunities for restoring habitat for special status species (e.g., steelhead).

- Larger scale watershed and stream restoration projects should be pursued concurrent with tidal wetland restoration projects.

- The timeframe for wetland restoration sites to evolve to maturity is longer than we previously anticipated—more on the scale of 50 years, not five, particularly for the types of sites currently being considered for restoration. We need to better estimate the timeframes for the evolution of restored sites.

SCIENCE QUESTION

Restoration "success" must address issues of site evolution, resiliency, and adaptability to future, uncertain ecological conditions. How does the time needed to characterize project success vary between ecosystems?

RIPARIAN RESTORATION AROUND THE BAY

A.L.RILEY
S.F. BAY REGIONAL WATER QUALITY CONTROL BOARD

Stream restoration projects around the Bay range from those that replace environmentally damaging flood control projects with more natural approaches, to rural landowner watershed management projects on rangelands and vineyards, to fisheries restoration in both rural and urban settings, including dam removal projects, to urban stream restoration as part of redevelopment, soil bioengineering/bank stabilization projects, and stream reshaping and revegetation. Programs range from watershed partnerships to watershed assessments to stream and watershed-based hands-on education projects and programs.

There are approximately 40 watershed partnerships in the Bay Area. They include large-scale efforts such the South Bay Watershed Management Initiative, the newly formed San Francisquito Watershed Joint Powers Authority, and the Alameda Creek watershed planning effort that focuses on ensuring water supply, reducing flood damages, and restoring the ecosystem and fishery.

Riparian or stream restoration in the Bay Area began with small, incremental rural fencing and gully repair projects and small urban stream demonstration projects, but has evolved to large projects that restore significant stream systems of up to a mile or more in length. An important change is that credibility is now given to the concept that functional ecological restoration is possible even in difficult, degraded urban or rural environments, as proven by many demonstration projects.

The impact of the streams entering the Bay on the Bay's water quality is being given greater attention. Toxic sediments contributed by Bay streams and their watersheds are now recognized to be responsible for some of the pollutants of greatest concern, including PCBs, mercury, pesticides, selenium, and dioxins. The fact that the status of riparian systems is now a topic at the State of the Estuary conference is indicative of this new focus on streams and their fisheries and water quality recovery.

The first generation of water treatment plants were brick and mortar buildings. The next generation of

EXAMPLES OF STREAM RESTORATION PROJECTS AND PROGRAMS

NEW GENERATION OF FLOOD DAMAGE REDUCTION/ RESTORATION PROJECTS	RURAL LANDOWNER STEWARDSHIP PROJECTS	FISHERIES RESTORATION	HANDS-ON RESTORATION-EDUCATION PROGRAMS
Napa River	Napa Valley Vineyard Association (i.e., the Rutherford Dust Restoration Team)	Lagunitas Creek	STRAW program (The Bay Institute), Sonoma-Marin
San Pedro Creek		Redwood Creek	Aquatic Outreach Institute (now The Watershed Project), East Bay
Pinole Creek	Marin Resource Conservation District: Walker, Stemple, Chileno, and Olema Creek Watersheds	Escoot Creek	CYCLE, Richmond
Alhambra Creek		Stevens Creek	San Francisquito Watershed Council
Wildcat-San Pablo Creeks		Guadelupe Creek	
Rheem Creek		Alameda Creek (migration barriers removal)	
Coyote Creek		Wildcat Creek	
Guadeloupe Creek		Sausal Creek (dam removals)	
San Francisquito Creek		San Francisquito Creek	
		Fishnet 4-C (coastal counties)	

water treatment plants will be the riparian systems restored along our waterways.

The sun has set on the era of using concrete and riprap to control streams and rivers and risen on a new paradigm that values balanced but dynamic ecosystems. The other profound trend is the proliferation of watershed partnerships and councils that use interdisciplinary approaches to solving watershed issues and increase the transparency of government agency work and citizen participation. The newly formed, statewide "California Watershed Council" has taken its cue from the locally based watershed partnership movement.

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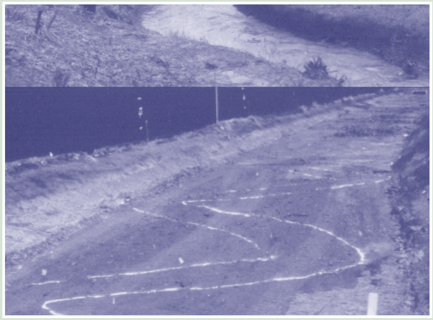
A Primer on Stream and River Protection for the Regulator and Program Manager.

www.swrcb.ca.gov/rwqcb2/Agenda/04-16-03/Stream%20Protection%20 circular.pdf



Village Creek at University Village in Berkeley/Albany: before daylighting (top); just after (bottom), and a few years later: a functioning riparian system in an urban setting (facing page). Photos: A.L. Riley.

Arroyo willow, typically used in urban stream restoration projects

TAKE HOME NOTES

- Information about the status of riparian ecosystems and planning and restoration activities is lacking.
- There is a crisis in restoration expertise. The professional restoration community is too small to meet the demand, and has not organized itself to address its needs for watershed data, research, monitoring, and education. There is a dearth of apprenticeship programs, which is the way restoration skills are attained.
- The restoration community also needs a way to formalize sharing experiences because restoration is an evolving practice. One conference speaker decried the wide range of restoration methods being practiced, but this can be viewed instead as a strength. One advancement being made is a move away from relying on overly simplistic hydraulic modeling tools and a move toward using a tool chest with a large assortment of design tools that can be combined differently in different environments.
- Watershed assessments are being given great attention, but they do not always meet the needs of the restoration profession. There is a split between those who study watersheds and those who actually practice restoration. A separate community of people generally present themselves to do assessments, and it is not uncommon for watershed restoration practitioners to have to perform different kinds of inventories and assessments in order to successfully address the problems that watershed councils want to have addressed. On the other hand, some restorationists act before they have acquired a reasonable amount of watershed information.

LEARNING FROM THE KLAMATH

JEFFREY MOUNT
U.C. DAVIS

The Klamath Basin is the second largest watershed—12,000 square miles—in California, producing extraordinary amounts of runoff. The Klamath is unique. Unlike the Bay-Delta system, it has no carryover capacity. It's turned upside down. The flat topography is in the upper watershed, where you can't build dams and store water. The steep parts—where all the runoff is—is in the lower watershed, where you have no need to store water. This geography lies at some of the roots of the problems in the Klamath Basin.

What we can learn from the Klamath is that when conflicting mandates come together, you have a crisis. The Klamath project was one of the first supported by the federal Reclamation Act. It drained and reclaimed the lower Klamath and Tule Lake, stored water, reduced flooding, and promoted homesteading, with a guarantee to farmers of water for life, something the Bureau of Reclamation doesn't do anymore. The project supplies irrigation to about 200,000 acres.

Yet long before the Reclamation Act, native tribal trusts were developed, in which the government guaranteed those tribes the right for water for their fish. More recent complications in the Klamath Basin include FERC relicensing, the federal wildlife refuges, and the Endangered Species Act (ESA).

In 2001-2002, reasonable and prudent alternatives (RPAs) were set-up in the Basin to try and recover the lost river and short-nosed sucker. Those alternatives included screening and structures, dam passage facilities, habitat restoration, water quality management, coordination, and higher lake levels. That produced a substantial crisis.

The Klamath has one federally listed and now state-listed salmonid, the coho. The RPAs, which were put forward by NMFS, focused on the main stem of the Klamath River, on improving water quality, temperature being one of the big issues, and called for increased releases from Iron Gate Dam. But both the suckers and the coho needed high lake levels. Then, in the great drought of 2001, the farmers were cut off from their water, and the National Research Council was invited in.

The NRC was asked to evaluate the science behind NMFS' RPAs. Some of theNRC's interim findings:

- Water quality is a major limiting factor for suckers in upper Klamath Lake. The nitrogen-fixing blue green algae that invaded upper Klamath Lake around 50 years ago is the major culprit in the decline of water quality and mass mortality of suckers in the Basin.
- Access to and quality of the spawning grounds is critical for the suckers.
- Reductions in phosphorus from the tributaries are unlikely to improve water quality in Klamath Lake in the near future. More than 60 percent of the phosphorus is from internal loads.
- High summer temperatures downstream of Iron Gate Dam, and lack of quality spawning and rearing habitat are the most significant limiting factor for coho. Coho do not rear in the main stem of the Klamath in the summer. So reoperating Iron Gate Dam to increase releases of water that is already too warm for the coho is unlikely to benefit them during the summer. Coho are spawning and rearing in the cool water tributaries.
- More water out of Iron Gate Dam would produce considerable benefit for the tribal trust species, the chinook salmon and the green sturgeon, which the government is obligated to support. Dams have degraded water quality in this system.
- There is significant competition between hatchery and coho salmon. Hatchery salmon are probably suppressing coho production.
- The Klamath Basin lacks an ecosystem-based approach to monitoring and research projects.

SCIENCE QUESTIONS

- How to save the suckers?

  A dam on Sprague River blocks 90 miles of the river; intakes need to be screened. Resource managers should focus on lake and river spawning areas. Other suggested actions include wetlands restoration, oxygenation trials (not a sustainable approach), and protection of existing populations outside of upper Klamath Lake—viable populations live elsewhere in the Basin. Tule and Lower Klamath Lakes could be re-watered and suckers re-established there, to disperse their genes.
- How to save the coho?

  We do not know enough about interactions between coho and other fish. One idea is to close one of the hatcheries for at least one full life cycle of the coho and evaluate whether coho respond.

  Emphasis must shift away from the main stem into the tributaries and sources of cold water—the most significant limiting factor. That will involve some land-use restrictions.

  Iron Dam, which blocks about 10-15 kilometers of high quality habitat and access to cold water, should be removed, as should Dwinelle Dam. The Trinity River Restoration Program should be completed.

TAKE HOME NOTES

- Single species management is destined to fail.
- Management needs to be adaptive and not predictive.
- Outside peer review works and serves us well.
- The ESA brings parties to the table that do not ordinarily cooperate.

MORE INFO?

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restoring the estuary

wetlands

"Just a decade ago, we were working hard to convince the government that wetlands restoration was worthwhile.

At just three bayshore sites in a little over two years, more than 12,000 people logged 36,000 volunteer hours, removed 20,000 pounds of invasive species and 15,000 pounds of trash, and planted more than 20,000 native plants to enhance 35 acres of wetland habitat."

DAVID LEWIS
SAVE THE BAY

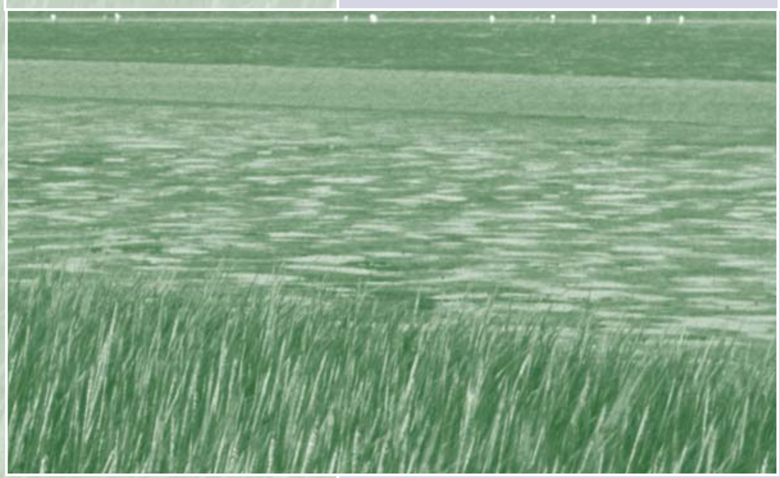


Photo: David Sanger

WETLAND RESTORATION EFFORTS AROUND THE BAY

STUART W. SIEGEL
WETLANDS AND WATER RESOURCES

Wetland restoration has been taking place for decades throughout the San Francisco Estuary—in the South Bay, Central Bay, San Pablo Bay, and Suisun Bay. Early projects were comparatively small and often were mitigation projects. Recent projects are comparatively large and in many cases are agency- and non-profit-sponsored efforts to promote recovery of the Estuary's wetland-dependent fish and wildlife resources.

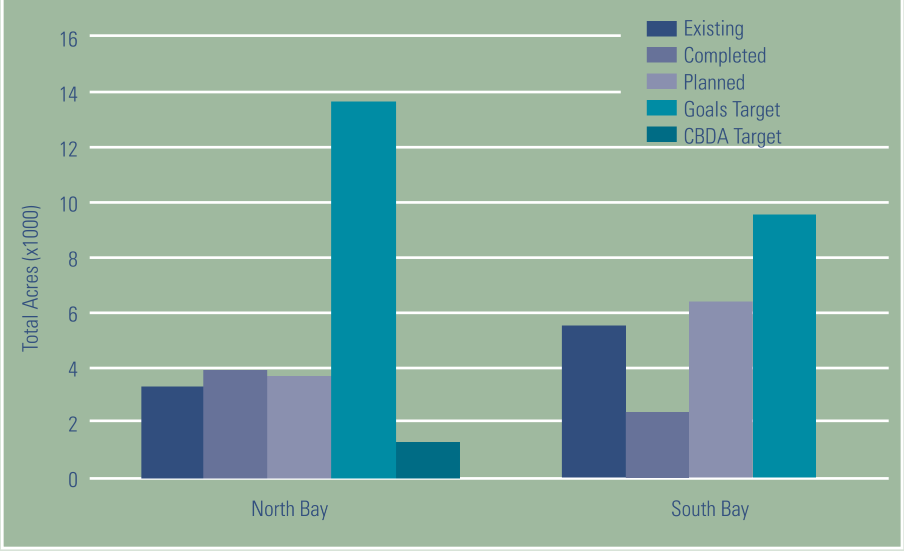
In cooperation with PRBO Conservation Science and the San Francisco Estuary Institute (SFEI), we inventoried completed and pending tidal and non-tidal wetland restoration and enhancement projects within the historic margins of tidal influence throughout most of the Estuary. We did not inventory wetland restoration projects in Suisun Marsh. We mapped projects on the EcoAtlas GIS and prepared a database providing a variety of information on each project. These data are now online at www.wetlandtracker.org, maintained by SFEI. This online resource contains downloadable project information, and the public is encouraged to contribute additional content.

Significant progress has been made since the 2001 State of the Estuary conference. The U.S. Fish and Wildlife Service and the California Department of Fish and Game acquired Cargill salt ponds and related lands (15,000 acres South Bay and 1,400 acres North Bay). The City of San Jose acquired an 850-acre South Bay salt pond. The proposed San Francisco Airport runway expansion plans and wetland mitigations have been put on hold. A proposed Indian gaming casino near Sears Point Raceway has focused attention on approximately 24,000 acres of privately owned North Bay diked baylands that could be restored. The Marin Audubon Society acquired 630 acres that had been slated for development at Bahia. The Department of Water Resources acquired lands in Suisun for restoration. Several projects have been constructed recently.

