STATE OF THE ESTUARY 2008

A Greener Shade of Blue?

San Francisco Estuary Project
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San Francisco Estuary Project

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STATE OF THE SAN FRANCISCO BAY-DELTA ESTUARY 2008

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Cordylanthus maritimus **subspecies** ***palustris*****. Extirpated in South Bay, remaining mostly in San Rafael Bay and Richardson Bay. Its stronghold is west Marin's marine tidal marshes. It can become very abundant locally. Photo and caption courtesy of Peter Baye.**

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Beavers in Alhambra Creek, downtown Martinez. Photo courtesy of Cheryl Reynolds (www.martinezbeavers.org).

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Snowy plover by Bob Lewis

OPENING REMARKS

How green—or ecologically sustainable—is the Estuary and its watershed? How much progress has been made since the CCMP, the Comprehensive Conservation and Management Plan for the Bay-Delta Estuary, was first signed in 1993? This was the question posed in many guises—with many different answers—at the October 2007 State of the Estuary conference on the 15 anniversary of the CCMP. The vital statistics and abstracts in this report present data, opinions, and the latest science about pressing issues and "to do" lists for the Estuary. And below, several Estuary thinkers share their thoughts on how well we are doing at accomplishing the CCMP goals of restoring wetlands, improving conditions for wildlife and aquatic organisms, achieving sustainable water and land use, preventing and cleaning up pollution, dealing with dredging, and educating the public about issues affecting the Estuary.

Marc Holmes, The Bay Institute

I think the question mark in "A Greener Shade?" is merited. Right now, almost every assumption that we made ten years ago about the future is in serious doubt, from the value of tidal wetland restoration with rising sea levels, to our ability to sustain Estuary fish in the face of drought and ongoing excessive water diversions. Add to those the unpredictable impact of thousands of pollutants on the ecosystem and, with these variables alone, it is becoming increasingly clear that we don't have much of a clue about how to proceed. As an environmental community, we certainly should be having frank conversations about this unpredictable future. Whereas in the past, we thought we were struggling only with the question of how to sustain the ecological vitality of the Estuary in the face of wildlife declines, since Katrina, the POD, and sea level rise, we now are faced with the reality that we also are unable to sustain California's traditional economic activities related to the Estuary. We now must consider not simply tweaking the plumbing to increase fish numbers, but retooling the entire Central Valley land use map, as well as the activities of all of urban California that relies on Estuary water. That is to say, the California way of life requires complete overhaul. Even if we agreed to sacrifice threatened and endangered species, we can't afford to armor the Delta and other low-lying areas against sea level rise, for instance.

This new awareness has stunned policy makers who believed that the California dream could continue indefinitely. Not only have they failed to plan for this new environmental world order, they continue to defend the old way of life. They can't have it both ways.

Leo Winternitz, CALFED Bay Delta Program

Clearly we're worse off than 15 years ago. We have the pelagic organism decline (POD); we have toxic algae in the environment, more invasive species, greater urbanization in the Delta. We're not better off, and those are the symptoms. The big symptoms are the numbers of lawsuits being filed once again in this arena: they are indicative of problems we're facing and haven't been able to resolve.

In terms of our thinking, we're better off. We understand more; we know better what we don't know. Perhaps we're a bit more sophisticated in recognizing that we don't have the answers and that therefore our plans have to be able to accommodate mistakes or things we don't know. For instance, we've recognized over the last 15-20 years the immense values of floodplain attenuation and the values of floodplains for the ecosystem.

We've come to recognize that water is a very limited resource, and that the system is probably overappropriated in terms of water diversions as we look at their effects on the environment. We've become smarter not just at doing things but in recognizing uncertainties in what we do and acknowledging those, so in that sense we're a lot greener. Can we put this knowledge to use, to action in the near future and for the long term? I don't know; we'll have to find out.

David Lewis, Save the Bay

In some areas we've made significant improvements, and in other areas I think we've lost ground. We've made the most progress meeting wetlands and habitat goals; 15 years ago we still had to convince people that wetlands were important; 5 and 10 years ago we still had to convince them that wetlands needed to be acquired and protected. Now we have almost 40,000 acres waiting to be restored. Save the Bay's polling shows strong support for helping pay for that work. Proposing to destroy wetlands on the Bay shoreline is pretty close to impossible these days—that's a big change in 15 years. Is there more work to do? More places to acquire? Obviously a lot. And there is increased pressure to expedite the pace because of sea level rise. We will be able to restore more and restore more easily and with more benefits the sooner we do it; the longer we wait the harder it will be to get it started, and the harder it will be to have a maximum benefit. I'm optimistic, though, because of public attitudes and institutions. We've also made big progress in 15 years on water quality, and we're on the verge of making more. Most of that progress has been in point source regulation. Where there hasn't been as much progress is on non-point source—trash and other pollutants. But there is growing public understanding, and potential for significant effective regulation. If something dramatic doesn't happen with the Bay Area stormwater permit and soon, I think the Bay Area will go the route Los Angeles did—with litigation.

Black-necked stilt
Photo courtesy of Jean Matuska.

Tom Mumley, Chair, CCMP Implementation Committee, S.F. Bay Regional Water Quality Control Board

There is heightened communication and awareness of Estuary issues, and we have much improved monitoring and planning. There is greater appreciation of the Estuary's values and the challenges in sustaining and improving them. We have stopped the loss of wetlands and we are now restoring them. We see benefits of pollution prevention and control actions resulting in continued decline of legacy pollutants such as mercury and PCBs and much improved management of copper and pesticides. We now manage dredging and disposal of dredge material in an environmentally beneficial way, and we are seeing more and better watershed-protection based land use. That said, we face major challenges with the continued emergence of new chemical pollutants and influx of invasive species, and as we make progress managing water use and floods, we must account for the future consequences of climate change. Fortunately, we have created partnerships and collaboration forums to give us cause to be optimistic that we will successfully conquer these challenges.

EXECUTIVE SUMMARY

A version of this summary appeared as a December 2007 ESTUARY newsletter article.

The stated theme of this year's State of the Estuary conference was "A Greener Shade of Blue," and the conference returned a mixed verdict on whether or not the Estuary and its watershed are in fact "greener." On an unusually rainy October morning, Oakland city council president Jean Quan welcomed a crowd of nearly 600 people to the Scottish Rite Center on Lake Merritt's shores, reminding them that water quality and restoration are a priority for Oakland, which was recently named the country's fifth-most-sustainable city and has passed Measure DD, which provides $200 million to restore Lake Merritt and Oakland's creeks. Following Quan, ABAG's Henry Gardner, the Bay Area Council's Jim Wunderman, NRDC's Barry Nelson, Delta Vision Blue Ribbon Task Force's Phil Isenberg, BCDC's Will Travis, and Redefining Progress's Michel Gelobter brainstormed about the role of the Delta in the future of the Bay Area.

"How can we balance social justice, sustainable development, and the environment while moving forward with the Bay-Delta?" asked Gardner. "We will have a continuing challenge in providing housing for all of those who need it. Many cities granted conditional use permits in the communities closest to the Bay in low-income and minority communities to support a variety of business activities. That had a devastating impact on some of those communities, conditions that persist today."

Wunderman spoke of the Bay's importance, both as a draw for tourists, with 260,000 area jobs devoted to tourism, and as a major attractor of new residents. He also spoke of the Port of Oakland's importance as the fifth-largest port in the United States and as a provider of blue-collar jobs. "The Port of Oakland has tremendous expansion capabilities consistent with the environmental sustainability of the Bay," Wunderman declared. "It's underutilized as a transportation mechanism." Wunderman concluded by assuring the crowd that the business community sees the health of the Bay-Delta as critical.

BCDC's Travis jumped right to climate change. He predicted that all of the Bay previously lost to fill will eventually be reclaimed by Bay waters. Other manifestations of climate change will include more frequent storm surges, heavy rains, high tides, and high winds, plus extended droughts and wildfires, he warned.

> **"The issue is not whether we are playing God—we are already doing that—but how to get it right."**
>
> Will Travis, BCDC

"[Climate change] will have profound local impacts. We need a plan that anticipates that." But the devil is in the details, he admitted. "How do we plan a region and a Bay that will surely get bigger? We are going to have to build a lot of levees that are big enough and strong enough to hold back floods around the airports. We also need to take a hard look at where it might be most cost-effective to remove existing developments and replace them with wetlands, which absorb floods and sequester carbon."

Also on Travis's to do list: "abandon any future plans to develop low-lying areas." Said Travis, "We need a plan for the Estuary that is bold and audacious. We've got to stop talking about how to restore it to the way it was; we need to design for different elevations, chemistry, species, to do proactive management. The issue is not whether we are playing God—we are already doing that—but how to get it right."

Isenberg addressed the Estuary's political geography. "Why are the Bay and Delta two different political regions despite being connected? I say it is a pure artifact of notions of regional self-importance—it's human nature that each of us is the center of the universe." Isenberg told the largely Bay Area crowd "your strength is your weakness. You agreed on what it meant to save the Bay, playing to the strength of regional importance." But now, the forgotten Delta must take center stage, said Isenberg.

The Delta Vision Task Force was charged with creating a plan to protect and improve the Delta ecosystem, said Isenberg, while at the same time protecting and improving the state's water supply system. "The Delta ecosystem is going to hell. Not one person or organization has said that the Delta is in good shape. [The Delta issue] is collectively much more than the Bay Area because it's the transfer point of all the water that comes in. Where should the state go on the question of the ecosystem?" Isenberg pointed out that it is not just the swimming pools of Southern California and Coachella Valley taking water from the Delta; it is also—and has been for a long time—the Bay Area. "It can't be 'our water projects are good, and theirs are bad.'"

NRDC's Nelson presented himself as the "panel historian," taking the crowd through key dates in the Bay's history and how its role has changed from when it was discovered by Europeans to mining and commercial interests to the building of the Central Valley Project, which he christened "the dawn of the golden age of the hydraulic frontier. We built the highest dam in America, the most elaborate plumbing system, and the largest pumps on the face of the planet. It was an astonishing accomplishment." But the frontier has closed, said Nelson. "We've operated on the assumption that we can always take out more water this year than the last. But there are real limits to how much water we can take out. The entire Colorado River has been captured; there are signs that we are hitting that limit in San Francisco Bay." The end result? "It's not a surprise that fisheries are down as diversions are up," said Nelson. "It's hard to make the case that we can take more water out." There are alternatives—cheaper ones—to pumping more water, said Nelson. "We could divert less, invest in recycled water, and save energy and greenhouse gases. We need to ask ourselves whether we are entering the era of sustainability or collapse."

Redefining Progress's Gelobter drew parallels between Hurricane Katrina and New Orleans and the potential for similar disaster in the Delta if we don't take action to prevent it. If we were to be pro-active in fixing the Delta, said Gelobter, "we could be a model for the world." The panel session concluded with Gardner asking what the business community can do to help protect the Bay and Delta. Wunderman responded that we need to focus on better integrating transit and development. "We made a mistake," said Wunderman. "We screwed it up by not having the proper balance between housing and public transit. But we're beginning to get it. It's time to focus on the urban core and develop a transit system that supports it. We have to figure out how to overcome the resistance to change that is inherent in the business community."

The late morning and afternoon sessions were devoted to presentations on important changes in the Estuary and how they will be managed. The S.F. Regional Board's Tom Mumley suggested that with new pollutants constantly emerging and possibly affecting water quality, the state should consider adopting a "California product stewardship council" that would require manufacturers to adopt a "cradle-to-cradle" approach for their products in order to reduce waste and pollution. The Board's Richard Looker built on that theme, pointing out how many societal benefits have a parallel environmental impact: controlling pests can equal aquatic toxicity; preventing fires can lead to PBDEs in the Bay and its wildlife; health and beauty products not removed in wastewater treatment can disrupt endocrine and other functions in fish; the products and processes leading to economic health have often led to long-lived environmental contaminants.

"We need to ask ourselves whether we are entering the era of sustainability or collapse."

Barry Nelson, NRDC

Another emerging challenge for Estuary resource managers is climate change (and associated sea level rise). The SFPUC's Michael Carlin discussed how urban water managers are trying to cope. "The San Francisco water supply is going to be rain dominated instead of snow dominated," said Carlin. The SFPUC plans to diversify its water sources, he said, by becoming part of a Bay Area-wide regional desalination project, by relying more on groundwater, and by using graywater to flush toilets.

U.C. Berkeley's Matt Kondolf also discussed the impacts climate change will have, particularly on the Delta, which he warned could be "New Orleans East. We have created the same conditions for a similar disaster in California," he said, describing how levees raise the flood stage. "The Delta region is growing faster than Mexico. Housing below sea level will inevitably flood." Kondolf also pointed out that a 100-year flood (a 1% chance every year) is not the only flood that could occur. "We could also get a 200- or 400-year flood," he warned.

SFEI's Josh Collins said scientists need to come up with a new set of tools for simulating habitat response to climate change, in order to make choices among scenarios. "Tracking change is not enough," said Collins. "With the increased rate of change, wetlands won't be protected. Wetlands should be viewed in their watershed context. There's a logical progression from watershed-based wetland planning to protection."

One positive change in Estuary management, according to BCDC's Steve Goldbeck, is the progress made in using dredged spoils for beneficial uses—i.e., wetland restoration projects. Since the Long Term Management Strategy (for dredged materials) was implemented in 1993, said Goldbeck, the volume of material disposed of in the Bay has been reduced by 50%. "Our long-term goal is to have no more than one million cubic yards per year of in-Bay disposal," said Goldbeck. "We are halfway there."

And Cal Fish & Game's Susan Ellis described another positive change, exemplified in how her agency responded rapidly to the quagga mussel invasion. "We had a unified response using incident command with state and federal agencies, Metropolitan Water District, the City of San Diego, and a multi-state quagga team. We have them contained in Southern California right now."

The afternoon session focused on important changes to aquatic resources and wildlife—fish, mammals, and birds—in the Estuary. DWR's Ted Sommer reviewed the state of the latest science on the "pelagic organism decline" (POD) of Delta and longfin smelt, threadfin shad, and striped bass. Probably the most pressing—and as yet unanswered—question is whether Delta smelt have dropped below critical population levels. As far as the cause of the decline, said Sommer, scientists are asking themselves where anything has changed in the Delta, and how and why. In 2007, there was increased toxicity in the Delta from contaminants and toxic algae that moved into core Delta smelt habitat, a decline in recruitment and habitat quality, reduced food availability due to invasive species, and increased mortality. There was also more smelt mortality at the pumps in recent winters when pumping increased to the point of creating negative flows in Old and Middle rivers, said Sommer. "At this very moment, scientists from all over the world are trying to figure [the POD] out," said Sommers.

U.S. EPA's Bruce Herbold built upon Sommer's talk, telling the audience that "scientists have found a lot of what caused the POD, but that's not going to solve the problem. Everything else is secondary to the fact that there's not many fish out there." Herbold said that genetic diversity in the smelt population may be so low at this point that the viability of their offspring is affected. Another problem is that their fall habitat has shrunk and moved eastward. Why? "We've stabilized flows," said Herbold. "They used to be very variable." Herbold suggested that the Delta has become more like a lake. "This means less estuarine fish. The POD may have been a tipping point—from a variable estuarine system to a steady state/lake-lagoon type of system."

Fish & Game's Kathy Hieb broadened the focus from the Delta to the Pacific Ocean, describing how changes in ocean temperatures and nutrients are affecting the Estuary's aquatic critters. In warm water years, Dungeness crab have poor embryo and larval survival, while Pacific herring, which go back and forth between the Bay and the ocean to spawn and rear, respond poorly to El Niño years. "They prey on zooplankton," said Hieb. "When the ocean is warmer, there's less zooplankton." With warmer ocean temperatures, Hieb predicted, there will be poor recruitment of cold temperature species and migration to the Bay of more warm water tropical species. She also predicted more "dead zones" from toxic algal blooms, caused by the increase in nutrients resulting from warmer water.

U.S. Fish & Wildlife's Joelle Buffa switched the focus to mammals, discussing the state of the endangered salt marsh harvest mouse and harbor seals at South Bay refuges. Buffa described how managers have taken various actions, including acquiring land, removing fill, reintroducing tidal action, and conducting other water management activities, to aid the mouse. In one instance, they created a "mouse pasture," transplanting mice from a proposed development site and tracking them afterwards. "We learned that the mice do colonize new habitats, and that salinity is important [to encourage pickleweed growth]," said Buffa. "Translocation can be successful where the population is low and where you create high tide refugia."

"A small change in the elevations of mudflats could make a different to shorebirds if we start having sea level rise."

John Takekawa, USGS

USGS's John Takekawa presented an avian perspective on the Bay—which, because there are so many species of birds with such different lifestyles—is complicated. "If you don't have long-term data, it is very hard to make sense of complex phenomena," said Takekawa. He and his colleagues are now studying the movements of individually marked birds. One surprise was that the South Bay's Colma Creek, surrounded by industry, is one of the most important spots for clapper rails in the entire Bay. With multiple restoration projects taking place around the Bay, said Takekawa, we need to keep looking at all of the projects from a bird's eye view to evaluate their effects. He added that migratory birds responded quickly to South Bay salt pond restoration, with overall numbers increasing at the ponds. "But will mudflat values be decreased?" he asked. "A small change in the elevations of mudflats could make a different to shorebirds if we start having sea level rise. Their time for foraging could be decreased, along with a corresponding decrease in population."

The morning session of Day Two refocused on the Delta. The CALFED Science Program's Michael Healey said that as sea level rises, new development will need to be better planned to reduce the risk of flooding. "The Delta of the future is not going to be the same as today," said Healey, echoing Travis's comments about the Bay. "We need to plan and design for a Delta that will deliver the services we value." Healey also stressed the need to "monitor and massage" what's happening in the Delta. "There are no right or wrong solutions; just better or worse. We need to take a much more adaptive approach. As soon as you impose one solution, the system changes in response, and you have a whole new set of problems to deal with."

The Public Policy Institute's Ellen Hanak gave an overview of the Delta's value to society—water supply, agriculture, ecosystems, infrastructure, recreation, and hunting, among others. With the housing market slowing down at least temporarily, said Hanak, there might be a short-term opportunity to make changes in the system. "There's the real possibility that we could encounter big problems in the Delta before a new management strategy is in place. There's a two-thirds risk of a catastrophic failure over the next 50 years, with earthquakes and sea level rise. What this means in terms of those services is that the holes [described by PWA's Phil Williams, see below] in the Delta would be filled with water coming from the Bay. We would have to shut down the pumps for a while. We can't go back to the Delta of 150 years ago, but we can't stand still either," said Hanak. "The Delta's fragility is California's central water management challenge." Hanak concluded by predicting that "everyone will not get better together in the Delta of the future."

USGS's Dan Cayan told the crowd that sea level rise in S.F. Bay has followed the historical patterns of global sea level rise, predicting that "we can expect both a drier and a more hazardous water future, and a saltier Bay-Delta environment compared with the historic environment." Cayan also predicted that a sediment deficit will probably be a critical part of the future Delta and said that warming temperatures are approaching lethal limits for fish. "For some fish species in the Delta, an increase of a couple of degrees could catapult the situation into catastrophe."

DWR's Ralph Svetich described the ongoing Delta Risk Management Strategy study examining the fragility of the Delta's levees. Phase 1 examined the risk to Delta levees from earthquakes, floods, sea level rise, subsidence, and a combination of all of those occurrences. An independent review panel was critical of the report, and a revision is pending. Phase 2 will evaluate individual risk reduction strategies based on risks found in Phase 1. So far, said Svetich, the preliminary phase 1 results show a risk of island inundation in flood events, with a high probability of failure for western and central Delta islands, a finding that closely matches U.S. Army Corps models.