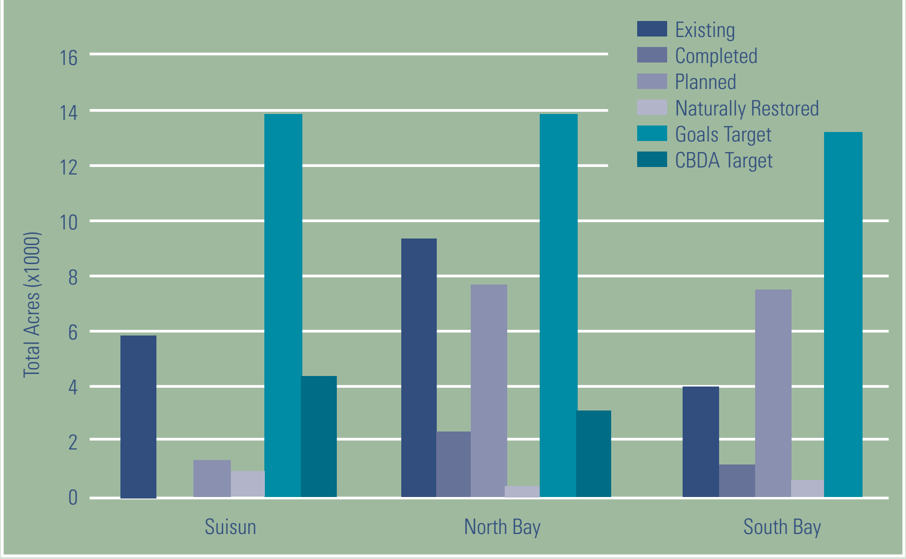
These inventories and maps provide a framework to evaluate the status and effects of regional efforts to manage and restore wetlands to benefit fish and wildlife species. The inventories show the spatial relationship between completed and planned restoration/enhancement projects and existing wetland areas and identify potentially restorable diked baylands, some of which may be subject to development pressures. Uses of these inventories include site selection for regional monitoring efforts and scientific research and identification of parcels for acquisition and restoration.

Planned projects include about 19,000 acres in the North Bay (13,000 acres tidal marsh and 6,000

WETLAND RESTORATION PROGRESS: NON-TIDAL MARSH



WETLAND RESTORATION PROGRESS: TIDAL MARSH



acres non-tidal or mixed hydrology) and 18,000 acres in the South/ Central Bay (breaking down tidal and non-tidal marsh is difficult because salt pond types remain to be determined). Constructed projects include tidal marsh (4,100 acres in the North Bay; 2,700 acres in the South Bay) and non-tidal and mixed-hydrology projects (3,900 acres in the North Bay; 2,100 acres in the South Bay). Acreage summaries for Suisun are not available at this time; the California Bay Delta Program's Ecosystem Restoration Program established a target of restoring 6,800 acres of tidal marsh and enhancing 40,000 to 50,000 acres of seasonal wetland habitat there. The Suisun Marsh Charter Group is preparing a plan for achieving these objectives.

MORE INFO? www.swampthing.org

Warm Springs, which was opened to the tides in 1986, shown here in 1995 and 2002.

Photos: Phyllis Faber

TIDAL RESTORATION IN WEEDY WETLANDS: PAST, PRESENT, AND FUTURE

PETER R. BAYE

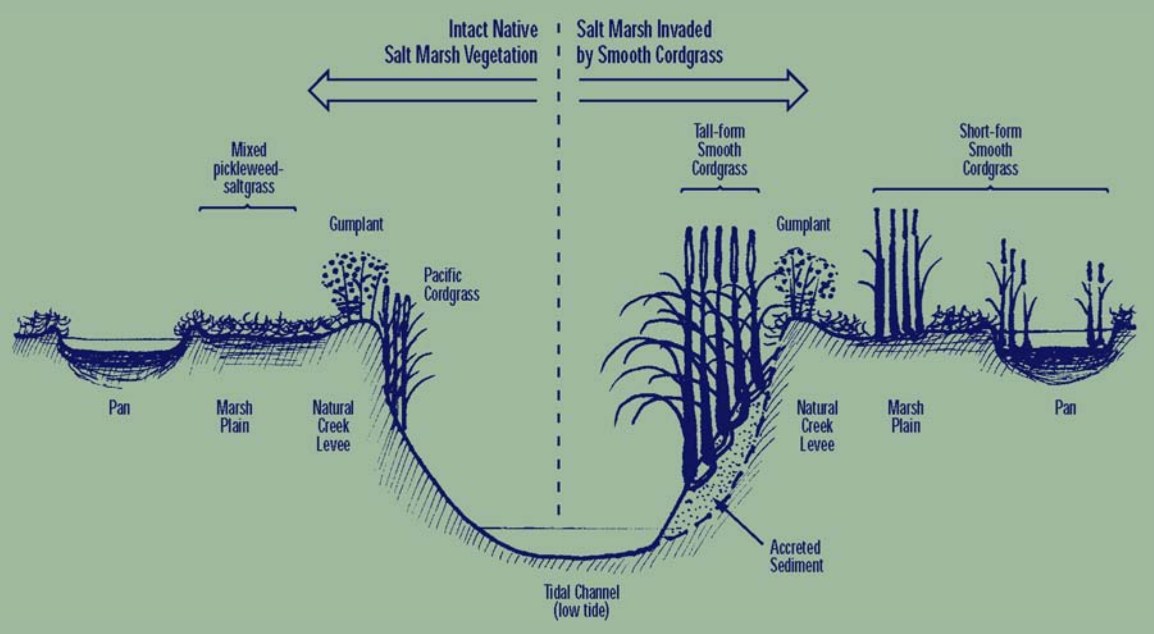
The extensive spread of pepperweed and Atlantic smooth cordgrass hybrids during the 1990s poses a challenge to former tenets of restoration planning in the San Francisco Bay region. Introduced tidal marsh plants have demonstrated their potential to become new, persistent dominant vegetation types in existing and restored tidal marshes across marsh zones historically occupied by native species.

Only a decade ago, discussions of noxious wetland weeds in San Francisco Estuary tidal marshes, such as perennial pepperweed (*Lepidium latifolium*) and Atlantic smooth cordgrass (*Spartina alterniflora*) were marginal or lacking in most in wetland restoration and management plans. At that time, large-scale tidal marsh restoration projects were novel proposals in the region. Until the 1990s, revegetation of salt marshes was presumed to occur by natural dispersal of a few dominant native plant species, following orderly and predictable zonation patterns and successional sequences defined by tidal elevations and marsh accretion. Control of wetland weeds was widely assumed to be feasible by normal monitoring and removal of isolated small infestations. Restoration designs generally did not address conservation of historic patterns of plant diversity, a concern that

SCIENCE QUESTIONS

- Will perennial pepperweed evolve more salt-tolerant ecotypes in San Francisco Bay, increasing its ecological range to salt marshes?
- Can perennial pepperweed colonization be pre-empted by rapid establishment of dense cover by native clonal herbaceous plant species?
- Will sea level rise accelerate the invasion of Atlantic smooth cordgrass hybrids in existing salt marshes or facilitate conversion of pickleweed marsh to cordgrass vegetation?
- Will long-distance dispersal events increase in frequency in the North Bay and Point Reyes as the population size of the Atlantic smooth cordgrass hybrids increases?
- What long-term effects on native Pacific cordgrass will result from introgression of smooth cordgrass hybrids, even if smooth cordgrass phenotypes are effectively eradicated?
- Will hybrid smooth cordgrass undergo succession to pickleweed marsh at threshold elevation ranges typical of Pacific cordgrass, or will it persist as a dominant short-form cordgrass vegetation, as in the native range of its Atlantic parent?
- Will geomorphic structure and tidal drainage patterns typical of smooth cordgrass marshes of the Atlantic and Gulf coasts replace

ATLANTIC VS. PACIFIC CORDGRASS MARSH STRUCTURE



emerged only after invasive non-native marsh plants began to dominate much of the Estuary.

Records show that perennial pepperweed appeared sporadically around the edges of the Estuary in the 1950s. It now dominates extensive areas of high brackish tidal marshes in Suisun Marsh and San Pablo Bay. In the South Bay, perennial pepperweed dominates extensive brackish fringing marshes of sloughs. Effective control techniques for this species in tidal wetlands are still undeveloped. A new regional control program for four invasive nonnative *Spartina* species has recently been implemented, but only as the hybrid swarm of smooth cordgrass proceeds to invasion stages of exponential (or greater) growth.

Smooth cordgrass hybrids have recently invaded high marsh zones in Newark. Saltmeadow cordgrass (*Spartina patens*) has been detected in San Pablo Bay, and has been found to be more widespread in Southhampton Marsh, Benicia, than previously known. Mature colonies of another nonnative colonial grasslike rush (*Juncus sp*., tentatively *J. gerardi*), have been detected in brackish high marsh at Southhampton. No regional control efforts for any other wetland weeds have been initiated.

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Pacific cordgrass

VARIABILITY IN WETLAND RESTORATION

DENISE J. REED
UNIVERSITY OF NEW ORLEANS

Wetland restoration efforts must embrace the natural variability of the estuarine system—daily tides, annual floods, and (less frequently) droughts—to be sustainable.

In the San Francisco Estuary we must consider not only the physical structure and everyday dynamics of restored wetlands but also how they might be influenced by water management decisions. Estuarine wetlands are very resilient to natural variability, but changing that natural variability has consequences for estuarine wetlands and associated biota. There is ample evidence from ecosystems throughout the world that changes in flooding, drought, or other elements of the hydrograph are likely to produce substantial consequences to the ecosystem. While the wetlands themselves may survive, the biological functions they support will change. However, for systems that are this dynamic, diverse, and complex, no methods are available that can define the extent to which natural flow regimes can be changed without causing significant ecosystem changes. Any change to the regime is, in effect, an experiment with, at best, a hypothesized outcome.

As we move forward with restoring the Estuary's wetlands, we need to keep in mind that we have a very complex hydrological dynamic to cope with. Hydrology is the lifeblood of tidal marshes: extremes and disturbances are important. Wetland restoration that depends on levees or structures—and their continued operation and maintenance—to modulate essential estuarine processes is sustainable only with a continued commitment of resources. While such restored lands might be "wet," they are not true estuarine or tidal wetlands and will not be resilient to natural stresses. The biological functions they provide represent a human-maintained disequilibrium. If particular functions are required or expected, lands can be managed for such purposes, but the result should not be considered wetland restoration. In recent years, the creation of engineered microtidal wetlands has been proposed for the Estuary. This approach calls for controlling the fundamental natural dynamics of tidal marshes, and expects that we can anticipate the changing dynamics of the system adequately enough to manipulate them to our advantage. This is not working with nature; this is working against nature. At the same time we have broad restoration goals that point toward a self-sustaining system. There is an inherent disconnect between those two approaches. "Muted" tidal wetlands is a misnomer – they are an artificial ecosystem not driven by the tide but by human management of the tide. We may get a mosaic of diverse habitats, but it is very unlikely that we will get natural self-sustaining systems, and it's also very unlikely that the inherent natural characteristics, the dynamic natural characteristics of an estuary, are going to be provided for.

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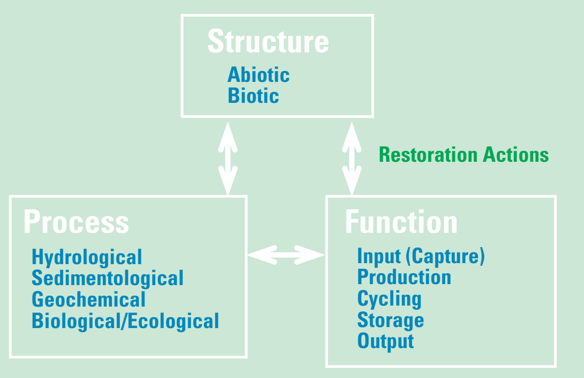
HOW WETLANDS WORK



TAKE HOME NOTES

- The concept of "pulsing" as a vital dynamic in estuarine ecosystems has been recognized for decades. While initial work focused on the role of tidal fluctuations in providing a subsidy to estuarine ecosystems, more recent work has identified energetic forcings occurring over a variety of time and space scales that regulate biological processes and control geomorphic structures.
- Within the San Francisco Estuary, tidal pulsing is superimposed on seasonal and interannual variability in freshwater flows. The geomorphology of the Estuary is still adjusting to the huge pulse of sediment delivered as a result of hydraulic mining activities, and massive alterations to the intertidal system caused by drainage of wetlands and Delta islands. While human actions have altered the system structurally, some elements of freshwater flow variability still exist, albeit much modified, and the inherent tidal nature of the system is still intact.
- We should focus on the variability in the Estuary, the tides and the floods, and think about how they make the system work and how important they are to the Estuary.
- If we want to restore tidal wetlands, we need to keep the daily tidal variability going and allow big flooding events to influence and benefit the Estuary.

MONITORING MARSHES

PHYLLIS M. FABER
PHYLLIS M. FABER & ASSOCIATES

Long-term monitoring is essential for us to gain an understanding of the evolution of tidal salt marshes in San Francisco Bay and to develop realistic expectations for future restoration projects. Three sites around the Bay have been monitored annually since 1986: the Muzzi Marsh in Corte Madera in Marin County; Coyote Creek Lagoon (formerly called Warm Springs) in Fremont in Alameda County; and China Camp in San Rafael in Marin County. A fourth site, Sonoma Baylands, has been monitored annually since 1996. China Camp serves as a control marsh.

A portion of the 200-acre Muzzi Marsh provided a dredge disposal site (70 acres), with overflow containing fines deposited onto the landward portion of the mitigation site (130 acres) for the Larkspur Ferry Terminal. Bayward portions received no spoils. The project was completed, and dikes were breached in 1976.

Coyote Creek Lagoon served both as a sediment supply site as well as a mitigation site for developing an industrial park in Fremont. In 1986, following the excavation of sediment for the industrial site, leaving a massive 200-acre basin, dikes were breached from the lagoon into Coyote Slough and a little later into Mud Slough. The mitigation was predicated on the refilling of the basin by sediment from the sloughs (and subsequent marsh development).

Muzzi Marsh South Channel, 1994
Photo: Phyllis Faber

China Camp provides an excellent control marsh for Bay Area restoration projects as it is one of the very few sites around San Francisco Bay where a healthy tidal salt marsh has its original surrounding watershed intact.

Monitoring included measuring sedimentation rates through annual surveys of the marsh plain, and collecting data on annual patterns of vegetation establishment and species distribution. We found that vegetation establishes itself naturally when the elevations and soils are appropriate. That said, a mature pickleweed marsh takes 30 to 40 years to develop. Because tidal channels enhance the ingress and egress of the tidal prism to more remote parts of a tidal marsh as well as provide habitat to an endangered species, the clapper rail, and species of fish, their evolution is of particular interest.