The Suisun Resource Conservation District's Steve Chappell reminded the audience of the importance of Suisun Marsh, the "forgotten link" between the Bay and Delta. Chappell described the river otters, salt marsh harvest mice, short-eared owls, Suisun thistle, and other native and non-native species, including fish, that live in and around the marsh, and the many migratory waterfowl and diving ducks that use it. Chappell also described the programmatic CEQA/NEPA process underway for a Suisun Marsh management plan that includes some tidal marsh restoration. "Opportunities are better in Suisun Marsh for restoration than in the Delta," said Chappell. "It is not as subsided." Of course all restoration is predicated on willing sellers, stressed Chappell. "Salinity intrusion is a big issue," said Chappell. "As are mercury and carbon. We have to consider those in plan implementation."

"The Delta's fragility is California's central water management challenge."

Ellen Hanak, PPIC

Following on the carbon theme, USGS's Roger Fujii described how a pilot project at Twitchell Island flooded tules to encourage decomposition, and rebuilt subsided soils at the same time. As the tules die and decay, the marsh sequesters carbon dioxide at higher rates than agricultural fields. With microbial decomposition offset by biomass accretion, the land surface builds back up. Fujii reported elevation gains of up to four inches per year. By increasing accretion rates to nine inches per year, the Delta's accommodation space could be reduced by 70% in five years, said Fujii. The amount of carbon dioxide sequestered would equal the reduction in emissions if all the SUVs in California were swapped for Priuses, said Fujii.

The afternoon session broadened the focus to the question of how to integrate restoration into managing watersheds for flood protection, recreation, water supply, and a laundry list of other beneficial human uses. First up was PWA's Phil Williams, who stressed that any management actions taken to improve the Delta will also affect the rest of the Estuary. "We've created a massive hole—up to 20 feet below sea level—on 340,000 acres of farmland behind levees in the Delta," said Williams. "I don't believe we've fully grasped how this will affect physical processes and how that will affect the rest of the Estuary."

That huge hole is subsiding about six times faster than sea level is rising, said Williams, which means that, in a "doomsday" scenario, a large portion of this volume could end up in tidal waters. "The whole tidal Estuary could get a lot bigger," said Williams. "The area of San Francisco Bay would be doubled, but just as important, the physical processes—the tides, the movement of saltwater and sediment that sustains the Bay—could be significantly altered."

U.C. Berkeley's Mark Stacey moved south, to the salt pond restoration project, discussing its possible effects on the rest of the South Bay. In a study of the island ponds adjoining Coyote Creek, Stacey found that as more water moved up the creek through the breaches into the ponds, there was an increase in the tidal prism, but the effects of the changes were different across different phases of the tides. "When you open up the restoration sites to tidal action, it dissipates the funnel effect that characterizes the far South Bay, which could change the inundation regime for high marsh habitat," said Stacey. A decrease in amplification is good for diminishing flooding, but bad for marsh habitat. "The changes in tidal prism increase water velocity locally, but also change dissipation and reduce inundation at a much larger scale," said Stacey. And because sources of sediment for the restoration project are "down Estuary," the restoration sites are not going to capture much sediment, said Stacey. There is very little sediment coming in directly from the watershed; instead the sediment reaching the restoration sites is likely to be coming from the far South Bay via recycling by tides and winds.

Moving to the North Bay, the Sonoma Land Trust's John Brosnan discussed the realities of trying to integrate watershed and wetlands restoration planning. Brosnan said his agency is trying to achieve the goals set forth in the Baylands Ecosystem Habitat Goals Report and the CCMP. Yet, using the ongoing Sears Point Restoration Project as a case study, he showed how constraints like flood protection, invasives control, remediation, multiple users, sea level rise, and physical infrastructure—in this case Highway 37 and a rail line—are not only splitting up the landscape, but also "dictating what we can and can't do with integrating wetlands and tidal wetlands." Having a rail line there triples the cost of restoration, said Brosnan. "Once the agricultural levees are taken down [for restoration], we have to build bigger, stronger levees for the railroad and Highway 37 because of sea level rise." Despite "huge buy-in" from neighbors, ranchers, and farmers, said Brosnan, "the highway and railroad line [which refuses to help defray the costs] are driving the outcome."

SFEI's Letitia Grenier stressed the need to give wildlife conservation equal stance with flood protection and clean water supply in our quest to restore the "physical, biological, and chemical integrity of the Estuary" as set forth in the CCMP. "It's all part of the same goal," said Grenier. "Wildlife inhabit landscapes. What we do in the Bay affects the whole flyway. There are four to five million birds coming through here. How can we act on a landscape scale to keep them here?" Our modern landscape has seen a huge loss of connectivity, she said. "We have the tools to plan for providing better connecting habitat for wildlife, but we lack a common vision. We haven't really specified what our wildlife goals are. Instead, we are stuck waiting for a crisis. How can we invest earlier in landscapes for wildlife? Conserving wildlife is like a lot of the other ecosystem functions we are interested in. We need to think and plan on a landscape scale."

Citizens Committee to Complete the Refuge's Arthur Feinstein offered a pragmatic perspective of wildlife conservation around the Bay. "What's not to be thrilled about?" asked Feinstein. "We have over 100 species of wildlife and plants listed as endangered or threatened. No Bay Area species has yet been delisted." As solutions, Feinstein suggested that we need to focus on habitat diversity, links between habitats, bigger areas of habitat, and freedom from human harassment.

Public access has had a negative impact on wildlife, said Feinstein, citing birders who harass the birds they are watching and boaters who disturb resting ducks on the Bay, and development near sensitive areas, such as the least tern habitat at the old Alameda Naval Air Station. "Once you get people into wild areas, even urban areas, you're going to lose your diversity," said Feinstein. "Even in very dense areas, if you keep people away, there are nice wildlife effects. If we want full environmental restoration and large diverse habitats," concluded Feinstein, "we also need to control us."

Coastal plant ecologist Peter Baye addressed the fact that many of our tidal marsh restoration projects to date have not included rare plants that could be collected from remnant sites and propagated, helping to ensure their survival as species. One example is a rare salt marsh owl's clover that still exists in Whittell Marsh near Point Pinole. "Almost none of these rare species are finding homes in tidal marsh restoration sites," said Baye.

"Even where there are well-developed marsh plains and channels, 30 years later [these restoration projects] still support only the most common tidal marsh species." Discussing the restored Muzzi Marsh, Baye pointed out that no uncommon species have dispersed from nearby Heerdt Marsh, the oldest prehistoric marsh in the area, to colonize Muzzi. Baye ended with a series of recommendations for restoring diversity, including designing restoration marshes more creatively.

> **"Almost none of these rare species are finding homes in tidal marsh restoration sites,"**
>
> **Peter Baye, Coastal Plant Ecologist**

Creativity has been critical in restoring the Napa River, according to Napa County Flood Control's Richard Thomasser, who described the history of this multi-year, multi-stakeholder, multi-objective ongoing effort. After the Army Corps presented a plan to channelize the river in concrete in the 1960s (and again in the 1990s), the community demanded that any plan for flood control also be a plan for a "living river" that would connect the river to its historical floodplain. As a result, the consensus-based project includes both a geomorphic channel design that will return proper sediment transport balance and the creation of 650 acres of wetlands. Five major bridges are being made higher and longer to free up hydraulic constrictions, and to span the channel and the new marshplains, said Thomasser; two bridges were completely rebuilt. "The river and habitat now have some room to move."

The S.F. Bay Regional Board's Bruce Wolfe gave an overview of his agency's efforts to protect both riverine and marsh wetlands. "We're better regulating development of upland areas," said Wolfe. "We are now trying to manage flows better than we have and the changes in runoff patterns that development causes." Wolfe said his agency no longer takes water quality-based effluent limits from a national list, but instead tackles them on a statewide and regional (Baylands) basis. "TMDLs are really watershed plans," said Wolfe. "We are now looking at wetlands and streams as a physical unit. Wetlands are really the deltas of riparian systems." Another change at his agency, said Wolfe, is recognizing that riparian zones have many benefits.

The Coastal Conservancy's Steve Ritchie built upon the "deltas" idea. As the salt pond restoration project nears the end of its five-year planning process, said Ritchie, "what about the ponds' connection to local watersheds?" But making that connection might be complicated. "It's flood protection with restoration, not just a fun little restoration project," said Ritchie. Key challenges are: The Guadalupe River watershed is the single worst source of mercury in the Bay, and dry weather runoff contributes to poor water quality.

Perhaps the most poignant example of trying to integrate restoration into watershed management and water supply was that of the long-term efforts to restore steelhead to Alameda Creek, the focus of the afternoon session. The National Marine Fisheries Services' Maura Moody started off by describing the recovery plan being drafted for Central California Coast salmon and steelhead. The Center for Ecosystem Management and Restoration's Andy Gunther said that while the Bay Area does possess a massive greenbelt, the creeks that connect to the Bay are under increasing pressure. "Choosing restoration will require that we conduct experiments on how to restore steelhead trout. Their fight upstream is both mysterious and inspiring. Returning these wild creatures provides something to us as well," said Gunther. The lifecycle and impact these fish have had over time, said Gunther, give them the cultural status of "charismatic megafauna. Steelhead can drive ecosystem management: They use an entire watershed in their lifecycle. They can help preserve the landscape for future generations."

"Returning these wild creatures provides something to us as well."

Andy Gunther, CEMAR

The Alameda County Water District's Eric Cartwright described some of the physical barriers that will need to be addressed to restore passage for these fish. "The question is how to provide passage through the flood control channel while keeping the existing benefits the channel provides," said Cartwright. When the Army Corps built the channel, it did not provide for fish passage, said Cartwright. However, the District has decided after conducting several studies that it can remove the lowest rubber dam and keep it out of the channel permanently. At the upper rubber dam, the District will build a fish ladder and install fish screens at several intake structures. Other challenges include funding and instream flows.

The Alameda Creek Alliance's Jeff Miller gave an historical overview of steelhead presence in the watershed, describing how Calaveras Dam, built in 1925, cut off access to the best habitat. The watershed also supported coho and Chinook salmon at one time, said Miller, and remnant steelhead runs persisted until 1964. Today, steelhead are still trying to make it up the creek, despite its obstacle course. But attitudes have changed during the last two decades, and during the last decade, 27 fish were successfully caught and moved upstream by volunteers, dramatizing the need for fish passage improvements. "We're poised to restore these fish," said Miller. "Their visibility and persistence in showing up every year has galvanized us." The Alliance now has more than 1,500 members and more than 15 agencies cooperating in restoration. Genetic analysis of landlocked fish and anadromous fish below the dams show their genes to be closely related. "The biggest question is whether there will be enough water left in the stream," said Miller. "Right now, none of the agencies release flows for fish. The draft EIR [for the Calaveras Dam replacement] does not allow for minimum flows for fish. We're hoping to work with the SFPUC to address the impacts of these dams."

POLLUTION: Can We Clean It Up?

Thursday's pollution session focused on legacy and emerging pollutants and their impacts on wildlife, as well as the trash epidemic in the Estuary and its watersheds, and the challenges and solutions involved—here and elsewhere—in cleaning up our mess.

First off on Thursday morning, the Marine Mammal Center's Denise Greig described her studies of Bay harbor seals and emerging contaminants. "They eat at the same trophic level humans do," said Greig. "PBDEs in San Francisco Bay seals increased between 1989 and 1998. They also have mercury, lead, PCBs, and DDT in their bodies." Between 1989 and 1998, the PBDE levels were higher even than those of contaminated Baltic Sea seals, said Greig, adding that PCB concentrations in healthy Bay seals appear to be decreasing, while DDT metabolites are increasing. "So even though they are banned now, they get stirred up from the sediment, are present in harbor seals, and passed from mother to pup," explained Greig. The latest worry is PFOS—perfluorooctane sulfonate—another flame retardant. "We only have a small sample so far, but the levels are high compared to Artic polar bears and ringed seals," said Greig.

Greig was followed by Collin Eagles-Smith, who described the risk to Bay birds from mercury. Eagles-Smith examined mercury concentrations in surf scoter, American avocet, black-necked stilt, Forster's tern, and Caspian tern adults, chicks, and eggs, finding mercury concentrations to be highest in Forster's terns, followed by stilts, Caspian terns, scoters, and avocets. Risk to hatching success was found to be greatest in the South Bay, and 58% of breeding Forster's tern adults and 46% of their eggs exceeded toxicity thresholds established for other birds, raising the question whether population impacts might be occurring. "This is striking and concerning," said Eagles-Smith.

Kevin Kelley from CSU Long Beach moved from birds to fish, describing the results of his studies on Pacific staghorn sculpin and shiner perch. He has found PCBS, PAHs, and chlorinated pesticides in the livers of both species, as well as evidence of endocrine-disrupted states. "Endocrine disruptors serve as biomarkers of environmental perturbations," said Kelley. "We have indeed seen endocrine disruption in the Bay in different fish species." Kelley is now looking beyond estrogenic effects to wider physiological impacts and performance. "We consistently find impairment near publicly owned treatment works sites," said Kelley.

Tracy Collier of NOAA and Sandie O'Neill of the Washington Department of Fish & Wildlife described their agencies' collaborative work on toxics in Puget Sound, pointing to the need for a biological observation system for toxic contaminants. "If you just look at the sediment community profile relative to other estuaries and bays, Puget Sound is not that contaminated," said Collier. Yet biologically based monitoring has shown contamination of the pelagic food web, including PCBs in herring, said Collier. "You would not have predicted that from sediment and water measurements."

He also showed results of their work on a syndrome they have termed "pre-spawn mortality" that is being observed in coho salmon returning to spawn in Puget Sound streams. "We're spending millions to restore ecosystem attributes that should be sufficient to support life, but 60% to 90% of these salmon die before spawning," said Collier. The bottom line, he said, is that "compared to monitoring sediment and water, the animals can tell you more."

> **"Ninety percent of [the plastic debris] will take years or decades to decompose; when it reaches the ocean, cold saltwater tends to preserve it."**
>
> David Lewis, Save the Bay

Steve Bay, of the Southern California Coastal Water Research Project Authority, wrapped up the session on the biological effects of pollution. Bay showed how his project uses a "multiple lines of evidence" approach to integrate chemistry, toxicity, and benthic fauna data to provide an overall assessment of sediment conditions in California. Most of S.F. Bay fell into the "possibly impacted category. We were surprised; we were expecting to see 60% of Bay sediments as having 'little or no evidence of impact,'" said Bay. "Instead, a very high amount turned out to be possibly impacted." Eighty percent of monitoring stations showed significant sediment toxicity, said Bay.

Midday, talk turned to trash, specifically to the overwhelming plastic problem in the Estuary, its creeks, and the ocean. Moderator Larry Kolb estimated that the number of plastic bags (which frequently end up in the Bay and its creeks and stormdrains) used by the public averages out to one bag per person per day. In the Bay Area, with seven million people, said Kolb, if only one in 1,000 people uses a plastic bag, that would still amount to 7,000 bags per day.

Save the Bay's David Lewis described the overall potpourri of trash in the Bay. "It's not from ships, but from us," said Lewis, adding that only 20% of water-borne trash comes from boats. Lewis said big sources of trash in Bay creeks are overflowing or inadequate trash receptacles and direct littering and dumping of household garbage. But Lewis emphasized that the biggest problem is plastic. "Ninety percent of it will take years or decades to decompose; when it reaches the ocean, cold saltwater tends to preserve it."

Possible partial solutions include Governor Schwarzenegger's newly formed Ocean Protection Council (tasked with tackling trash) and Coastal Cleanup Days (in 2006, more than 686,000 pounds of trash were removed from the Bay shoreline in a single day). Save the Bay is using ad campaigns to try to change people's behavior while some cities are implementing source reduction, banning plastic bags and Styrofoam food containers. But changing individual behavior will take some time to have an impact, said Lewis, who would like to see the S.F. Bay Regional Board implement stronger stormwater permits regarding trash. Trash separators and booms will work but not unless they are mandatory, said Lewis. "The Water Board could require significant trash reduction. Save the Bay has presented thousands of petitions asking the Board to do so." Lewis also described "end-of-pipe" capture nets used in places like Southern California that help divert trash before it ends up in the ocean. Lake Merritt is one of the few places around the Bay where vortex separators (mechanical devices) are being used to collect trash. The lack of effort to do so elsewhere around the Bay "should be an intense source of shame," said Lewis. "We need much stronger controls."

Lewis was followed by Nute Engineering's Steve Moore, formerly of the S.F. Bay Regional Board, who, while working there, designed and undertook a "trash rapid assessment" study to examine the sources, patterns, and amounts of trash in Bay Area waterways. "We certainly noticed the elephant in the watershed and felt compelled to come up with a method to measure it," he said. With Board coworkers, Moore surveyed 26 creeks around the Bay, from Petaluma to San Mateo, looked for longitudinal patterns in the watersheds they surveyed, and performed return surveys to determine the trash return rate. Oakland's Peralta Creek scored the worst of all of the sites, polluted with human waste and syringes. "We had to stop out of concern for our own health at one point," recalled Moore.

On 93 site visits, Moore's team picked up more than 25,000 pieces of trash, or three pieces for every foot of stream. Half of the trash was plastic, followed by glass and paper. The highest trash deposition rates were found in both wet and dry weather.

"It shows you that if you care about the Bay, you have to care about the creeks.

Steve Moore, Nute Engineering, S.F. Bay Regional Water Quality Control Board member

"We have to address trash in the dry season, too, not just after the first flush," said Moore. "It's either being tossed, washed, or blown in." Not surprisingly, the worst sites tended to be located at the bottoms of watersheds that receive runoff from an entire water- or pipe-shed. "As the low point in the landscape, these streams are sticky places," said Moore.

"It shows you that if you care about the Bay, you have to care about the creeks. Streams are the likely main pathway of floatable plastic to marine waters, and our trash levels are not improving but perhaps getting worse," said Moore, who added that he found trash in watersheds across all socioeconomic strata. "We need to invest in structural or other solutions and address it in a systematic way," concluded Moore. "Trash is today's sewage."

The next trash talker, the City of Oakland's Leslie Estes, described herself as a "visitor from the real world." Oakland has a toolbox of strategies for dealing with trash, Estes explained, from anti-littering programs in schools where street sweepers get to interact with kids, to "adopt a spot" cleanup programs with citizens, to enforcing penalties for illegal dumping, conducting clean creeks campaigns, and hiring kids to go out and pick up trash. The city recently banned non-biodegradable takeout containers and established an "excess litter" fee for all food facilities. It tried to implement a plastic bag ban like San Francisco's but was sued. It has also installed a boom across the mouth of Damon Slough (a trash "hot spot") and is targeting other known polluters upstream of the slough, like the Oakland Coliseum and flea market. But nothing is simple, says Estes. To install the boom, they had to build a road to service it and buy a truck to hold a crane. After the first flush, says Estes, as much as 6,000 pounds of trash is removed from the boom, an act that requires several days of cleanup. The city received $4.5 million from Measure DD to install structural controls at Lake Merritt. "This is our jewel, and it's trashed," said Estes. "In addition to the environmental impacts, what economic impact does that have?" The city is also installing drain inlet baskets (which need frequent maintenance) and stormwater separators in various watersheds. But these projects, says Estes, "are a big deal and mean big construction." Oftentimes, construction interferes with underground utilities, and being an old, built-out city, Oakland is full of surprises in that regard, said Estes. Her conclusion? "We would like to find the key answer but I believe the solution is a combination."

Estes was followed by Mark Cuneo of Santa Monica, who, after assuring the largely Bay Area audience that, unlike the stereotype of a Southern California water-sucking city, Santa Monica plans to be 80% independent from imported water by 2010, described his city's efforts to tackle stormwater pollution. Santa Monica only receives 14 inches of rain per year, but, surrounded on three sides by Los Angeles County, it nonetheless receives plenty of trash in runoff. Ballona Creek and the Los Angeles River have been put on the

303(d) list of impaired waterways due to trash (their mouths have had trash booms installed), and a trash TMDL has been put in place. "If you can avoid litigation over TMDLs and regulations, you're way ahead of the game," he advised. Over the past 10 years, Santa Monica has spent $120 million installing catch basin insets and screens, and a state-of-the-art stormwater treatment plant. In dry years, the city also "boards over" storm drain inlets to keep trash out. "But trash doesn't magically disappear out of these things; we have to do the maintenance," said Cuneo.