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Muzzi Marsh South Channel, 2003
Photo: Phyllis Faber

TAKE HOME NOTES

- Getting elevations correct is very important if we are going to use dredge spoils.
- Vegetation establishes naturally making planting wasteful and unnecessary.
- We need to be patient in allowing natural processes to evolve.
- Plants species distribution is sensitive to changes in tidal prism, to elevational and salinity changes, and to seasonal rainfall patterns.
- Simplicity should be a goal in designing monitoring programs to assure long-term success.

SCIENCE QUESTIONS

- What role does long-term monitoring play in adaptive management?
- How do we recognize differences between sites around the Bay?
- Can we develop realistic expectations for future restoration work without long-term monitoring?
- What should be monitored, and where do we start?

MIASMA REVISITED: WILL WETLAND RESTORATION KILL YOU?

KARL MALAMUD-ROAM
CONTRA COSTA MOSQUITO & VECTOR CONTROL DISTRICT

The recent spread of West Nile virus as a threat to humans and wildlife has rekindled old public fears about wetlands and forced wetlands advocates and managers to reevaluate those fears and how best to address them. This year—2004—is going to be tough for California, with West Nile expected to hit hard, budgets being cut, and new regulations—and created wetlands—being put into place. Wetland restoration is possible and compatible with mosquito control, but it has to be done right.

Although wetlands are widely viewed today as important natural resources, they have historically been seen as noxious and dangerous, and it is crucial for wetland advocates and managers to understand the objective risks to public health posed by these landscapes, the public perceptions associated with these risks, and strategies which might reconcile wetland restoration with public health.

Environmental factors have been postulated as causes of human or animal disease since at least the time of Hippocrates, and a specific apparent association between wet vegetated areas and ill health is still reflected in the French term for malaria – paludisme (literally "marsh fever"). "Malaria" ("bad air") was itself introduced into the English medical literature in 1827 as a shorthand for the earlier "paludal poison" and "marsh miasma," terms which illustrate negative attitudes both towards wetlands (the apparent ultimate cause of disease) and foul air (the hypothesized proximal cause).

While "malaria" increasingly was used to describe the symptoms of a specific disease complex, rather than its cause, an ancient term—"miasma"—continued to denote foul or unhealthy air, especially where it smelled of rot, and, more broadly, any polluted or noxious environment. The "miasmic theory of disease" – that air or some matter in it carried disease from rotting matter to victims—was largely discredited by the recognition in the 1880s that cholera was spread by waterborne bacteria, but the words, and the aversion to wetlands, continued.

This dislike was apparently justified some two decades later when Ronald Ross and others finally demonstrated a mechanistic link between wetlands and diseases. Although the link was not a miasmic mist, it was another air-borne disease vector—the mosquito. Following this discovery and the subsequent success of some regional programs to reduce malaria, yellow fever, and other mosquito-borne diseases by reducing mosquito habitats, the old fears of marshes and swamps were widely seen as scientifically justified, and publicly-funded mosquito control, often involving draining wetlands, became widespread by the mid-1920s. During the Great Depression, the imperative to put men to work led to a massive expansion of ditching in the name of mosquito control in the United States, including in many areas where mosquitoes had probably not been prevalent. At the same time, natural resource managers had increasingly begun to demonstrate the significance of wetlands as habitats for migratory waterfowl (other species were recognized, but elicited much less public or regulatory support initially), and mosquito-borne diseases had declined. A tension developed between natural resource management and public health personnel, which continues to the present day.

Perhaps ironically, the development of DDT and other pesticides during World War II initially reduced this tension, as these chemicals allowed mosquito control without drainage and with few immediately apparent environmental impacts. Over the following decades, however, and in particular after Rachel Carson published *Silent Spring*, pesticides themselves became scrutinized by resource managers and the public, leading to the development of more safe and selective pesticides, and to a reevaluation of the role of water and/or vegetation management in mosquito control. These changes, together with the cultivation of working relationships between resource managers and mosquito control personnel, allowed wetlands restoration to take place over the last two decades without an apparent rise in mosquito-borne diseases.

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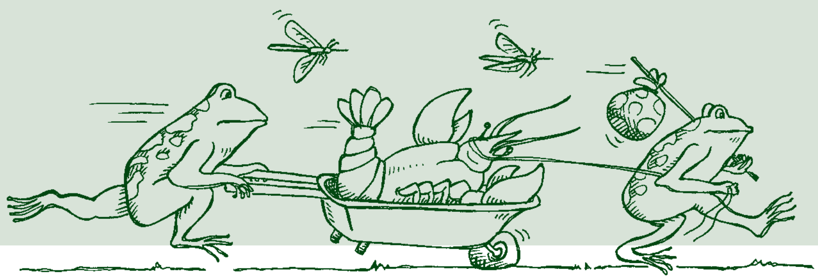
TAKE HOME NOTES

- Some wetlands are more mosquito-prone than others. High-risk wetlands include seasonal wetlands, wetlands with dense vegetation, wetlands without good drainage or operations and maintenance budgets, and lots of small dispersed sites for which it is harder to track down the landowner.
- Good tidal flushing helps prevent mosquitoes.
- Juvenile mosquitoes need three-plus days of standing water in order to reproduce.
- See : www.sfbayjv.org for up-to-date info on West Nile Virus.



Reproduction of an illustration in an 1888 edition of Drainage Journal *showing critters fleeing a drained swamp.* *Lisa Krieshok*

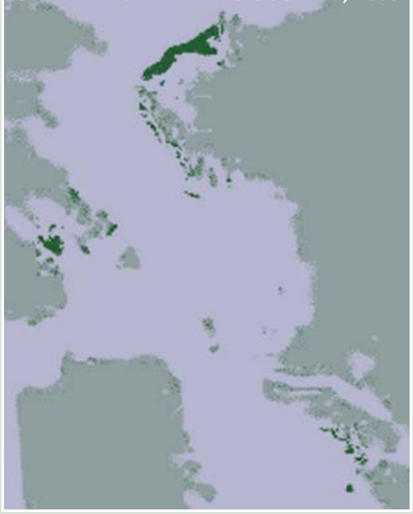
EELGRASS: INVENTORY, CHARACTERIZATION, AND A PREDICTIVE MODEL

KEITH W. MERKEL
MERKEL & ASSOCIATES, INC.

The San Francisco Bay-Delta Estuary is the largest estuarine system on the West Coast of North America, but relative to other major estuaries along the Pacific Coast, it has the lowest coverage per area of eelgrass (*Zostera marina*), a flowering marine plant that provides excellent habitat for other plants and animals. In the late 1920s, eelgrass was reportedly abundant along the shores of San Francisco Bay. However, in 1987, a National Marine Fisheries Service survey indicated that only 0.1 percent of the total Bay bottom supported eelgrass, and that much of the eelgrass was highly stressed. This eelgrass coverage in San Francisco Bay was at least an order of magnitude lower than other bays in California; over 14 percent of the bottom of San Diego Bay is covered with eelgrass, and the bottoms of Mission Bay (San Diego) and Humboldt Bay are covered by approximately 54 and 20 percent, respectively.

Eelgrass occurs in shallow bays and estuaries throughout the world. It creates a unique structural and biological environment, and plays many roles within estuarine systems. Eelgrass clarifies water through sediment trapping and stabilization, transforms nutrients, and oxygenates the water. It is a primary producer in a detritus-based food web and provides physical structure for epiphytic plants and animals, which in turn are grazed upon by other invertebrates, larval and juvenile fish, and birds, contributing to the ecosystem at multiple trophic levels. It also serves as a nursery area for many commercially and recreationally important finfish and shellfish species, including those that are resident within bays and estuaries, as well as for oceanic species that enter estuaries to spawn.

In recent years, resource managers have become more interested in eelgrass in San Francisco Bay, and greater concerns for this habitat type have emerged. Part of this increased attention was a result of the San Francisco Bay Area Wetlands Ecosystem Goals Project, which illuminated the imperiled status of the Bay's eelgrass. In addition, several high profile projects, such as the San Francisco-Oakland Bay Bridge Seismic Safety Project, sought to restore significant eelgrass beds. Given this increased attention, Caltrans, in consultation with NOAA Fisheries, funded a resource management program to document eelgrass bed abundance, distribution, and characteristics in the Bay in order to improve the state of management science and policy for this habitat. Work for this program included surveying the entire Bay for eelgrass, comparing the genetics of eelgrass beds, characterizing physical parameters within eelgrass beds, and creating a predictive model of eelgrass habitat based on physical parameters.



EELGRASS LOCATIONS
CENTRAL SAN FRANCISCO BAY, 2003

Results of the 2003 eelgrass survey indicated that more than 1 percent of San Francisco Bay supports eelgrass, an order of magnitude greater than the amount documented in the late 1980s. In addition to the baseline established by this survey, eelgrass bed characterization through this program has provided a much-needed understanding of eelgrass habitat requirements. These data have been incorporated into a model that can be used to predict potential eelgrass habitat throughout the Bay.

EELGRASS IN WEST COAST ESTUARINE SYSTEMS

SYSTEM COVERAGE	EELGRASS (ACRES)	PERCENT COVERAGE
Mission Bay	1,210	54%
San Diego Bay	1,626	14%
Humboldt Bay	4,821	10%
San Francisco Bay	2,611	1%

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SCIENCE QUESTIONS

- What is the rate of recovery of eelgrass following disturbance?
- What is the genetic relationship of eelgrass populations within the Bay and between other bays and estuaries on the West Coast?
- What is the composition of faunal communities that utilize eelgrass beds in the Bay?

TAKE HOME NOTES

- Access to the Bay allows the public to discover, experience, and appreciate the Bay's natural resources and can foster public support for Bay resource protection, yet studies indicate that public access may have immediate effects on wildlife, including flushing, increased stress, interrupted foraging, or nest abandonment, and may result in adverse long-term population and species effects.
- Because effects on wildlife are site-specific, it is important to accurately characterize site, habitat, wildlife conditions, and human activities.
- Potential adverse effects from public access may be avoided or minimized through appropriate siting, design, and management. The relative advantages and disadvantages of specific strategies depend on the environmental characteristics and the likely human use of the site.
- Providing diverse and satisfying public access opportunities can reduce the creation of informal access routes, which will help decrease interactions between humans and wildlife, trampling and erosion of vegetation, and fragmentation of habitat. Formal public access also provides for more predictable human actions, which may help wildlife adjust to human use.
- The integration of public access early in the project design phase,and an integrated public process will increase the potential for success in balancing public access and wildlife protection.

WILDLIFE AND PUBLIC ACCESS

CAITLIN SWEENEY
SAN FRANCISCO BAY CONSERVATION AND DEVELOPMENT COMMISSION

As more people take part in recreational activities in and around the Bay, and as the shoreline and wildlife habitat shrink as more land is developed, interactions between humans and wildlife are increasing. To address these concerns, the San Francisco Bay Conservation and Development Commission (BCDC) embarked upon an in-depth two-year research and policy development process, the Public Access and Wildlife Compatibility Project, which culminated in the revision of BCDC's San Francisco Bay Plan public access findings and policies. The revised findings and policies better reflect current knowledge about interactions between public access and wildlife, and provide more detailed policy guidance on providing maximum feasible public access while protecting wildlife from significant adverse effects.

SCIENCE QUESTIONS

- What are the effects on wildlife of specific types of human activities at various frequencies and scales?
- Do certain wildlife species become adapted to human interaction, and are there other impacts to wildlife as a result?
- How effective are specific site, design, and management strategies in avoiding or reducing adverse effects of human activities on wildlife?

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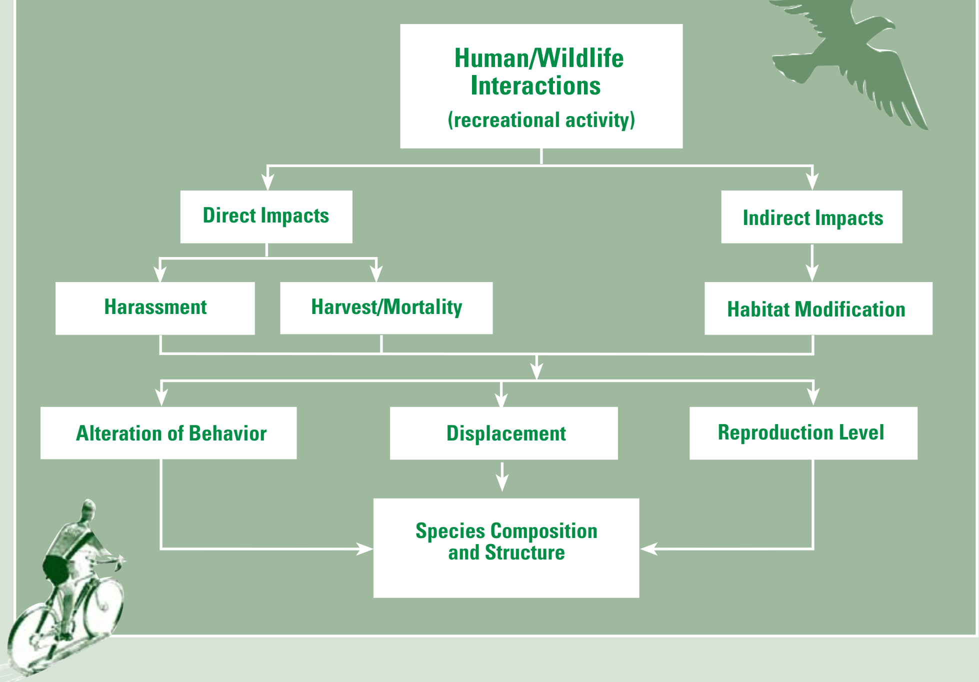
PUBLIC ACCESS: EFFECTS ON WILDLIFE



FUNDING WETLAND RESTORATION

MARC HOLMES
THE BAY INSTITUTE

Many wetland restoration projects ripe for implementation lie idle for lack of funds, despite the fact that numerous sources of funding are available to finance them. Part of the problem is that systematic efforts to fund regional wetland restorations are largely absent. In their place is a system of ad hoc initiatives guided more by opportunity than by plan. This approach fails to capitalize on the additional funding that could be tapped by highlighting the national and international ecological significance of the restoration goals.

One challenge for San Francisco Bay is its lack of a strong identity in Washington, D.C. "Historic diked baylands" doesn't quite compete with the poetic "river of grass" image of the Everglades.

Estuary wetland goals have been partially detailed in the Baylands Ecosystem Habitat Goals Report and in the CALFED Ecosystem Restoration Plan. The establishment of the San Francisco Bay Habitat Joint Venture has enabled novice applicants to find assistance and has encouraged veteran applicants to coordinate their efforts and optimize chances for success, all within the parameters of the existing funding system. These are first steps in raising the importance of restoration goals from the point of view of state, national, and private funding sources. It is not enough, however.

The Joint Venture now should work with state, federal and private partners to develop a restoration funding strategy that enables attainment of restoration goals. To my knowledge, no such strategy has ever been developed. We also need a planned strategy to finance restoration and operations and maintenance, not merely acquisition. The Joint Venture should publish such a plan.