The afternoon session segued from trash back to other pollutants and what to do about them. SFEI's Lester McKee reported on our state of knowledge about pollutants in the Bay, citing PBDEs here as among the highest in the world. Pollutants in stormwater continue to prevent the Bay from achieving better water quality, said McKee, and though recent TMDLs call for significant reductions in mercury and PCBs, we do not have enough information about where the highest concentrations occur and how they cycle through the urban environment. However, he added, recent, first-of-their-kind studies have demonstrated that PCBs probably linger in greater concentrations in older industrial areas in the Bay Area, a clue that can tell regulators where to focus.

Alameda Countywide Clean Water Program's Jim Scanlin spoke of the challenges in trying to comply with the new TMDLs for mercury and PCBs. To do its part in reducing total mercury inputs to the Bay by 50%, Alameda would need to reduce its mercury inputs by 78 kilograms per year; similarly it would have to reduce PCBs by about nine kilograms per year. "Can we get there from here?" asked Scanlin, adding that his agency has found frequent street sweeping to be more effective than is generally thought at removing mercury.

EBMUD's Gayle Tupper described her agency's successes in working with dental offices to install amalgam separators that remove mercury, and in collecting mercury thermometers from residents, hospitals, and schools.

"Because so many heavy metals and other urban pollutants lodge in sediment, we ought to be looking at getting sediment out of stormwater."

Mike Stenstrom, UCLA

Seventy-five pounds of mercury was collected from East Bay residents in take-back events last year, said Tupper. An ongoing challenge is the pharmaceuticals that make their way into the Bay from being flushed or dumped down drains. "We're looking for ways to control these substances and raise awareness to convince people [the substances] shouldn't go down the drain," said Tupper.

Concluding the pollution session, UCLA's Mike Stenstrom told the crowd that "for better or worse, TMDLs are the driving force" behind cleanup efforts. He described modeling tools and data being used to evaluate alternatives for meeting TMDLs in the upper Ballona Creek watershed. Because so many heavy metals and other urban pollutants lodge in sediment, said Stenstrom, "we ought to be looking at getting sediment out of stormwater." To that end, he described some of the low-tech, green, "biofiltration" solutions that places like Seattle have implemented using vegetation—swales and stormwater planters (aka "infiltration trenches"), among others.

RESTORATION: Diverse Ecosystems And Challenges

Assessing progress on the Baylands Ecosystem Habitat Goals, Carl Wilcox of Cal Fish & Game recalled a colleague's optimism in 1995: "We'll do this in six months and 50 pages or less." Four years and countless meetings later, the goals—a biologically based vision for ecosystem restoration—launched a new era in Bay conservation, providing guidance for the S.F. Bay Joint Venture, the South Bay Salt Ponds Restoration Project, and county-level Habitat Conservation Plans. Next step: linkage with anticipated Subtidal, Upland, and Streams Habitat Goals, and with CALFED's Ecosystem Restoration Program.

NOAA Fisheries' Korie Schaeffer gave an update on the process of establishing goals for managing and restoring S.F. Bay's "hidden" subtidal habitat. "The focus will be on habitats we want to see more of or in better condition," she said. Her group is factoring in human stressors. "We can't just wave our arms and come up with some goals without realizing past impacts are still active," she said. A final goals document is expected by December 2008.

Nancy Schaefer of Land Conservation Services, Stuart Weiss of the Center for Earth Observation, and Ryan Branciforte of GreenInfo Network discussed another goal-setting project, this one for upland habitat. Phase I involves identifying how much land in what kind of condition will be needed to conserve the Bay Area's upland biodiversity, racing against urban sprawl. Vegetation mapping is already completed. Weiss said goals include preserving 90% of globally rare habitat and allowing room for ecosystems to change. "We set high goals because we can," he said. He foresaw partnerships with private landowners, including ranchers. "In grassland, a moderate amount of grazing is really the key to management over large areas," he said.

U.S. Fish & Wildlife's Eric Tattersall took on the contentious subject of habitat conservation planning. "If regional HCP is done the right way, we end up preserving large functioning ecosystems," he said, while project-by-project approaches lead to fragmented habitat. Tattersall described recently permitted plans in Santa Clara County and east Contra Costa County, and a pending plan in Solano County. "Every successful plan has a political champion who can bring it to fruition," he concluded. "Consensus? Forget it! There's too much conflict. What we're after is informed consent. It's not all you want, but better than the status quo."

Turning to the past, SFEI's Robin Grossinger looked at historical ecosystems as guides to restoration. "The historical landscape may be even more directly relevant than we had realized," he said. "Our society took over this landscape quite suddenly. We didn't ask for the owner's manual." Using old maps and written records, Grossinger is attempting to identify the wet and dry places, the intermittent streams, and the overlooked "B-side" habitat types, like sycamore alluvial woodland. Remnant seasonal wetlands in Santa Clara and Napa counties "are tiny fragments of former perennial wetlands. If you're interested in wetland restoration, historic wetlands show you where to look."

If ecological history can be obscure, the future of estuarine environments is up for grabs—with climate change a prime source of uncertainty. PWA's Jeremy Lowe said the S.F. Bay's marshes have handled historic sea level rises well. "But sea level rise will accelerate. Will the marshes keep up?" he asks. As the waters rise, mudflat and marsh systems tend to move landward—if enough sediment is available. In the long-term, we may need to recharge mudflats with dredge soil. Lowe discussed tradeoffs between leaving levees in place for wave protection and reconnecting marsh and mudflat, and possible engineering fixes.

Naomi Feger of the S.F. Bay Regional Board and Roger Leventhal of FarWest Restoration Engineering titled their joint presentation "Sediment—the Good, the Bad and the Buried." Feger presented case studies of three remediation efforts using dredged material: Hamilton Marsh, Peyton Slough, and the Peninsula Sportsmen's Club (the last a lead-shot contamination site). Leventhal noted some "regulatory discomfort with using fill at all; it's not a normal mouse-hugging kind of wetland project." But he argued that if you know your contaminants, dredged sediment can benefit restoration with "no net degradation." He said economic constraints must be overcome in order to increase beneficial reuse of sediments and reduce ocean disposal.

Next up was San Jose State University professor emeritus Howard Shellhammer, now with H.T. Harvey, who has spent 50 years studying the endangered salt marsh harvest mouse. He discussed small mammals—the mouse and the elusive salt marsh wandering shrew—in tidal marsh restoration projects. The shrew may or may not still exist in the Bay's marshes; if it's there, it will benefit from mouse conservation measures. Both need mature marshes with internal escape cover and high marsh tidal refugia, but very little high marsh remains. Reducing the slope of outboard dikes to allow for high marsh development would help, as would connectivity between mouse habitat sites. "We think we can meet these architectural guidelines in the next few decades," Shellhammer said.

> **"Sea level rise will accelerate. Will the marshes keep up?"**
>
> Jeremy Lowe, PWA

PRBO Conservation Science's Nadav Nur reviewed birds as indicators of marsh restoration success, measured by demographic metrics: reproductive success, recruitment of juveniles, survival of adults, emigration, and immigration. He said local-scale data is important. "There's concern that restoration sites are ecological traps—sinks, not sources." Nur documented different patterns for different bird species. Mature marsh sites had a 1,500% higher density of salt marsh common yellowthroats than restoration sites. However, song sparrow nestling survival rates were highest in some of the restored marshes. Biologists are also looking at demographics of California clapper rails, great blue herons, and upland songbirds.

Christy Smith of the San Pablo Bay National Wildlife Refuge reported on tidal marsh restoration and enhancement projects at Tolay Creek, Tubbs Island, and Cullinan Ranch, each presenting its own set of challenges. At Cullinan Ranch, for example, partial or full restoration would require new levees to protect Highway 37 from flooding. Smith stressed adaptive management ("measure three times, cut once") and the need to keep restoration partners involved.

Smith's South Bay counterpart, Clyde Morris of the Don Edwards S.F. Bay National Wildlife Refuge, looked back on seven restoration projects spanning 20 years. "It must have been really fun back in the 80s to restore things," he said. "You didn't worry too much about permits, and plans were something you did on the back of an envelope." But he's seen things improve—with the South Bay Salt Pond Restoration, "for the first time in my career we're doing adaptive management instead of knee-jerk management." Still there have been surprises, like the challenge of dealing with dissolved oxygen. "You don't always know what you don't know," said Morris. "We need to commit not to do more restoration without funding for adaptive management, because without that we won't be successful."

In his talk on restoring Delta ecosystems, Stuart Siegel of Wetlands and Water Resources called this huge area "a case study in complexity." Manmade changes—diking islands, shortening channels—complicate the goal of maintaining "viable populations of desirable species. In the Delta, we don't say 'native'; there are some non-natives people like to have, like striped bass." Climate change introduces further complexities. "Wetlands can move up gentle slopes as sea level rises, but not with levees," Siegel said. He sketched ideas emerging from current planning efforts, including new floodplains and "green" levees.

When S.F. State University's Tom Parker took the podium, it was late in the day. "When I go to conferences, usually by this time I'm out drinking somewhere," he quipped. But his message was no joke: global climate change imperils the Estuary's marshes. Temperature increase may decrease primary production; inundation and flooding will increase, with restored marsh sites inundated more than natural sites. Rising salinity will reduce species diversity. "Given temperature and salinity increase and marsh accretion rates failing to keep up with sea level rise, what's the scenario?" he asked. "The winner is pickleweed," which occurs now in a variety of salinity and inundation conditions. But it's more sensitive to salinity in poorly drained sites. So an increase in salinity and inundation will significantly reduce wetland productivity, "especially in pickleweed, the one species most likely to expand under those conditions."

Closing the restoration session, Peggy Olofson of the Invasive Spartina Project reported on the ongoing war against aggressive hybrid cordgrass strains (see ESTUARY, October 2007). She called for the development of best practices for regional agencies. "Monitor and remove it—just monitoring has gotten us nowhere," she said. "Don't open a new marsh too early near existing hybrid *Spartina.* And be careful with equipment and dredge sediment."