Until a strategy is developed and implemented to fund systematic implementation of wetland restoration goals, funding will remain at inadequate levels and worthy restoration opportunities will be lost. We also need to encourage those who are not part of the known constituency—poets, writers, and photographers like John Hart and David Sanger, for example—to help develop a greater sense of identity for the Bay, and increase funding opportunities to help restore it.

MORE INFO? Holmes@bay.org

Photo: David Sanger

PREDICTING THE FUTURE OF SAN FRANCISCO BAY

PHILIP B. WILLIAMS
PWA LTD, CONSULTANTS IN HYDROLOGY

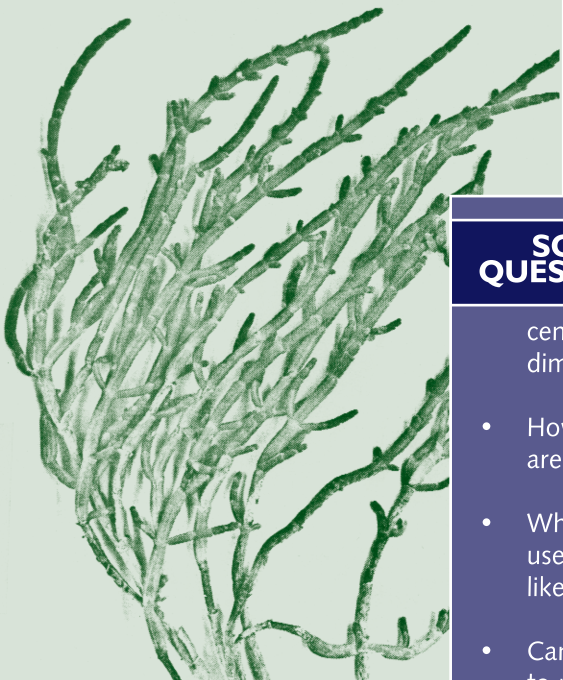
Over the last 150 years we have seen major changes to the size, shape, and habitats of San Francisco Bay. The most dramatic recent changes have been due to human actions—whether hydraulic mining in the Sierra or conversion of tidal marshes to farmland—but we also understand that for the last 10,000 years, the Bay has been changing its shape and character as sea level rose and the Estuary expanded inland.

We can see the Estuary as a single dynamic evolving system, whose shape at any point in time is determined by sedimentary processes responding to sea level rise, sediment inflows from the watershed, the prevailing winds, waves, climate, tidal flows, and the geomorphic legacy of the drowned valley of the pre-historic Sacramento River. The San Francisco Estuary Institute's EcoAtlas provides us with a snapshot of what Bay habitats looked like on this evolutionary path 200 years ago. Human intervention has altered both the estuarine landscape and the sedimentary processes that determine this evolutionary trajectory.

Over the last two decades our understanding of sediment dynamics and how Bay habitats are evolving has significantly improved. For example, USGS research is showing that mudflats are shrinking while long term monitoring is showing how long it takes for restored marshes to become established. With accelerated sea level rise and diminishing sediment delivery, we can anticipate that 50 years from now, Bay morphology and habitats will be significantly different, with smaller mudflats and eroding marshes—even with no further human intervention. Today, we are making decisions about actions such as large-scale habitat restoration, or disposal of dredged sediments, that will affect how the mix of Bay habitats will evolve.

Fortunately, we now have a variety of analytic and empirical tools that can be used together to make projections of how the Estuary's shape will evolve. We can use these to predict the mix of habitats we will see in the future. Constructing this future "snapshot" of Bay habitats in the year 2053 will be a powerful tool for Estuary-wide restoration planning. It will allow us to better assess the future impact of large scale changes such as those proposed for airport runway expansion, inform the design of large restoration projects to ensure we achieve net gains in all types of habitats, and allow us to anticipate likely future changes such as shoreline erosion or deepening tidal channels. The images and maps of past habitats have powerfully influenced our thinking about restoration goals. Equally important is an understanding of what the future Bay will look like.

MORE INFO? p.williams@pwa-ltd.com



Pickleweed

TAKE HOME NOTES

- The Estuary as a geomorphic system is dynamic and evolving, whether or not humans are on its periphery. Inherent, integral erosional and depositional processes determine its physical form and hence its mix of habitats. The young Estuary is still a drowning river valley and has not yet achieved equilibrium between sediment deposition and erosion.
- We are faced with a diminishing sediment supply in the Estuary and accelerated sea level rise. It will be easier to restore vegetated marshes on subsided sites now than if we wait until later. As sea level rises, we risk losing valued mudflats and marshes.
- We now have a better understanding of how to predict future geomorphic and habitat changes. Relying exclusively on numerical models can get in the way of how we think about the Estuary. We need to use empirical or analytical tools as well, based on monitoring of and research on the Bay's restored marshes.
- The challenge is not just to restore individual wetland sites but also to cumulatively manage and restore the Estuary as a whole to make sure we maintain or increase the extent and mix of desired habitats into the next century.

SCIENCE QUESTIONS

- How will the morphology — or shape — of the Estuary change in the next century in response to rising sea level and diminishing sediment supply?
- How will these changes affect the overall area of mudflats and marshes?
- What analytic and empirical tools can we use to predict how the physical Estuary is likely to evolve?
- Can we plan individual restoration projects to provide cumulative net habitat increases at the Estuary scale?

restoring the estuary

salt ponds

"This is the largest single habitat restoration project, the most complicated restoration project ever envisioned for the Estuary."

MIKE MONROE
U.S. EPA

Photo: David Sanger

PLANNING FOR SALT POND RESTORATION

AMY HUTZEL
CALIFORNIA STATE COASTAL CONSERVANCY

Resource managers in the San Francisco Bay face an unprecedented opportunity to meet many of the goals and objectives of the Baylands Ecosystem Habitat Goals Report by restoring large areas of tidal habitats and enhancing the management of former commercial salt ponds for wildlife. In 1994, Cargill ceased production of salt in the North San Francisco Bay and sold 9,850 acres, consisting of twelve evaporator ponds and associated remnant sloughs and fringing marsh, to the state. In 2003, California and the federal government acquired15,100 acres of salt evaporator ponds in South San Francisco Bay and an additional 1,400 acres of crystallizer ponds along the Napa River from Cargill.

The California State Coastal Conservancy, California Department of Fish and Game, and U.S. Army Corps of Engineers have undertaken a Feasibility Study to evaluate alternatives for reducing salinity and restoring or enhancing habitats in the North Bay ponds. The project objectives for the Napa River Unit 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.

The work undertaken in the North Bay provides lessons for the restoration planning of the South Bay Salt Ponds, including the need for interim management, the need for scientific oversight and involvement, and the benefits of working collaboratively with partners and stakeholders. The Conservancy will facilitate long-term restoration planning for the South Bay Salt Ponds with the California Department of Fish and Game and the U.S. Fish and Wildlife Service, the land managers, and the Santa Clara Valley Water District, Alameda County Flood Control District, and the U.S. Army Corps of Engineers. The agencies will engage trustee and regulatory agencies, local governments, community groups, recreation and access advocates, environmental organizations, and the public in this multi-objective project that will combine habitat restoration, flood control, and public access.

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SOUTH BAY SALT POND RESTORATION PROJECT

SNOWY PLOVERS

JOY ALBERTSON
U.S. FISH & WILDLIFE SERVICE

In the near future, large-scale restoration and management of South Bay salt ponds will offer a challenging and unique opportunity to conserve the Pacific coast population of the western snowy plover (*Charadrius alexandrinus nivosus*), which is listed as federally threatened. Current threats include habitat degradation caused by human disturbance, urban development, invasive plants, and expanding predator populations. Management actions to reduce these threats and to satisfy the biological needs of the plover must be undertaken to assure recovery.

San Francisco Bay is one of 20 remaining snowy plover breeding areas in California, supporting approximately 10 percent of the state-wide population, underlining the potential importance of the Bay in recovery of the plover. Recovery criteria include maintaining 500 breeding adults in the San Francisco Bay unit. The current breeding population in San Francisco Bay is between 100 and 150 breeding adults, with the majority breeding on dry salt pan areas of man-made salt ponds in the southern part of the Bay. In particular, the medium-salinity salt ponds with dry pond-bottoms provide both nesting and foraging requirements for the plover.

In the past, most of these salt ponds were under commercial salt production, and snowy plovers nested opportunistically only when ponds happened to be dry during the breeding season. To date, management activities have focused on protection of existing plover breeding populations, but there have been few opportunities to enhance plover nesting and foraging habitat through water management. Current management activities include controlling mammalian predators, building nest exclosures, and closing nesting areas during nesting season to minimize human disturbance.

Recently, more than 15,000 acres of south San Francisco Bay salt ponds were acquired by the U.S. Fish and Wildlife Service and the California Department of Fish and Game. The ponds will be restored to a mosaic of tidal marsh, managed ponds, and salt pans. The salt pan habitat to be managed for snowy plovers will include several managed pond complexes in different areas of the South Bay. This new opportunity for active habitat management—including managing pond water levels and salinities, removing problem predators, minimizing human trespass and disturbance, controlling vegetation, and resolving conflicts with management for other special status species—will be crucial to the recovery of local breeding populations and will greatly benefit the health of the Pacific coast population.

One of the most difficult challenges to overcome will likely be predation by species such as corvids (ravens and crows) and gulls, which exploit nesting and foraging opportunities provided by transmission towers, landfills, and urban development. Although many challenges lie ahead in plover recovery, these challenges can be overcome with the help of additional research, protective measures, and adaptive habitat management.

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Lisa Krieshok

WATERBIRDS IN THE SOUTH BAY

NILS WARNOCK, ET AL.
PRBO CONSERVATION SCIENCE

Millions of waterbirds (shorebirds, waterfowl, gulls, terns, grebes, and waders) have come to depend on commercial salt ponds as a replacement for tidal mudflats and other natural shallow water habitats, such as salt pannes and seasonal wetlands, which have declined from their historic extent around the Bay. Although the recent acquisition of over 6,000 hectares of salt ponds by state and federal wildlife agencies provides an unprecedented opportunity to restore large areas of contiguous tidal wetlands in the South Bay, the science of tidal marsh restoration is new and evolving, and studies of tidal marsh restoration trajectories and outcomes are few, especially with respect to bird and other vertebrates.

PRBO has completed the first phase of a long-term effort to evaluate the potential effects of salt pond restoration on San Francisco Bay wetland bird communities. We used comprehensive, standardized bird survey data from salt pond and tidal marsh habitat to develop models that predict the impact of specific restoration scenarios on South Bay bird species richness and abundance.

Preliminary results demonstrate that while restoring significant amounts of tidal marsh habitat will benefit birds that depend on tidal marshes, we need to plan carefully and develop a mosaic of interspersed tidal marsh and shallow water habitat to reduce the likely costs to waterbirds that currently depend on salt ponds.

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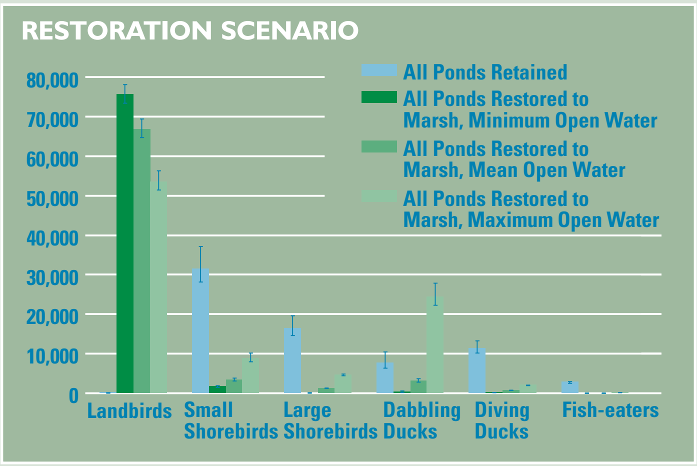
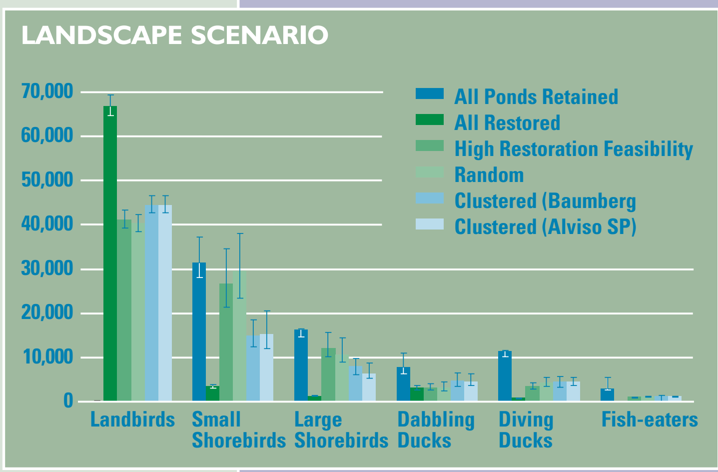
SCIENCE QUESTIONS

- What is the optimal mix of tidal marsh, salt pond, and other Bay habitats that maximizes the diversity and numbers of waterbirds using the restored area?
- What will happen to birds displaced by the restoration process? Will they and can they move to other parts of the Estuary? Conversely, how quickly will bird populations use new habitat that is created?
- Will tidal flats be affected by habitat restoration in the South Bay and how will this impact waterbirds?
- How will threatened and endangered species and other species of conservation concern respond to habitat restoration in the Estuary?

TAKE HOME NOTES

- Numbers of waterbirds using the restored areas of the South Bay will decrease dramatically if all salt ponds are restored to homogeneous tidal marshes.
- Habitat modifications such as the creation of large channels and ponded areas within tidal marsh areas can greatly reduce negative effects on waterbird populations.
- Leaving some salt ponds within a wetland mosaic can mitigate or even eliminate negative effects on waterbird populations.
- Landscape setting, including proximity to urban development or the Bay/mudflat edge, can affect the value of salt ponds and restored marshes for birds and is an important consideration in the design of marsh restoration projects.
- The selection of which salt ponds to retain and the salinities and depths at which they are managed will affect use of the restored area by waterbird populations.





Restoration scenario predictions for all species groups (all ponds restored, variation in tidal marsh restoration endpoints). Landscape scenario predictions for species group numbers with varying salt pond/tidal marsh configurations, assuming mean open water habitat conditions. Numbers are total numbers over all ponds surveyed (based on sum of regression model density predictions for each pond). Error bars represent sums of standard errors for each pond prediction.

restoring the estuary

the delta

"Operating aspects of the water projects at the tidal timescale could provide opportunities for managing both ecosystem function and water supply reliability and improve Delta salinities without costing more water."

JON BURAU
USGS

Horsetail

AN OVERVIEW OF DELTA RESTORATION

LAUREN L. HASTINGS
ECOSYSTEM RESTORATION PROGRAM, CALIFORNIA BAY-DELTA AUTHORITY

The Sacramento-San Joaquin Delta is the hub of California's two largest water distribution systems—the federal Central Valley Project (CVP) and the State Water Project (SWP), which, with other local distribution systems, supply drinking water to over 22 million Californians and irrigation water for over 7 million acres of productive agricultural land. The Delta's mosaic of habitats is home to over 750 plant and animal species, and serves as the migratory path for anadromous Central Valley fish and Pacific Flyway waterfowl, shorebirds, and songbirds.

The California Bay-Delta Program was established in 1995 to address the complex issues associated with multiple demands for limited water resources. The Ecosystem Restoration Program (ERP) element is designed to restore the ecological health of the Bay-Delta ecosystem by restoring ecological processes, increasing and improving aquatic and terrestrial habitats, and minimizing stress on the system in order to support stable, self-sustaining populations of diverse and valuable species.

The ERP's vision for Delta restoration includes increasing natural freshwater flow and improving channel configurations; increasing aquatic foodweb production; and reducing stresses from land use and development, diversions, non-native species, and contaminants. Current ERP Delta habitat actions and targets include increasing the amount of aquatic, slough, midchannel island, wetland (tidal, seasonal, and permanent), riparian, and upland habitat, including wildlife-friendly agricultural land.

Since 1995, ERP funds have been awarded for planning, pilot, and full-scale implementation of protection and restoration of all of these habitat types. The AB360 Delta Levee Protection Program, the Department of Fish and Game's Wildlife Conservation Board, the Natural Resource Conservation Service, and others have also funded Delta habitat protection and restoration projects. Most of the large-scale habitat restoration projects are in the planning or pilot-scale implementation stages, including those in the Yolo Bypass and Jepson Prairie-Prospect Island Corridor in the North Delta, McCormack-Williamson Tract (part of the North Delta Flood Control and Ecosystem Restoration Project), and Grizzly Slough in the East Delta, and Decker Island, Frank's Tract, and Dutch Slough/Marsh Creek in the Central/West Delta. Implemented projects include Barker Slough riparian restoration in the North Delta, Cosumnes floodplain restoration in the East Delta, and Georgianna Slough and North Fork Mokelumne levee protection and riparian restoration in the Central/West Delta.

The ERP is currently in the process of developing the Delta Regional Ecosystem Restoration Implementation Plan (DRERIP), which will refine the ERP planning foundation for the Delta, including refining the set of Delta-specific restoration actions and targets, and provide Delta-specific implementation guidance, program tracking, and guidance for performance evaluation and adaptive management feedback. This first regional ERP implementation plan will incorporate scientific evaluation of previously planned actions in light of current knowledge and restoration projects implemented to date.

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Arrowhead

USING TIDES TO MANAGE THE SYSTEM

JON BURAU
U.S. GEOLOGICAL SURVEY

A flooded island in the Central Delta may hold the key to improving water quality during low flood periods without additional water costs. After a four-month experiment in Frank's Tract in 2002, tracking tidal flows with drifters and measuring salinity and bathymetry, we discovered hydrodynamic patterns that may help address an age-old water quality management problem. We now know that the tides transport salt through a series of narrow levee breaches into the pool of water in Frank's Tract. Water sloshes back and forth, but channel configurations keep the salt from draining out on the outgoing tide. The result of this tidal "pumping" and "trapping" process can be a gradual buildup of salt in the Central Delta during late summer through early winter.

From the results of computer modeling, we believe the Central Delta acts like a large mixing bowl. This means that freshwater inflows from the North Delta and diversion rates in the South Delta appear to only have an indirect effect on salinity in the Central Delta—and that tidal currents significantly contribute to salinity levels in Frank's Tract.

These findings suggest an opportunity to improve Delta water quality without requiring additional upstream water releases or curtailments of pumping by the state and federal diversions and may explain why at times salinity in the Central Delta can be slow to respond to releasing water from upstream reservoirs, lowering pumping rates by the state and federal diversions, and opening the Delta Cross Channel gates. These management tools are all located on the periphery of the Delta, and their effects are relatively small compared to the transport of salt due to the mixing of the tides in the Central Delta.

With Frank's Tract right in the middle of the Central Delta, there may be opportunities to work directly with the natural tidal processes. Physical changes such as repairing the northern and western section of levees, or constructing tidal gates could allow operators to manage tidal processes that influence salt concentrations and other water quality conditions, such as temperature and depth.

Much more work on fish passage and the transport of organisms in this area is needed, as well as more detailed examinations of how this Central Delta "pool" of freshwater works. However, our new findings suggest that operating aspects of the water projects at the tidal timescale could provide great opportunities for managing both ecosystem function and water supply reliability and improve Delta salinities without costing more water.

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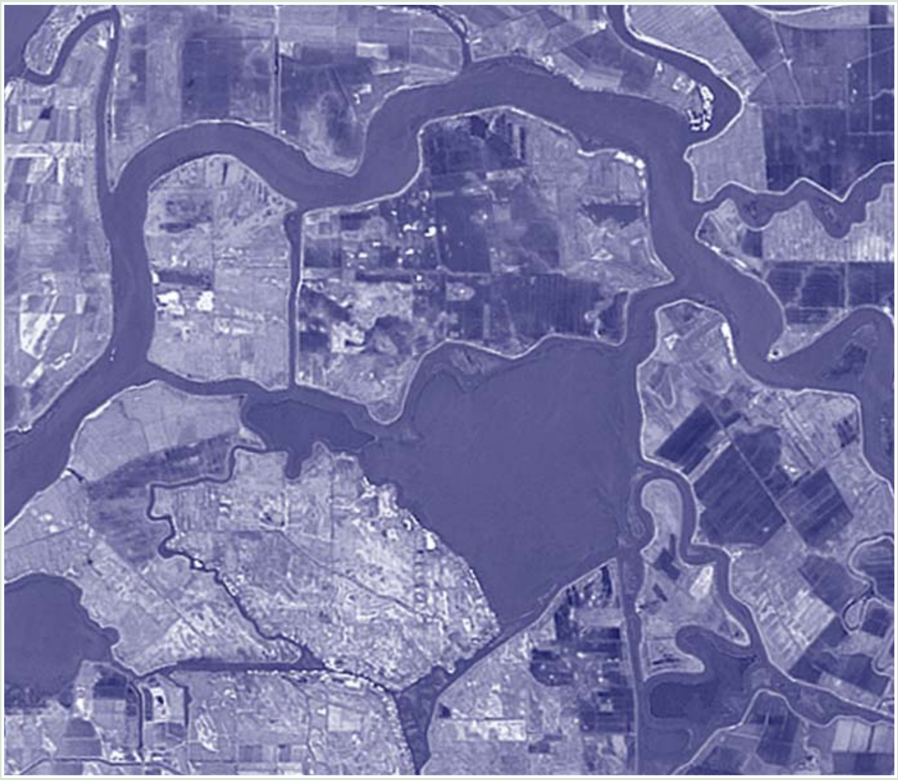


Franks Tract, fed by tides from the False River at left, and by the San Joaquin River at top, and the Old River at right.

Fremont cottonwood

restoring the estuary

focus on fish

"Instead of asking whether fish can survive, now we're asking if fish can thrive—can they grow and reproduce?"

LORETTA BARSAMIAN
FORMER EXECUTIVE DIRECTOR
S.F. BAY REGIONAL WATER QUALITY CONTROL BOARD

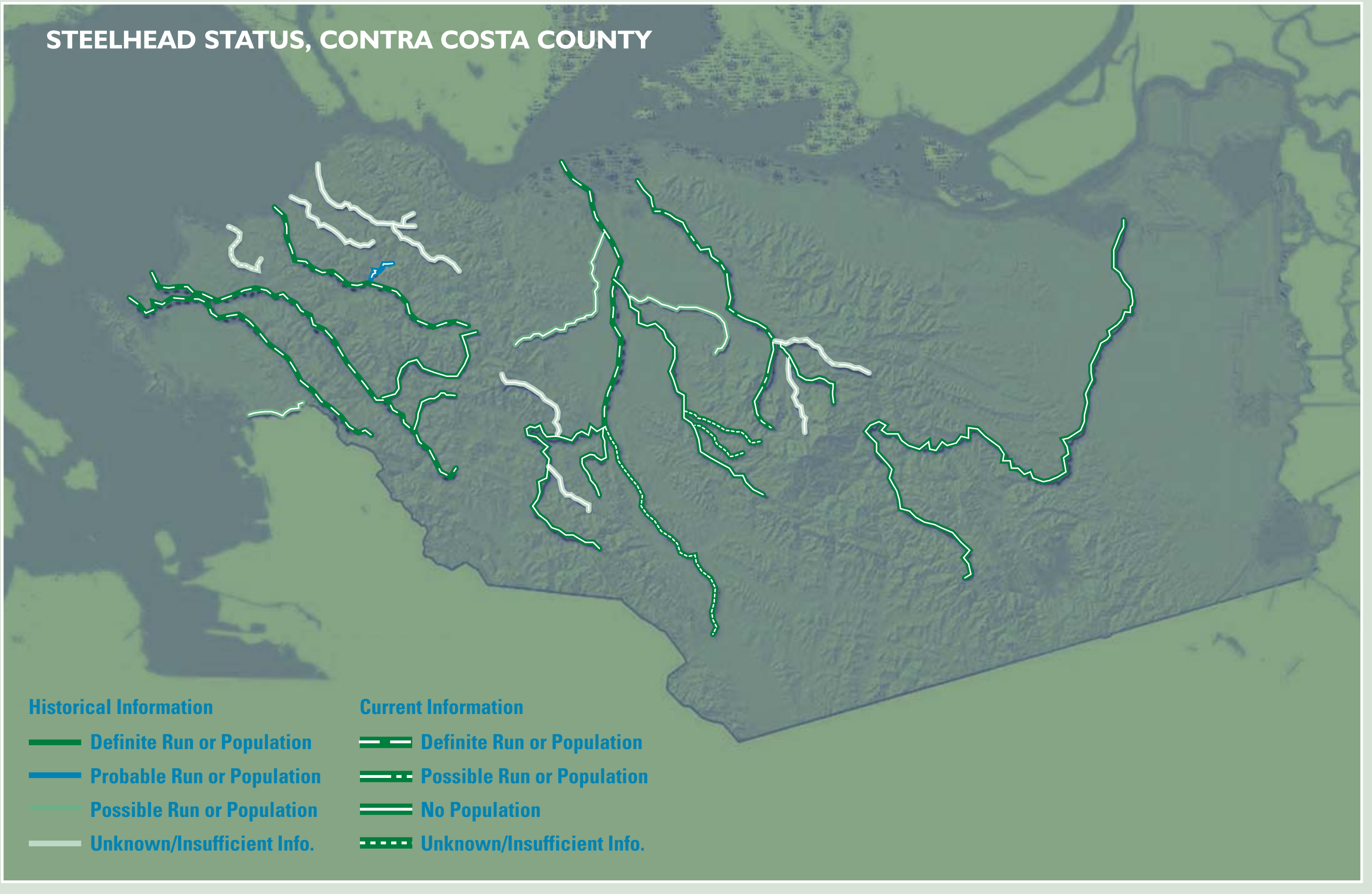
SALMON AND STEELHEAD IN BAY TRIBUTARIES

GORDON BECKER, ET AL.
CENTER FOR ECOSYSTEM MANAGEMENT AND RESTORATION

Three *Oncorhynchus* species—steelhead, coho, and Chinook salmon—are known to use or have used the Bay and its tributaries commonly. We looked at 278 streams in 59 watersheds tributary to the Bay for evidence of their past or current presence. We evaluated source information for reliability, and assigned one of four status designations—definite run or population, probable, possible, or no run or population—for past (pre-1992) and current presence/absence of anadromous salmonids. In some cases, we were unable to determine historical or current run status.

Of the 278 streams we studied, 70 percent definitely supported steelhead historically, with an additional nine percent having probable or possible runs. Currently, about half of the streams have at least resident *O. mykiss* populations. We did not find any evidence that any Bay Area stream did not support steelhead in the past, whereas currently at least 83 streams are known not to have even resident *O. mykiss*. We noted an almost one-third decrease in the number of streams containing *O. mykiss* over time. Streams shown in the future to have only fish of hatchery origin will lead to a larger measured decline in distribution, since this project is intended to characterize wild *O. mykiss*.

We found 14 definite, probable, or possible historical coho runs in Bay Area watersheds. Coho are now extirpated from the region. For Chinook, we noted only evidence suggesting possible historical use of estuary streams. Now, though, several streams are experiencing regular runs. It is clear that some portion of this population is comprised of Central Valley hatchery strays, but it has yet to be determined if there is a component representing a remnant historical population. Current information does not appear to justify managing Bay Area streams for coho or Chinook salmon restoration purposes if the associated actions



O. MYKISS AROUND THE BAY: RUN OR POPULATION

	DEFINITE	PROBABLE	POSSIBLE	NONE	UNKNOWN
Historical	194 (70%)	14 (5%)	11 (4%)	0 (0%)	59 (21%)
Current	134 (48%)	11 (4%)	6 (2%)	83 (30%)	44 (16%)

would conflict with, or detract from, steelhead restoration.

A third of the study streams had two or fewer surveys on record. Almost half had no quantitative information that we could use to characterize populations, such as fish size or relative density. As little information was found regarding abundance, we noted instances of streams with reliable evidence of *O. mykiss* population decrease. More than half of the study streams qualified for this classification.

Sixty-seven streams presently have *O. mykiss* populations with no total passage barriers between the fish and the Bay. If we assume that all 194 definite historical population streams originally supported anadromy, we arrive at a decrease of over two-thirds over time. Of the 59 studied watersheds, just over half of the historical steelhead systems have *O. mykiss* populations with no downstream barriers.

Our study streams included 39 reservoirs with greater than 200 acre-feet capacity. *Oncorhynchus mykiss* populations are found in 17 watersheds that do not have dams, while 15 watersheds have populations downstream from dams. Revisiting dam operations has the potential to substantially improve conditions for *O. mykiss* in both priority and non-priority watersheds around the Estuary. On dammed streams, the effect of flow alterations on downstream habitat should be evaluated, and releases should be provided to maintain fisheries in good condition.

San Francisco Estuary streams are important to steelhead restoration by virtue of their proximity to the ocean and the high level of public support in the region. Selecting a limited number of priority watersheds offers the best chance of success in re-establishing viable steelhead populations. Criteria for evaluating watersheds should include where *O. mykiss* are reproducing now, where hydrologic conditions remain favorable, the amount of available habitat, and issues of cost, technology, and logistics.

Restoration plans for the watersheds should focus on passage and instream flows, as well as habitat improvements based on natural stream function rather than structural changes. Water supply represents a key restoration challenge that will involve re-thinking our approach to granting and conditioning diversion permits, to controls on groundwater withdrawal, and to enforcement regarding illegal diversions. We recommend monitoring every two years in priority watersheds to provide a measure of progress toward restoration goals and to allow strategies to be retooled as our understanding of steelhead natural history improves.