> **"Monitor and remove it—just monitoring has gotten us nowhere."**
>
> Peggy Olofson,
> Invasive Spartina Project

LAND USE: Making Connections

That land-dependent creatures—and the farms and other upland areas they inhabit—are in some way related to estuaries was once a foreign concept. But now, said U.C. Davis's Jeff Loux at the land use session of October's conference, "It's self-evident that water and land use planning are linked." And as the state population grows, that link will need to tighten, requiring multiple agencies—city planning departments, utilities districts, water agencies, and transportation departments—at local and regional levels to work together more closely.

"The region will add five more Oaklands by 2035," said the Joint Policy Committee's Ted Droettboom, commenting that growth will have to be planned much more carefully to mitigate the additional traffic and its effects on air and water quality. Regional bodies like ABAG are finally looking into the nexus among air quality, land use, transportation, and water quality. "Our land use patterns will dictate the need for better transit," said ABAG's Dave Burch.

Municipalities and regional bodies are trying to focus growth in specific areas to direct planning and investments into "priority development areas," said ABAG's Ken Kirkey. A key element of priority development areas is proximity to transit, so that driving can be reduced to create what Cities 21's Steve Raney called a "low-miles community."

The projections for the Bay Area's growth mean that managers and policymakers will need to get creative about where to put people and how to make those living places more sustainable, the topic of a panel discussion in the afternoon session. "We want to make it so that people get to as much as they can on foot," said the Greenbelt Alliance's Marla Wilson. To accomplish that, cities must build compactly and have walkable streets and neighborhoods, and they need to write these ideas into their general plans. "That gives elected officials the will to do it," said Laurel Prevetti of the City of San Jose.

Prevetti noted that in the 1970s, San Jose officials drew a line around the city, indicating its boundary for growth. That forced later administrations to recycle land—developing infill on grayfields like underused parking lots. Much of the development of the 1970s and 1980s also resulted in office parks—large buildings surrounded by huge parking lots. One way that nature has been brought back to such environs, said Prevetti, is through greenways and restored urban streams.

The topic of creek restoration brought insight from the S.F. Bay Regional Board's Ann Riley, who described how creeks can be creatively integrated into cities, such as in San Luis Obispo. When it comes to restoring streams in cities, said Riley, one of the most common problems is negotiating for more room for the stream—which often means negotiating for fewer parking spaces in conjunction with development or redevelopment. Even a small reduction in the number of parking spaces can often make a critical difference for a city stream. Riley's lesson: "Don't accept a plan as given."

But one given is that cities have infrastructure—like stormdrains—that greatly affects their watersheds, so planners are finding ways to reduce pollution through greener solutions. The SFPUC's Rosey Jenks spoke of her agency's efforts to reduce the number of impervious surfaces that carry pollution to watersheds. When roads are repaved, for example, their impermeability can be reduced so they can act as filters. Jenks also described how green roofs—like the new one at the California Academy of Sciences —are helping reduce runoff.

The idea of green building is currently popular among architects and developers, noted Paul Okamoto of Okamoto Saijo Architecture. But more needs to be done in light of the consequences of global climate change. Three design concepts should be integrated into green building. First is the 2030 Initiative (a standard where all buildings shall be carbon-neutral by 2030), which has already been adopted by the U.S. Conference of Mayors and American Institute of Architects. Second is analyzing intensity of transportation as part of a green building analysis. "We need to understand how much energy is spent on transportation due to the location of buildings and our current land-use patterns," said Okamoto. Third, buildings should incorporate the design concept of "passive survivability"—in which buildings are still functional when services like electricity, water, and sewer are interrupted.

Water management for all new development must also be considered, and Phil Bobel of the City of Palo Alto discussed how the South Bay is starting to use less freshwater and more recycled water for irrigation. Palo Alto and other cities have been testing ecoroofs, cisterns, and permeable pavers. Said Bobel, "What's innovative about this? The Babylonians were doing cisterns."

"We're at the end of the road of the system of using water once and spending a half a billion dollars to treat and put it back."

Michele Pla, BACWA

The NRDC's Kristina Ortiz said lots of little gadgets that might not seem so innovative, incorporated into planning, can collectively save a lot of water. Using satellite technology and sensors can help with water savings, particularly in landscaping, where most urban water is used. Another big consumer of water is the toilet: New dual flush models can save gallons. "It's to the point where turning off the tap is like turning off the light," Ortiz said, noting that people need to become as attuned to conserving water as they are to energy. To that end, EBMUD and PG&E have teamed up to offer rebates and tiered pricing as incentives to get customers to save. EBMUD bills now include a water budget that not only presents consumption, but also provides climate information to show customers how to cut down on landscape watering. "It's the low-hanging fruit, but it helps," said EBMUD's Richard Harris.

Using recycled water can save energy and reduce stress on the Bay, said Michele Pla of the Bay Area Clean Water Agencies. Pla explained that using more recycled water lowers the need to treat water, brings down energy consumption, and curbs pollutant loads to the Bay. "We're at the end of the road of the system of using water once and spending a half a billion dollars to treat and put it back," said Pla.

DWR's Kamyar Guivetchi summarized his agency's efforts to work hand-in-hand with federal and state agencies, tribal governments, local governments, and members of the public to update the California Water Plan. Among the key changes from the current plan—last updated in 2005—is the inclusion of impacts from global warming.

Linda Fiack of the Delta Protection Commission compared the Delta and its water supply to the country cows that provide milk for city folks. "Most people don't know where their water comes from," she noted. "The Delta is that cow in the country." But regional and county planners do know where their water comes from, and they're planning for it now. Fiack explained how the five Delta counties of Contra Costa, San Joaquin, Sacramento, Solano, and Yolo—all revamping their general plans—are including a Delta element.

And Benicia mayor Elizabeth Patterson, who said her city has integrated watershed restoration into its general plan, wrapped up the session by describing the importance of connecting small grassroots groups with movers and shakers. "We need to get their ideas to where the power is."

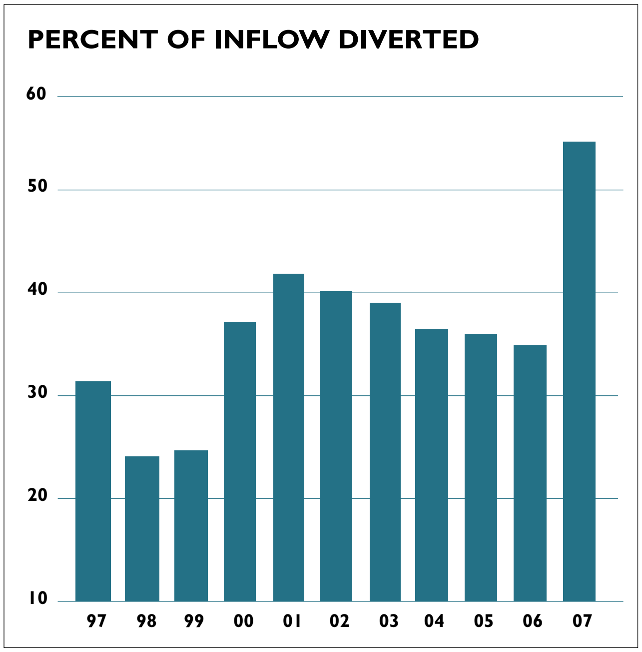
Vital Statistics

Water

Recent Inflows

Normal or above normal rainfall has meant improved Delta inflows in recent years, but the dry winter of 2006-2007 ran counter to that trend. Inflows to the Delta and Estuary were 25.6 million acre-feet (MAF) in water-year 2006 (October 1, 2005 - September 30, 2006) and 6.7 million acre-feet (MAF) in water-year 2007 (October 1, 2006 - September 30, 2007). Delta outflows were 22 MAF in 2006 and 2.9 MAF in 2007 (Inter-agency Ecological Program, 2008).

MORE INFO?
www.iep.ca.gov/dayflow/index.html



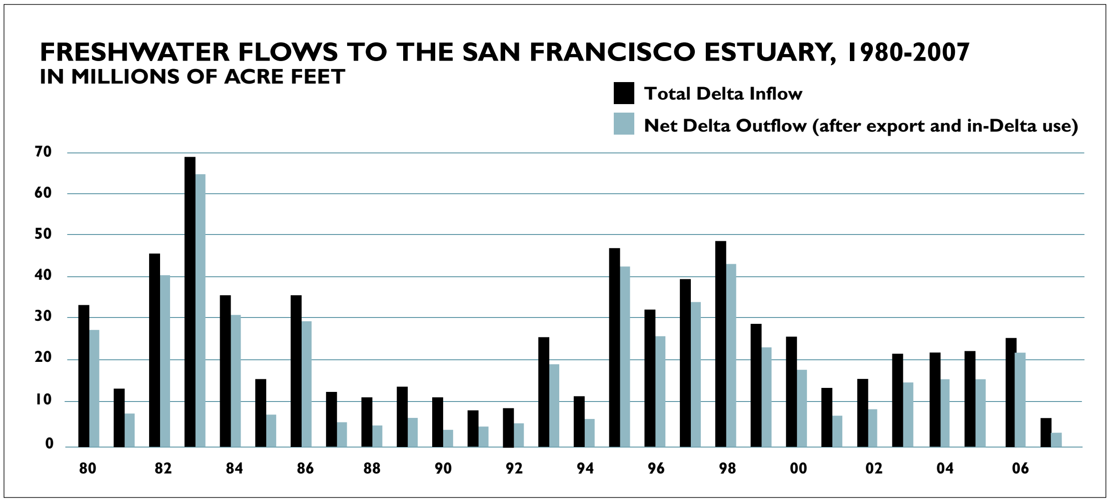
Diversions for Beneficial Use

Water is diverted both within the Delta and upstream in the Estuary's watersheds to irrigate farmland and supply cities. Total exports were 3.2 MAF in water-year 2006 and 6.7 MAF in water-year 2007. The average percentages of total Delta inflows diverted were 34.4 in water-year 2006 and 54.3 in 2007 (Interagency Ecological Program, 2008).