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TAKE HOME NOTES

- Selecting a limited number of priority watersheds in which to attempt to re-establish steelhead populations offers the highest chance of success. The criteria for evaluating watersheds should include where *O. mykiss* are reproducing now, where hydrologic conditions remain favorable, the amount of available habitat, and cost, technology, and logistics.
- Restoration plans for priority watersheds should focus on passage and instream flows, as well as habitat improvements based on natural stream function rather than structural changes that have been shown to be ineffective.
- Water supply represents a key restoration challenge that will involve re-thinking our approach to granting and conditioning diversion permits, to controls on groundwater withdrawal, and to enforcement regarding illegal diversions.
- We recommend monitoring every two years in priority watersheds to provide a measure of progress toward restoration goals and to allow strategies to be retooled as our understanding of steelhead natural history improves.
- Too few resource dollars are going toward Bay Area streams. Steelhead restoration should be integrated into watershed management efforts now underway.
- Restoring steelhead will benefit numerous fish and wildlife species that use aquatic and riparian habitat.

SCIENCE QUESTIONS

- How does groundwater use affect steelhead habitat in Bay Area streams?
- Have studies shown that groundwater pumping reduces the extent and duration of pool habitat in systems limited by over-summering conditions?

RESTORING CENTRAL VALLEY CHINOOK SALMON AND STEELHEAD — ADVICE TO CALIFORNIA

JIM ANDERSON
UNIVERSITY OF WASHINGTON, SEATTLE

Fishery scientists and managers in the Pacific Northwest have focused on the effects of freshwater flows on salmon and steelhead for 40 years; however, recent research indicates that water temperature may be just as important as flows.

Although my own studies comprise only 20 years, some of my observations, in terms of science and policy, may provide a useful perspective to California in dealing with very similar issues. We can consider independently the evolution of fish/water science and management over the past four decades. After the first decade of research, culminating in seven data points relating flow and smolt survival, fisheries scientists universally believed that increasing flows in the system produced significant positive improvements in juvenile fish survival. Consequently, managers established a modest flow augmentation program of 3.5 million acre feet to assist smolts on their spring migration. Today, after over 10,000 measurements of fish survival, there is no clear evidence that water augmentation in the Columbia/Snake River system improves fish survival. However, the flow augmentation program now targets up to 16 MAF, and a moratorium is in place on new water withdrawals and transfers in the Columbia Basin. While fish and water managers are concerned with the impacts of single water actions on specific fish runs as urbanization and agricultural development increase, their real concerns are the cumulative impacts of many future water withdrawals. But water and fish managers simply do not have the scientific tools to assess these cumulative impacts, especially in the face of global warming, and as a result, management has become largely disconnected from science. Today there is more controversy, uncertainty, and legal action in the basin than ever before.

New research points to an important factor that would reconnect water management and fishery science. In particular, the research shows that temperature is of much greater importance than flow in structuring the life-history strategies of salmon and steelhead. Temperature determines when eggs emerge from the gravel, the timing and survival of smolt migrations, and when and where the adults spawn. Temperature also appears to be a primary factor in the growth and survival of salmon and steelhead in the ocean.

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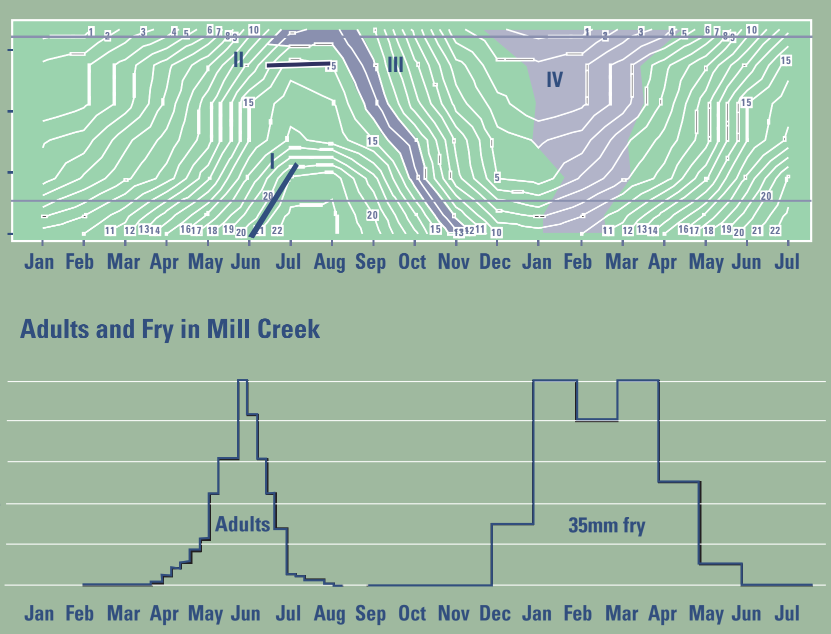
TAKE HOME NOTES

- Scientists need to develop the data and models to characterize and predict the effect of water policy actions on temperature as well as flow, and then link these properties to fish life history fitness through their physiological and behavioral mechanisms.
- Only with an ability to evaluate individual decisions in terms of their cumulative impacts will managers be able to effectively balance the competing demands for water.

SCIENCE QUESTIONS

- Will anthropogenic and natural changes in stream temperature patterns shrink the window of opportunity for certain salmonid life history strategies?
- What changes in water operations might expand windows of opportunity for salmonid life history strategies?

STREAM TEMPERATURE AND SALMON



Salmon life history strategy fits within a window of opportunity determined by seasonal changes of water temperature with stream elevation. The upper panel shows isotherm (°C) contours representative of northern Sierra Nevada streams. The lower panel shows adult and fry relative abundances in Mill Creek, a tributary of the Sacramento River. Spring chinook upstream migration occurs to the left of Line I, which depicts the 20°C isotherm that blocks migration. Line II depicts the elevation at which salmon can survive the summer warming. Area III depicts 12° and 14°C isotherms, which bracket the temperature range for spawning. Area IV depicts the modeled fry mergence pattern.

HOW FISH USE TIDAL MARSHES

KATHRYN HIEB
CALIFORNIA DEPARTMENT OF FISH AND GAME

Tidal marshes are one of the least-studied fish habitats in the Estuary. The Estuary supports a rich fish fauna, including transient, resident, and migratory species, with habitats ranging from deep channels to eelgrass beds, tidal flats, and tidal marshes. Many species found in the open waters of the Estuary have been collected in tidal marshes, but the role and importance of these marshes to the Estuary's fishes are largely unknown. This is especially true for many of the transient species that use the Estuary as a nursery, including the surfperches, silversides, and many of the gobies, sculpins, and flatfishes.

The mere presence of juveniles in a tidal marsh does not mean that it is a nursery. We do not know if densities, growth, or survival are higher in the Estuary's tidal marshes compared to other nearby juvenile habitats or if juveniles are able to successfully emigrate from all of the Estuary's marshes to the species' adult habitat. In addition, we lack basic life history information for some of these transient species, such as the timing of immigration to marshes, duration of stay, and habitat types used in the marshes.

The Estuary's tidal marshes also support a somewhat unique resident fish community. This includes the longjaw mudsucker, threespine stickleback, rainwater killifish, and western mosquitofish, which are rarely collected in the open waters of the Estuary. These resident species are in some respects even less studied than the transient species, as they occupy habitat types within the marshes that have been rarely sampled. Recent studies in San Pablo Bay marshes have shown that there is a transition from resident species in the higher elevation marsh habitat types to transient species in the lower elevation habitat types. In designing restoration projects and monitoring plans we need to remember that tidal marshes are a mosaic of habitat types, including pannes, vegetated marsh plain, emergent vegetation, and unvegetated channels, and each species and life stage may use these habitat types differently.

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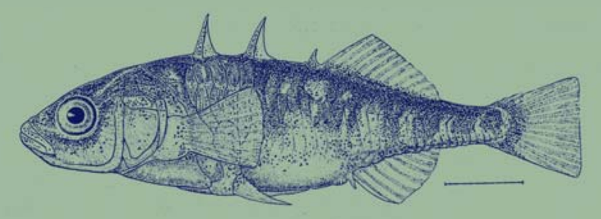
SCIENCE QUESTIONS

- Are densities, growth, or survival higher in the Estuary's tidal marshes compared to other nearby juvenile habitats?
- Are juvenile fish able to successfully emigrate from all of the Estuary's marshes to the species' adult habitat?

TAKE HOME NOTES

- We need to remember that tidal marshes are a mosaic of habitat types, including pannes, vegetated marsh plain, emergent vegetation, and unvegetated channels, and each species and life stage may use these habitat types differently.

WEST COAST THREESPINE STICKLEBACK



CAN WE SEPARATE HUMAN FROM NATURAL INFLUENCES ON FISH?

WILLIAM A. BENNETT
JOHN MUIR INSTITUTE
OF THE ENVIRONMENT
BODEGA MARINE LABORATORY
UNIVERSITY OF CALIFORNIA, DAVIS

Although human alterations to the Estuary are frequently promoted as causes for declines in its fish populations, little work has been done to distinguish among a variety of potential human and natural causes, or at the level of the population as opposed to individuals. This problem is scientifically challenging because human and natural influences may be co-occurring and interacting in complex ways to cause population declines.

Recently, interdisciplinary research teams have been successful at separating mortality in large numbers of individuals of striped bass and Delta smelt populations caused by exposure to toxic pesticides from mortality due to poor feeding success. Use of this information with estimated birth-dates of individuals and statistical analyses of monitoring data is currently helping to identify the relative contribution of fish losses in water export operations. Recent statistical analyses also show that larger-scale climate cycling can have direct effects on populations as well as potential indirect influences on the Estuary's capacity to maintain fish abundances. Climate cycling or "regime-shifting" has been shown to have a dominant influence on oceanic fish beyond that attributed to human fishing. Under certain circumstances, the influences of natural climate cycling may also outweigh other human and natural influences on fish populations within the Estuary.

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STRIPED BASS

DELTA SMELT

TAKE HOME NOTES

- There are many complex influences on fish populations at regional and local scales. Subtle and unseen natural effects can have larger influences than episodic and conspicuous human effects.
- Separating human from natural influences on fish populations remains a challenge, and one that will require considerable investment before reliable management and restoration strategies can be determined. That said, we can now distinguish and measure many effects and are developing models to provide quantitative estimates of these effects on populations.
- It will be crucial to maintain a population-level focus and an awareness of how larger-scale climate cycles may interact with other influences within the Estuary to collectively determine fish abundances.
- We do know that El Niños constrict or delay spawning season and may decrease carrying capacity of the habitat. We predict that Delta smelt will do poorly under global warming.

politics & plumbing

"The Estuary fits into the grand scheme of water management in California through both physical connections and political connections. We increasingly hear about how things happening on the Klamath River are tied to Southern California; how things happening on the Colorado River in San Diego are tied to the Bay-Delta system…"

TIM RAMIREZ
CALIFORNIA BAY DELTA AUTHORITY

A REGIONAL APPROACH TO WATER MANAGEMENT

PATRICK WRIGHT
CALIFORNIA BAY DELTA AUTHORITY

The U.S. Department of Interior's cutoff of California's surplus supplies from the Colorado River sent shock waves through the state's water system and the hallways of the Legislature and Congress. But from a statewide perspective, more revealing is the lack of panic from the Metropolitan Water District (MWD) and other local water agencies, which have been developing alternative supplies in an enlightened shift toward regional water management planning.

Despite losing up to 600,000 acre-feet of supply after two consecutive dry years—enough to supply 3 million people—MWD is saying that shortages are at least two years away, and there's no talk of rationing. What gives? In the past, agencies faced with shortages would have demanded to be bailed out by a new generation of state or federal water projects. Instead, they are taking matters into their own hands by developing diverse, regionally-based plans that reduce their dependence on the Sacramento-San Joaquin Delta and the Colorado River and that are better tailored to each region's variable climate and hydrology.

Like prudent bankers, regional agencies are developing portfolios of assets to improve the quality and reliability of their supplies. From the Sacramento Valley Water Management Agreement to the Santa Ana Watershed Project Authority, these agencies are investing in surface and groundwater storage, conservation, reclamation, desalination, land retirement, water transfers, and other projects to diversify their plans. With few exceptions, the plans are being developed locally rather than by agencies in Sacramento or Washington, D.C.

State and federal agencies, under the umbrella of the CALFED Bay Delta program, continue to invest in programs to meet the state's water needs, but CALFED-directed water-supply projects are focused primarily on improving system-wide reliability and reducing bottlenecks in the Delta. The recent emergence of strong local and regional programs marks the beginning of a historic shift from a decades-long era of centralized state and federal water planning that began in the 1930s, to a regionally and market-driven approach that better reflects the state's variable hydrology, regional differences, and the growing sophistication of local water districts.

To provide a framework for these efforts, CALFED has brought the water and environmental interests together after decades of gridlock, reducing conflicts over Delta exports and smoothing passage for three consecutive water bonds. Billions of dollars are now flowing to local and regional communities throughout the state to meet their most pressing water needs.

Four bills promoting regional efforts were enacted in 2002, including one that established regionally based seats for public members of the new California Bay Delta Authority to govern CALFED. And perhaps most significantly, voters passed Proposition 50, the largest water bond in California history, largely on the promise of more funding dedicated to reducing dependence on imported supplies.

None of this means that a failure in negotiations to reduce California's surplus from the Colorado River will not have serious repercussions. As the success of the CALFED program demonstrates, money and water are more likely to flow to regional projects under a comprehensive plan that reduces conflict than to those under a cloud of gridlock and litigation. The CALFED and Colorado River agreements provide the framework and the stability for regional and market-based water plans already well under way in reshaping California's water future.

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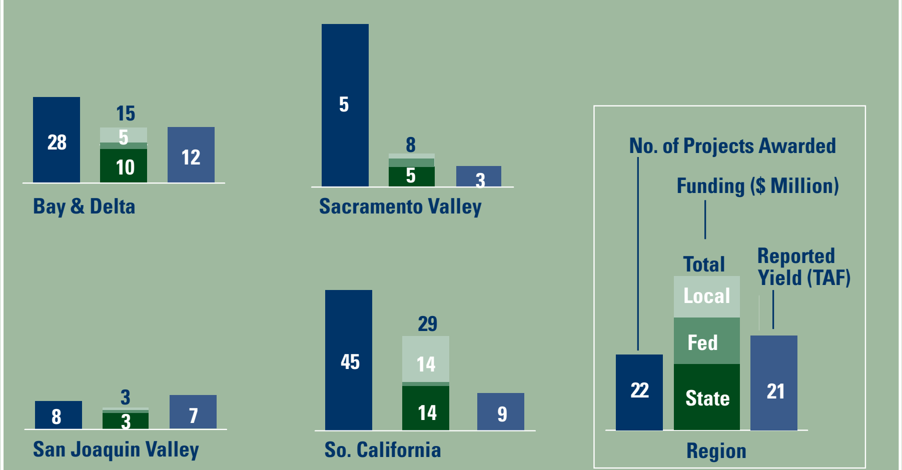
WATER SUPPLY RELIABILITY
WATER USE EFFICIENCY ACCOMPLISHMENTS



AN AGRICULTURAL PERSPECTIVE ON CALIFORNIA'S WATER MANAGEMENT

BRENT WALTHALL
KERN COUNTY WATER AGENCY

The State Water Project (SWP) supply is very important to our agency. We have contracts for about a million acre feet, and that water is what gets us through long- and short-term droughts. In dry years, current reliability curves show that about 20 percent of the time we can expect only 50 percent of that water. So over the long term, in 1 out of 5 years we can expect to have only one half of our SWP supply available. In 1991, as an agricultural contractor, we got zero water, which is not conducive to farming in California. That was a difficult year for us; it was a wake-up year for us. It was the first year it had ever happened, and it made drastic changes in the way we viewed our future. Since then, we have done additional studies on reliability. What we examined most specifically was if the 1987-1992 drought recurred, how would it affect us? Under the existing environmental regulations and existing infrastructure, in a repeat of that drought, we would have about a 40 percent supply, not sufficient to sustain agriculture over the long term in our area.

There are potential future reductions to our water supply: additional ESA listings, increasing urban demands. We believe that the new Bulletin 160 relies far too heavily on securing additional supplies from agriculture in order to meet those urban and environmental needs. Agriculture should not be the new supply of first resort.

So what do we do? Our long term water supply future is not assured and is in fact threatened. The era of large infrastructure projects built by state and federal governments to meet water supply needs is over and will not reoccur again in our lifetimes. We cannot depend on large-scale planning or construction programs or dollars from Washington or Sacramento to make Kern County agriculture viable. That responsibility lies with the Kern County Water Agency and its members. So we embarked on a very ambitious local projects program focused mainly on water conservation and conjunctive groundwater use. Kern County is well known as one of the areas in the state that has aggressively pursued groundwater conjunctive use as a way to manage water supply reliability. We have built over 10,000 acres of storage—groundwater percolation—basins, and 60,000 acre feet per month can be put into the ground in years when water is available. That is a lot of water, and it can be done fairly quickly. We have over 124 recovery wells throughout our service area, many of them operated by our 13 member units. They were built so that water can be taken back out quickly. They are large—and quite expensive—wells. We have over 409,000 acre feet that can be extracted from those basins on an annual basis. So we can meet a significant portion of our demand from our own internal, underground storage reservoirs—if we can fill them. We have the infrastructure; we understand the groundwater basins well enough; and we have implemented groundwater management plans consistent with AB 3030.

> "Agriculture should not be the new supply of first resort."

Our experience is that the best groundwater management plan is a groundwater conjunctive use program. Once you put water into the ground, everybody who participated wants to know exactly what the rules are for taking it out and who gets it. And by doing that you have the vested interest of each of those participants, motivating them to make sure that that groundwater is managed in a responsible way. The best groundwater management plans aren't those that are mandated by Sacramento but those that are in fact are necessary to operate groundwater basins. The construction and operations of our groundwater basins is expensive. We take water from the SWP. We are not subsidized; the SWP contractors pay 100 percent of the cost of that project, and in some cases pay a little more. We are thus accustomed to paying the actual cost of water delivery, so when it comes to building our own local facilities, we have been willing to absorb that cost ourselves, largely with local dollars in conjunction with outside interests.

Participants in our groundwater banks come from throughout the state. The Metropolitan Water District partners with the Semitropic Water District in our area, and they have a groundwater conjunctive use program that they operate themselves. That program also includes Santa Clara Valley; it has included the City and County of San Francisco in the past, and the Environmental Water Account. Our groundwater banks can be used not only for our own benefit, but for the benefit of others as well.

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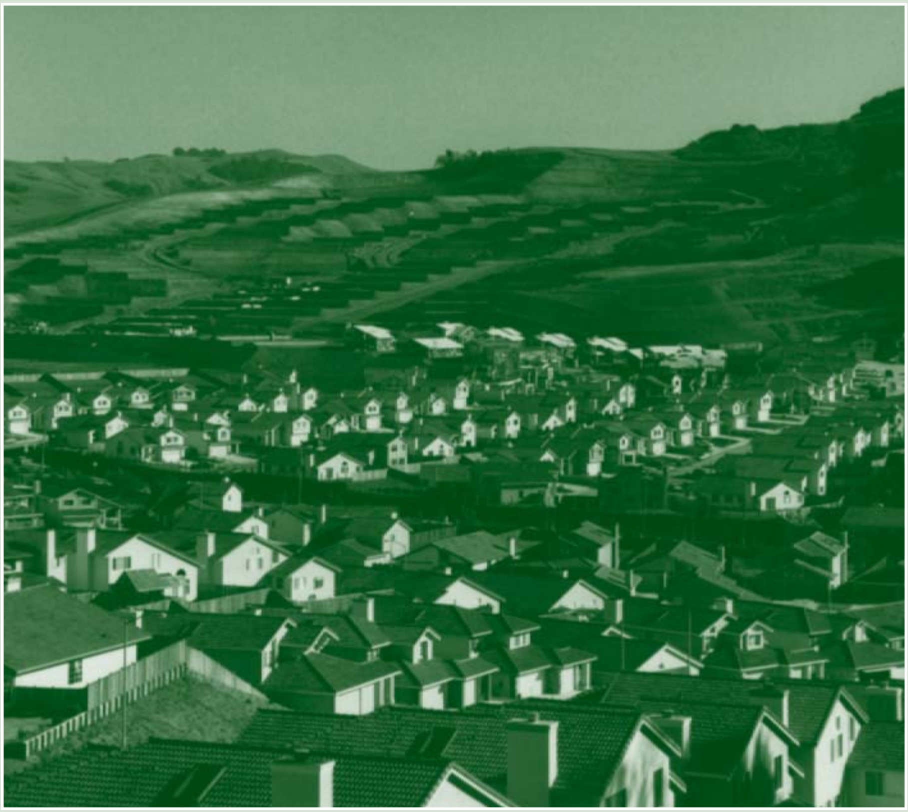
AN URBAN PERSPECTIVE

STEVE MACAULAY
CALIFORNIA URBAN WATER AGENCIES (CUWA)

2003 was a year of change: A permanent Bay-Delta Authority was created, the CALFED Bay-Delta Program had its third full year; decades of study of the "Delta conveyance problem" culminated in a Draft EIR/EIS; and appropriations from both the state and federal governments came close to collapsing, due to continued, serious budgetary problems.

In 2004, the key issues remained—as they have been for 30 years—water supply reliability, improvements in water quality, and conflicts between water diversions and fish. The promise of CALFED has been resolution of these problems and developing a physical/institutional/regulatory solution that works within the comprehensive CALFED framework. Hundreds of millions of dollars are being spent on ecosystem restoration, a program begun in late 1994 when several CUWA member agencies committed more than $30 million with the recognition that urban water supply reliability is directly linked to a healthy aquatic environment. This was a risk nine years ago, but it was followed by a financial commitment to ecosystem restoration in three subsequent bond issues. CALFED is founded on a principle that a comprehensive (more balanced) approach to restoration works best. The "CALFED way" makes environmental restoration and affordable improvements in water supply complementary actions within an overall program.

At the time this abstract was first prepared (mid-August 2003), there was cautious optimism that a successful solution could be reached. Longstanding conflicts among State Water Project and Central Valley Project export water users, the Department of Water Resources and the U.S. Bureau of Reclamation regarding sharing of the benefits of the South Delta Improvements Program looked like they were on the way to being resolved as a result of separate discussions among these parties. Fishery agencies have been heavily engaged in the issues related to environmental features of a possible program. Discussions with environmental organizations commenced immediately upon development of a proposed program, and the public involvement process continues. This program is very much a work in progress.



By spring 2004, a "Delta improvements package" had emerged, which both the Bay-Delta Authority Board and the Bay-Delta Public Advisory Committee were briefed on. The "package" included water quality improvement, ecosystem restoration, and other features, including proposals to address the quality of water coming into the Delta from the San Joaquin River. The "package," as it may be modified throughout the summer of 2004, will be an alternative in a Draft EIR/EIS to be issued in late 2004. Urban water agencies are particularly interested in the proposals to improve Delta water quality for drinking water purposes.

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AN ENVIRONMENTAL PERSPECTIVE

SPRECK ROSEKRANS
ENVIRONMENTAL DEFENSE

The flexibility to modify water projects for the protection and restoration of fish and wildlife in the Central Valley and Bay-Delta is significantly less than what the CALFED ROD provided when it was signed three years ago. Both the Central Valley Project Improvement Act's B2 account and the Environmental Water Account are deficient by hundreds of thousands of acre-feet.

In 2003, the B2 Account used only 462,000 of the 800,000 acre-feet of dedicated yield provided by the CVPIA, according to the measurement system in place when the CALFED agreement was signed. Furthermore, the Department of the Interior has not yet revealed how it will implement the Appellate Court's ruling on the "Primary Purpose" of the B2 account. Finally, Interior has offered only a token allocation of water pursuant to the "reoperation" provision of Section B1 of the CVPIA.

Implementation of the Environmental Water Account has been less contentious than that of the CVPIA operational provisions. Its long-term funding stream is uncertain, however. Also, the operational flexibility that was intended to provide supplies to the EWA has fallen far short of expectations. Over three years, an annual average of only 43,000 acre-feet has been acquired for the EWA through operational flexibility, 152,000 acre-feet less than the 195,000 acre-feet that were projected by project operators and fishery biologists when the EWA was developed.

There are opportunities for these gaps to be filled, but it is unclear whether the federal and state agencies have the institutional and political will to do so.

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Photo: David Sanger

THE POTENTIAL FOR WATER RECYCLING

JONAS MINTON
CALIFORNIA DEPARTMENT OF WATER RESOURCES

California is able to meet many, but not all, of its water demands most years. Except in multi-year droughts, most urban areas have sufficient supplies. However, even in average years, some agricultural and environmental needs are not fully met. In addition, California continues to overdraft some of its groundwater basins and surface reservoirs. By the year 2030, California's population is projected to increase by about 50 percent—17 million more Californians needing water for domestic use and for the commerce, industry, and agriculture that will employ them. If this is not formidable enough, we must also reduce our use of Colorado River water. For many years, we have been using more than our 4.4 million acre-feet per year allocation.

In order to balance our demands for water with other values, such as protection of our environment and public health, we must seek a portfolio of new water supplies and water management options—increased water conservation, conjunctive use of surface and ground water, desalination, storage in surface and groundwater basins, and water recycling.

A 40-member Recycled Water Task Force, including federal, state, and local governmental and private sector entities, environmental organizations, public health professionals, world-renowned researchers, water managers, and community activists was established pursuant to Assembly Bill No. 331. That bill, authored by Assembly Member Goldberg and signed by Governor Davis in 2001, found that the potential exists for increasing the amount of recycled water used in California from approximately 500,000 acre-feet annually to about two million acre-feet annually by 2030. This could free up enough fresh water to meet the household water needs of 30 to 50 percent of the additional 17 million new Californians expected by 2030. An investment of $11 billion (approximately $400 million annually) would be needed to achieve this goal.

The task force identified 26 issues and made recommendations for addressing obstacles, impediments, and opportunities for California to expand recycled water use. Among the recommendations were:

- Expand funding for health research, recycling projects, public awareness, and academic programs
- Engage the public in an active dialogue in the media, communities, and schools across California
- Adopt uniform state-wide regulations for dual plumbing and indoor use of recycled water
- Include conservation, improved storage, desalination, and voluntary water exchanges between California communities and industries as part of the solution.

Most recycled water projects now occur in urban areas. Yet other potential uses of recycled water might include wetlands restoration, stream flow augmentation, or Estuary enhancements.

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HIGHLIGHTS OF THE CALIFORNIA WATER PLAN 2003

KAMYAR GUIVETCHI
CALIFORNIA DEPARTMENT OF WATER RESOURCES

New Planning Framework:

- Uses input from a 65-member public advisory committee
- Develops water "portfolios" using 1998, 2000, 2001 data
- Develops regional reports reflecting regional goals and plans
- Uses multiple scenarios to account for future uncertainties and risks
- Uses many strategies to help meet future demands

Issues and Challenges:

- There are gaps in data and information
- Modeling tools not fully developed
- Revising the process impacted schedule
- Staff and budget are reduced
- There is a lack of consensus whether new surface storage should be included as a future strategy

Recommendations for the Future:

- Promote and assist regionally based, integrated, multi-resource planning
- Improve coordination of land use planning and water management
- Diversify regional portfolios using 25 resource management strategies
- Reduce uncertainty (fill in data and tool gaps)

Estimates for Additional Demand by 2030:

- To accommodate 17 million more Californians: need an additional 2-3 million acre-feet
- To recover groundwater overdraft: need an additional 1-2 million acre-feet
- To restore the environment: more is required (range being estimated)
- To maintain irrigated agriculture (about the same as now)

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DEVELOPING A RELIABLE WATER SUPPLY PORTFOLIO

TIMOTHY H. QUINN
METROPOLITAN WATER DISTRICT OF SOUTHERN CALIFORNIA

Coping with uncertainty in water supply is the biggest concern of urban water agen-cies. Even a threat of shortage creates concern for the economy. About a third of Southern California's water supply comes from the State Water Project (SWP). As originally envisioned, the SWP was to be a nearly 100% reliable source. It would capture water in the wettest portion of the state, the north coast mountains, and deliver it to urban water users in the Bay Area, Central Coast, and Southern California, and to agricultural water users in the Central Valley. However, changing environmental and financial priorities kept the SWP from building its full vision. As a result, the ability of the SWP to deliver water depends greatly on precipitation.

In response, the Metropolitan Water District (MWD) works in many ways to reduce supply uncertainty. MWD supports the following programs, to reduce uncertainty over the needs of the environment:

- The CALFED Science Program, to better understand the environment's needs and possible resolutions to water shortages;
- CALFED's Ecosystem Restoration Program, to recover endangered species; and
- The Environmental Water Account, to give fishery managers the water they need to take action when most needed.

Recognizing the variable nature of precipitation, MWD plans to survive droughts by storing water, made possible by the following actions:

- CALFED's South Delta Improvement Program, including increasing the peak capacity at the Banks Pumping Plant, to capture more water when it is available;
- Investments in demand management, to have water to store in wet years; and
- Investments in regional storage capacity, to provide a location to place any extra water captured.

MWD also supports increasing the supply of water, within the constraint of financial affordability, through the following actions:

- Implementing the Sacramento Valley Water Management Agreement, which develops water through conjunctive use programs to help meet Delta water quality objectives and implements improvements in infrastructure, which will reduce gross river diversions, leaving additional water in critical reaches of the Sacramento River and tributaries.
- Negotiating agreements with willing sellers to transfer water during dry years.

None of these programs in isolation provides the needed reliability. Yet, together they can work synergistically to meet the needs of the Estuary and the economy of California.