MORE INFO?
www.iep.ca.gov/dayflow/index.html

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. At the local level, the Bay Area Water Recycling Program's (BAWRP) 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. The Marin Municipal Water District has pioneered the use of recycled water for non-agricultural purposes, including car washes and commercial laundries, and several Bay Area cities, including Novato, Petaluma, and Santa Rosa, have their own programs. Many other Bay Area agencies are forging ahead with the design, construction and operation of water recycling projects. The East Bay Municipal Utility District has set a water recycling goal of 14 mgd by 2020. 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 EBMUD have jointly developed the San Ramon Valley Recycled Water Program (SRVRWP), serving areas of Blackhawk, Danville, Dublin, and San Ramon. When complete, this multi-phased 6.7-mgd project is expected to deliver 3.3 mgd to DSRSD's service area and 2.4 mgd to EBMUD's service area with 1 mgd available to either. DSRSD has been delivering recycled water since November 2005. EBMUD customers including the City of San Ramon, the San Ramon Valley Unified School District, and Chevron's world headquarters began receiving recycled irrigation water in February 2006. Meanwhile, EBMUD currently produces over 5 mgd of recycled water. EBMUD's multi-phased East Bayshore Recycled Water Project (EBRWP) is expected to begin delivery to some Oakland and Emeryville customers in the spring of 2008, subsequently expanding to Albany, Berkeley, and Emeryville. In addition to parks and industrial users (including Pixar and Novartis), the project will supply recycled water for toilet flushing to EBMUD's Oakland headquarters and another Oakland highrise. The EBRWP will ultimately include nearly 30 miles of pipeline through parts of Alameda, Albany, Berkeley, Emeryville, and Oakland and will save 2.5 mgd (2,800 acre-feet/year) once all recycled water customers are hooked up to the system. The first phase will supply up to 0.7 mgd. Eventually, EBWRP water may be used in wetlands restoration. EBMUD is also planning additional recycling projects for industrial users in Richmond and Rodeo and for irrigation in San Leandro. A bill sponsored by Rep. George Miller (D-Martinez) to authorize a federal role in water recycling projects elsewhere around the Bay (Palo Alto, Mountain View, Pittsburg, Antioch, Redwood City, and San Jose) passed the House of Representatives in July 2007.

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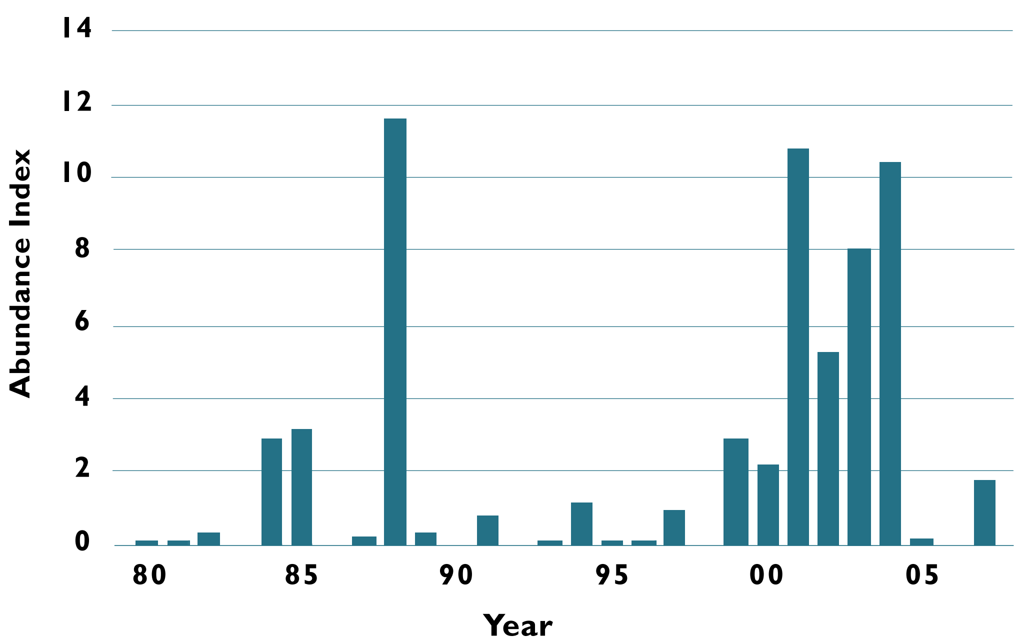
Fish and Fisheries

Dungeness Crab

The Dungeness crab (*Cancer magister*) is a valuable sport and commercial species that reproduces in the ocean in winter and rears in nearshore coastal areas and estuaries. Small juvenile Dungeness crabs immigrate to the Estuary in spring, rear for 8-10 months, and then emigrate from the Estuary at approximately 4" carapace width. Estuary-reared crabs grow faster than ocean-reared crabs, mainly due to warmer water temperatures and increased prey density in the Estuary. Estuary-reared crabs reach legal size at the end of their third year, 1-2 years before ocean-reared crabs.

AGE-0 DUNGENESS CRAB ABUNDANCE INDICES FROM THE SAN FRANCISCO ESTUARY, 1980-2007



The 2006 abundance index of age-0 Dungeness crabs was near record low in the Estuary, similar to the low abundance observed in previous years with strong El Niño events. Abundance rebounded to a modest level in 2007. Neither winter 2005-06 nor 2006-07 had strong El Niño events, with sea surface temperatures in the Gulf of the Farallones near average. However, frequent winter storms in winter 2005-06 resulted in a strong northward-flowing Davidson Current. This surface ocean current likely transported Dungeness crab larvae north of the Gulf of the Farallones. Since the San Francisco Estuary is near the southern limit of Dungeness crab distribution, there is no large population to the south to replace this larval loss. The planktonic larvae transported north were not able to return to the Gulf, resulting in poor Dungeness crab recruitment here in 2006. Nearshore currents and ocean temperatures were more favorable for Dungeness crab larvae in winter 2006-07, resulting in higher abundance. Low to modest Dungeness crab abundance in the Estuary from 2005 to 2007 was preceded by 4 years of very high abundance from 2001 to 2004. These high abundance indices resulted from cooler than average ocean temperatures and favorable nearshore currents (less northward flow) during the crab's larval period.

The recent strong Dungeness crab year classes in the Estuary were reflected in the commercial landings for several years. Central California Dungeness crab landings surpassed 5 million pounds annually in the 2002-03 to 2006-07 fishing seasons, the first time landings last exceeded 4 million pounds here since the late 1950s. The 2001 year class of San Francisco Estuary-reared crabs reached legal size and became available to the fishery in the 2003-04 season, and the 2002 through 2004 year classes entered the fishery consecutively through the 2006-07 season. Landings decreased dramatically in the 2007-08 season, with less than 1 million pounds landed in Central California through January 2008.

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Kern Brook Lamprey

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

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

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

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Green Sturgeon

The southern Distinct Population Segment (DPS) of North American green sturgeon (*Acipenser medirostris*) was listed as threatened under the Endangered Species Act on April 7, 2006, and represents the southernmost breeding distribution for this species. Its current spawning habitat appears to be limited to the upper mainstem Sacramento River, though recent sightings in the Yuba River (Gary Reedy, SYRCL, pers. comm.) suggest adult sturgeon cryptically occupy other Central Valley rivers. Recent modeling of spawning habitat suggests only 4.6% of the available Central Valley habitat has characteristics similar to spawning habitat of northern DPS green sturgeon (Klamath and Rogue rivers), and 44.2% of their historic spawning habitat in the Sacramento-San Joaquin system has been lost over the past century (Neuman et al. 2007).

Sacramento River green sturgeon are late-maturing and exhibit extensive marine migrations along the west coast, constituting the primary stock present in summer aggregations in the Columbia River and Willapa Bay (Israel 2007; Lindley et al. in press). Spawning fish enter San Francisco Bay between March and May, pass through the Estuary in a few weeks, and then ascend the Sacramento River to reach fast-flowing turbulent habitats with optimal temperatures. If these fish arrive at the Red Bluff Diversion Dam (RBDD) prior to its gates closing, then they appear to spawn in areas above RBDD (Heublein 2006). Green sturgeons are observed below RBDD following its closure, and this barrier eliminates upstream passage for these later migrating adults. Under certain conditions, green sturgeon successfully emigrate underneath RBDD's gates, although in 2007, 10 green sturgeon were observed to have been killed under the RBDD gates in late May. This may represent a significant portion of the annual spawning population, which, using genetic estimation methods, was determined to range between 10 and 54 spawners above RBDD from 2002 to 2006 (Israel 2007). Adult green sturgeons occupy the Sacramento River's deepest holes as late as November (Richard Corwin, USBR, pers. comm.).

Recent laboratory research has focused on understanding the green sturgeon's ability to tolerate thermal and salinity gradients. Water temperatures above 17.5°C constituted the upper thermal optima for green sturgeon embryos, and temperatures >22°C resulted in mortality (Van Eenennaam et al. 2005). Young green sturgeon are more temperature tolerant and their growth was not negatively impacted between 19 and 24°C (Allen et al. 2006). Juvenile green sturgeon develop critical osmoregulatory capacities between their first and second years that permit them to enter saltwater by 1.5 years (Allen and Cech 2007). Dissolved oxygen is also a critical parameter for juvenile green sturgeon, since they have high oxygen consumption (Mayfield and Cech 2004), and suboptimal conditions likely represent a chronic stressor. The information scientists have gained about habitat loss, limited spawner abundance, and risks associated with current water management activities support the precautionary management and increasingly intensive monitoring of Southern DPS green sturgeon. Regulatory efforts continue to move forward, including a draft 4(d) Rule outlining permitted activities and take for green sturgeon. Collaborative research is underway to assess green sturgeon productivity, evaluate threats, and characterize habitats.