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CALIFORNIA'S ECONOMY CAN GROW WITH A NEW APPROACH TO MANAGING THE ESTUARY

GARY WOLFF
THE PACIFIC INSTITUTE FOR STUDIES IN DEVELOPMENT, ENVIRONMENT, AND SECURITY

In California and most modern economies today, economic growth does not require more water. Statistics for the United States and other countries show a sustained and clear "de-coupling" of economic growth and water extracted from the environment beginning several decades ago.

California rivers and groundwater basins are nearly all over-allocated. New water is simply not available. The health of our ecosystems, the strength of segments of our economy that depend on healthy aquatic systems (e.g., fishing, recreation, tourism), and the quality of our children's lives would be significantly improved if we took less water from natural systems, at least some of the time (e.g., dry years, when marginal flows may have higher ecological value).

The good news is that California's economy can grow for decades to come without taking more water from the environment. The "hard path" of centralized capital investments in concrete and steel is slowly being converted to a "soft path" that supplements existing infrastructure with decentralized investments in efficient appliances, public education and behavioral changes, water recycling and dual piping systems, land use practices that recharge groundwater aquifers, and other human-capital intensive techniques. In many cases, water use efficiency is a profitable investment. Cost-effective conservation techniques for homes and businesses are available now. The Institute's recent report, *Waste Not, Want Not: The Potential for Urban Water Use Efficiency in California* presents data supporting a softer path.

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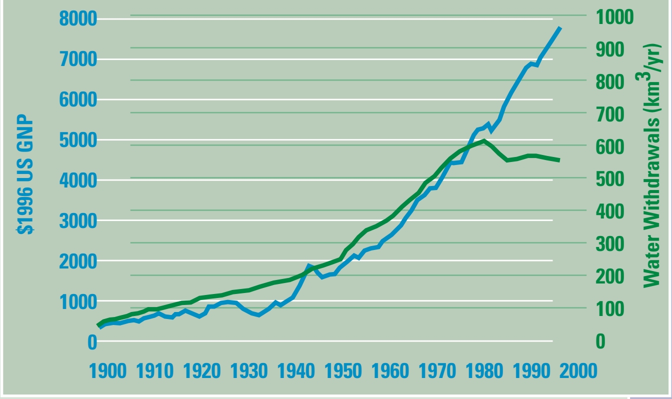
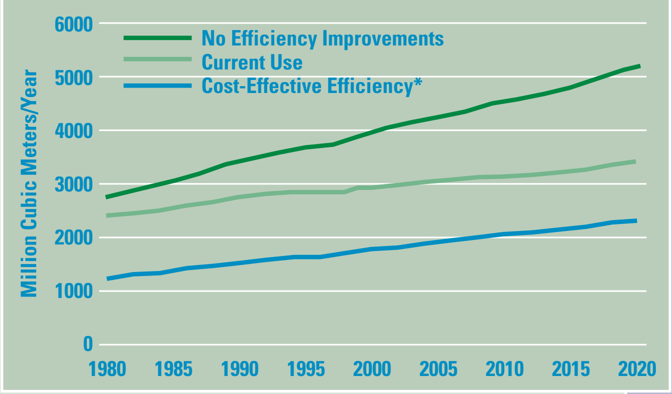
www.pacinst.org/reports/urban_usage/waste_not_want_not_full_report.pdf

THE LINK BETWEEN WATER USE AND ECONOMIC GROWTH CAN BE BROKEN



CALIFORNIA'S INDOOR RESIDENTIAL WATER USE



TAKE HOME NOTES

- Additional baseline withdrawals from waterways aren't necessary in future decades, and baseline withdrawals can be reduced if conservation and efficiency are pursued more aggressively. We must keep in mind that baseline withdrawals (those made to satisfy average annual consumption needs) are different in concept than withdrawals made to fill storage (surface or subsurface). In other words, our findings do not rule out additional withdrawals to support new storage projects. Presumably these withdrawals could take place in wet years, with minimal environmental impacts.
- We need to think more clearly and "separately" about withdrawals for storage versus withdrawals to meet baseline needs. These categories have been blurred historically, which is politically advantageous for those who advocate more withdrawals—because they can justify everything as a response to drought. But we need to stop doing that, and justify withdrawals for storage based on drought needs and withdrawals for baseline based on baseline needs. Certainly, these are related (a growing baseline means the percentage of years that are drought years will grow as well), but they can and should be separated analytically.

SCIENCE QUESTIONS

- How much more than baseline needs can we withdraw in wet years for storage purposes?

Recent studies suggest that periodic pulse flows are very important for ecological reasons; that is, that the economic notion of diminishing marginal utility is at least partially wrong when it comes to instream flows in some streams. Maybe higher annual flows have diminishing utility some years but strongly increasing utility once every three-five years or so. The three-five years is an example, which we need science to estimate, and similarly we need science to estimate the size of the pulses that are beneficial.

CAN WE PUMP MORE WATER AND PROTECT THE ENVIRONMENT?

DIANA JACOBS
CALIFORNIA DEPARTMENT OF FISH AND GAME

The major freshwater sources to the Estuary are the rivers of the Central Valley. These rivers are also the source of drinking water for two-thirds of the state's population and provide irrigation for millions of acres of farmland. Providing water for people and farms at this large scale requires massive infrastructure and substantial control of water ("operations"). Large-scale structures and operations such as the State Water Project and the federal Central Valley Project have large and long-lasting effects on the ecosystems of rivers and the Bay-Delta Estuary. In the future, we will likely see big changes in operations but not necessarily to infrastructure. What will operations changes mean to the environment? The way we manage water may create conflicts among competing human uses of water: the stakes are high for people and ecosystems.

The premise of the California Bay-Delta Program, CALFED, is that resolving conflicts among and between human water uses and ecosystems requires a solution commensurate with the problems—one that is large and comprehensive. The CALFED program strives to resolve conflicts over water by taking a balanced, comprehensive approach.

Some of the major challenges facing the CALFED program can be restated in several questions:

- How much freshwater does the Estuary need?
- How much water can we remove from the Estuary and have a sustainable estuarine ecosystem?
- How much freshwater do people need?
- Are there other ways of providing water to people than the freshwater sources to the Estuary?

Such questions raise still more questions, for example, how do we define "need"? Do we aim for just barely getting enough or for getting the most we can get? With regard to ecosystem needs, we have the scientific challenges of not knowing all the major determinants of ecosystem health and not knowing the relative importance of those factors we can manage. For example, we may assume that freshwater inflow is one management knob we can adjust. However, as we study the Estuary we find that detecting the effects of flow changes in the context of everything else which influences the system—whether natural or anthropogenic—can be difficult.

> "The stakes are high for people and ecosystems."

Different policy perspectives will lead down different paths in the face of incomplete knowledge. Using the CALFED approach means that our management decisions should be incremental and balanced, and rely heavily on scientific research targeted to key uncertainties. The CALFED Record of Decision (ROD) proposes increasing pumping from the Delta to 8,500 cfs, under the South Delta Improvements Program. The ROD also requires that this apparently incremental change in diversion be conditioned upon avoiding adverse impacts to fishery protection and in-Delta water interests.

TAKE HOME NOTES

- We need to know more about the biology of at-risk species in the Delta, especially population-level effects of water management actions. We must continue to invest in science. We must continue to collaborate, have patience, and acquire more knowledge.

SCIENCE QUESTIONS

- Will proposed flow changes cause detectable effects in the ecosystem?
- Will proposed flow changes add to cumulative impacts on the ecosystem?

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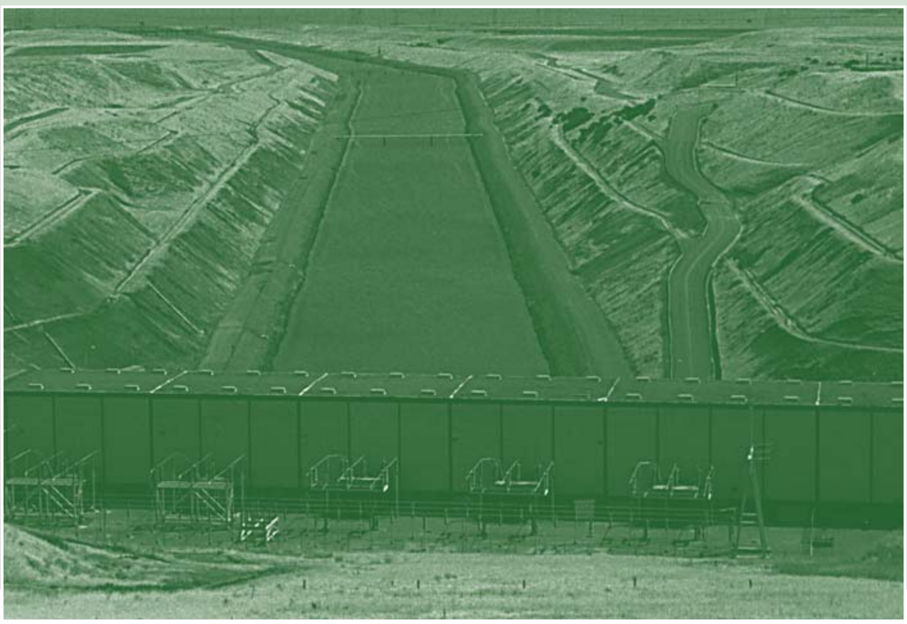

Photo: David Sanger

WHERE TO FROM HERE?

JERRY JOHNS
CALIFORNIA DEPARTMENT OF WATER RESOURCES

For the first time in recent history, both agricultural and urban water users are supporting the continuation of the Environmental Water Account (EWA) and maybe even paying for it. The EWA was the glue that put CALFED together. We had the environmental community and fishery agencies looking for additional environmental protection. And we had water contractors that felt they had already given enough, and wanted more supply. The EWA provided both water supply reliability and a trajectory for recovery for the fish and environmental folks.

The EWA is the piece that provides the environmental protection that allows us to move forward in a productive way. The ROD says that the EWA is to provide protection for fish in the Bay-Delta system with no changes in the operations of the CVP and SWP in an uncompensated manner. It was a four-year program, a test, to see if we could make things work—get the water to provide environmental benefits.

Management of the EWA is done by the three state and federal fisheries agencies and the two state and federal water agencies. Operators and fish folks sit down in the room at the same time and make decisions about how to operate the SWP and provide additional protection for fish.

The EWA is working. We've had two dry years and an above-normal year, with no big environmental or water fights, nothing like we saw in the mid-1990s. The fisheries benefited—we have taken actions way before you could have done them under the ESA—and water supply reliability has been there. In 2002, we had a 70 percent supply to the CVP and the SWP. We've focused principally on Delta actions, but we've coordinated those actions upstream on the Yuba and Merced, and we've done some power bypasses on the American to better protect upstream resources when moving water south. Over these last three years, 918,000 acre-feet of water has been used for fishery actions at a cost of about $120 million. For perspective, when New Melones, the last major on-stream reservoir was built, when it had yield, it had yield of 200,000 acre feet. Over the last three years, we've been able to provide that kind of yield to the system without building a new on-stream reservoir. This is a big benefit to the system. It's not cheap, and we have to figure out how to finance it as we move down the road. What price peace? We have, for the first time in a long time, the environmental and the water folks getting along with Delta actions.

We are moving more to a north-south strategy of moving water for EWA; it provides upstream benefits and takes advantage of capacity that becomes available to EWA. We've taken actions on both the state and federal sides of the system to provide assurances to both projects. We need to coordinate this program with other types of transfer programs in the Estuary. In terms of transfers, we need to remember three things. You can have no injury to legal users of water. You can have no unreasonable effects to fish or wildlife and no unreasonable economic impacts to the economy of the county from which the water is transferred. The question is, do we continue the EWA or not? Who benefits? What size should it be? How do we split the costs between the water uses and the public in a reasonable and effective manner?

Large problems are best addressed in pieces; you have to take things apart, figure out how to best integrate the problems—figure out what to do with EWA, Delta water quality—and then put it all back together again in a reasonable fashion. The key is getting to an integrated solution that works. Adaptive solutions are a better way to handle additional environmental protection. We need to have a regulatory floor; a baseline. But if we're looking for water supply assurances or a trajectory for recovery, we can do that better in an adaptive mode that incorporates science as we're making decisions. As we try to put these things together, we need to remember that everything that counts can't be counted. We are going to have to move forward sometimes when we don't have all of the answers to all of the problems. We can't count all the fish species we're worried about. We can't do everything. We have to move forward with the best knowledge we have.

MORE INFO? (916)653-8045

EWA EXPENDITURES
OCTOBER 2000 THRU SEPTEMBER 2003

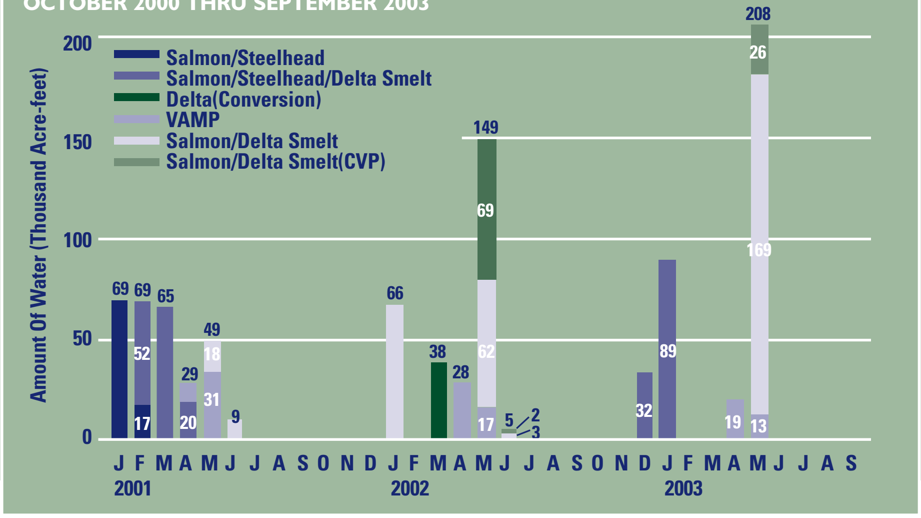

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Photo: David Sanger

KEY ON P. 88

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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.*

ACRONYM KEY

CALFED: CALFED Bay-Delta Program

DFG: California Department of Fish and Game

DHS: California Department of Health Services

DWR: California Department of Water Resources

GGNRA: Golden Gate National Recreation Area

MWD: Metropolitan Water District of Southern California

NMFS: National Marine Fisheries Service

NOAA: National Oceanic and Atmospheric Administration

NOS: National Ocean Service

PRBO: Point Reyes Bird Observatory

RCD: Resource Conservation District

SFBBO: San Francisco Bay Bird Observatory

SFBCDC: San Francisco Bay Conservation and Development Commission

SFBRWQCB: San Francisco Bay Regional Water Quality Control Board

SFEI: San Francisco Estuary Institute

SFEP: San Francisco Estuary Project

SWRQB: State Water Resources Control Board

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