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Pacific Herring

Between the 1997 El Niño and the 2004-2005 season, the spawning biomass of Pacific herring (*Clupea pallasi*), which supports the Bay's largest commercial fishery, has remained below the long-term (since 1978) average of 52,234 short tons. In response to this decline, the Fish and Game Commission, which manages the fishery, lowered catch quotas. Although ocean productivity has been favorable for herring over the last several years, a large recruitment of young fish to the spawning population has yet to occur, and older age classes have been declining. Following record high biomass levels of 99,050 short tons in 1995-1996 and 89,570 short tons in 1996-1997, spawning biomass plunged to 20,000 short tons following the 1997 El Niño. Between 1997 and 2003, estimates fluctuated between 27,400 and 39,500 short tons. The 2004-2005 spawning biomass estimate was 58,934 short tons, the first estimate to exceed the long-term average of 51,825 tons used to set fishery quotas since the 1996-1997 season. That was also the first season since the 1997 El Niño in which the number of 4 year old and older herring increased. 2005-2006 saw a record high of 145,054 tons, more than twice the 27-year average. Since 85% of the spawning activity occurred in Richardson Bay, which is closed to the commercial fishery, the catch for that season remained low. Then in 2006-2007, the estimate plummeted to 10,935 tons, even lower than 1997-1998, and San Francisco Bay landings fell to 292 tons, with an historic low in the percentage of 2- and 3 year old fish. The 92% drop in the spawning biomass estimate appears related to another El Niño event and an unusually dry winter. Dive surveys in Richardson Bay found sharp declines in the density of the subtidal plants (*Zostera* and *Gracilaria*) to which the herring attach their eggs, suggesting that spawning fish may have been displaced to more favorable habitat. The quota for 2007-2008 was 1,057 tons, divided among three platoons of herring boats.

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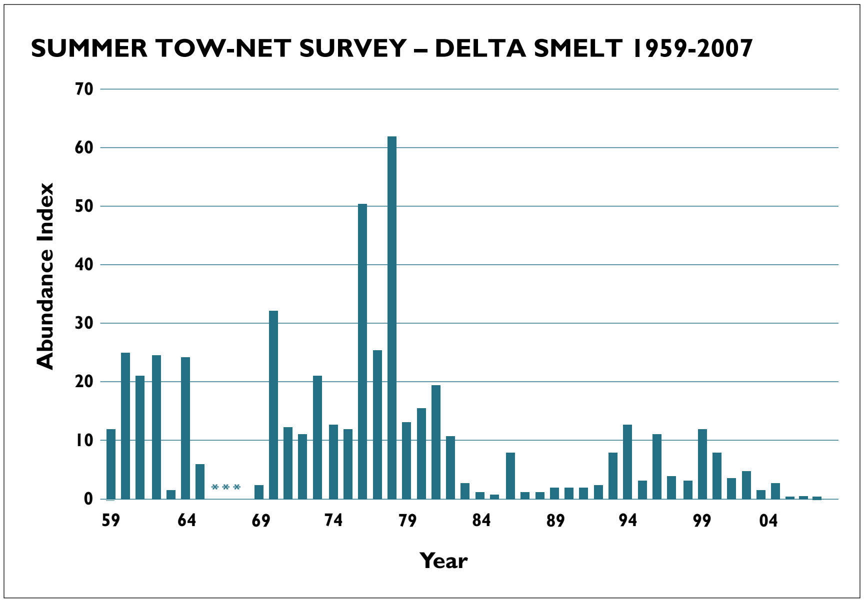
Delta Smelt

The Delta smelt (*Hypomesus transpacificus*), a 55-70 mm long osmerid, is endemic to the upper San Francisco Estuary. Once quite common, a dramatic decline in the 1980s led to the federal and state listing of this fish as a threatened species in 1993. It is the annual life cycle, limited diet, low fecundity, and restricted distribution within the Estuary that makes Delta smelt environmentally sensitive. Possible reasons for the decline of Delta smelt include stock-recruitment effects, declining habitat quality, increased mortality rates (largely related to water exports), and reduced food availability due to invasive species.

To reduce the impact of Delta pumping operations on Delta smelt, CALFED developed the Environmental Water Account (2000), which helps to reduce Delta smelt take by shifting the timing of pumping. Despite this measure, Delta smelt abundance indices have reached all time lows for two of California Department of Fish and Game's (DFG) long-term monitoring surveys, the Summer Townet



Survey (TNS, since 1959) and the Fall Midwater Trawl (MWT, since 1967), even in fairly plentiful water years like 2006. For example, TNS indices from 2005-2007 were 0.3, 0.4, and 0.4 respectively, compared with an average of 6.4 for 1991-2001. MWT indices for the same years were 27, 41, and 28, compared with an average of 545 for 1991-2001.

Such abrupt decreases in Delta smelt and other pelagic fishes (longfin smelt, striped bass, and threadfin shad) prompted studies led by the Interagency Ecological Program to address this Pelagic Organism Decline (POD). Research so far has included analysis of changes in the estuarine food web (with the introduction of the overbite clam and several copepod species, and low phytoplankton productivity), in water conditions (salinity, turbidity, temperature), in water export patterns, and in the Delta smelt's fecundity and growth rate. A final POD report is expected by the end of 2008.

Early in 2007, data from the DFG 20 mm survey of larval Delta smelt showed an 89% reduction from 2006 levels. In response, the Delta Smelt Working Group recommended emergency actions including addressing negative flows in Old and Middle Rivers and opening the Delta Cross Channel gates to improve transport of juvenile smelt beyond the influence of the export pumps.

Meanwhile, in response to a suit by the California Sport Fishing Protection Alliance, Alameda County Superior Court Judge Frank Roesch ordered DWR in March 2007 to reduce smelt mortality through entrainment in the Delta pumps, resulting in the temporary shutdown of the Harvey O. Banks pumping station. In August 2007, U.S. District Court Judge Oliver Wanger ordered state and federal water agencies to either reduce pumping or release more water upstream of the Delta to maintain sufficient flow to prevent entrainment. He subsequently set September 25, 2008 for a new Biological Opinion from state and federal wildlife agencies.

On yet another track, UC Davis' Fish Conservation and Culture Lab, which has raised smelt in captivity for the past 15 years, is attempting to establish a captive population as a hedge against the species' extinction.

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Longfin Smelt

Longfin smelt (*Spirinchus thaleichthys*) in the San Francisco Estuary represent the southernmost spawning population in North America. The Estuary is not as hospitable to longfin smelt as it once was. Abundance of longfin smelt continues to be a positive function of Delta outflow during its December-May larval period (Baxter 1999), but this relationship has changed over time. The first change—a decline in the intercept but no change in the slope of the outflow-abundance relationship—occurred subsequent to the 1986 introduction of the over-bite clam, *Corbula amurensis,* which changed the upper Estuary food web (Kimmerer 2002). After 2000, the longfin smelt outflow-abundance relationship appeared to change again, this time in concert with abundance declines of three other upper Estuary pelagic fishes, Delta smelt, young striped bass, and threadfin shad (Sommer et al. 2007). Even though longfin smelt abundance increased following high winter-spring outflows of 2006, the outflow-abundance pattern for years 2003-2006 was lower than expected and hints at a second decline in the relationship. In addition, some evidence indicates that survival from their first to their second winter has also declined since 1994 (Rosenfield and Baxter 2007).

In August 2007, concern about the decline and numerous potential stressors led several environmental groups to petition the California Fish and Game Commission (Commission) and the U.S. Fish and Wildlife Service to provide emergency Threatened or Endangered Species status for longfin smelt (The Bay Institute et al. 2007). At its October 11, 2007 meeting, the Commission rejected the emergency listing request, opting instead to evaluate the petition through standard rulemaking procedures and directing the Department of Fish and

Game to proceed with the standard rulemaking as quickly as possible. On November 30, 2007, the DFG submitted its initial evaluation of the petition to the Commission, concluding that the petition incorporated sufficient, accurate, and pertinent up-to-date information on longfin smelt populations, habitat and threats, and recommending the petition be accepted for consideration. At its February 7, 2008 meeting, the Commission voted to designate the smelt a candidate species for formal listing under the California Endangered Species Act. The Commission also approved interim regulations to require reduction of water exports from the Delta when longfin smelt are present in areas where they could be entrained at the pumps.

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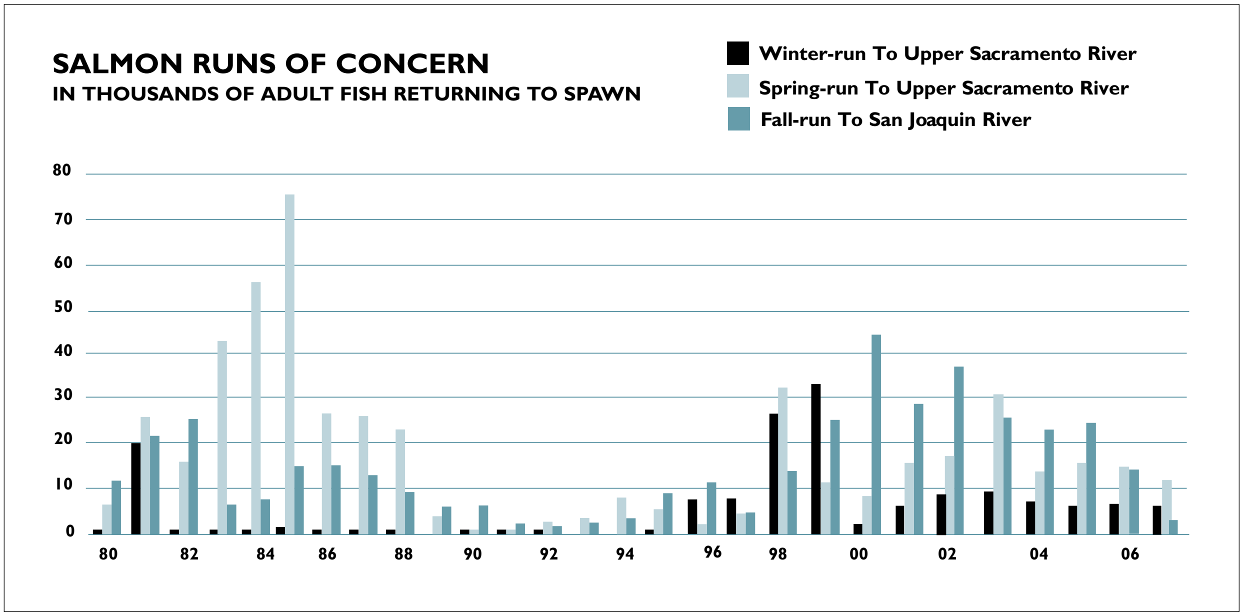
Central Valley Chinook Salmon

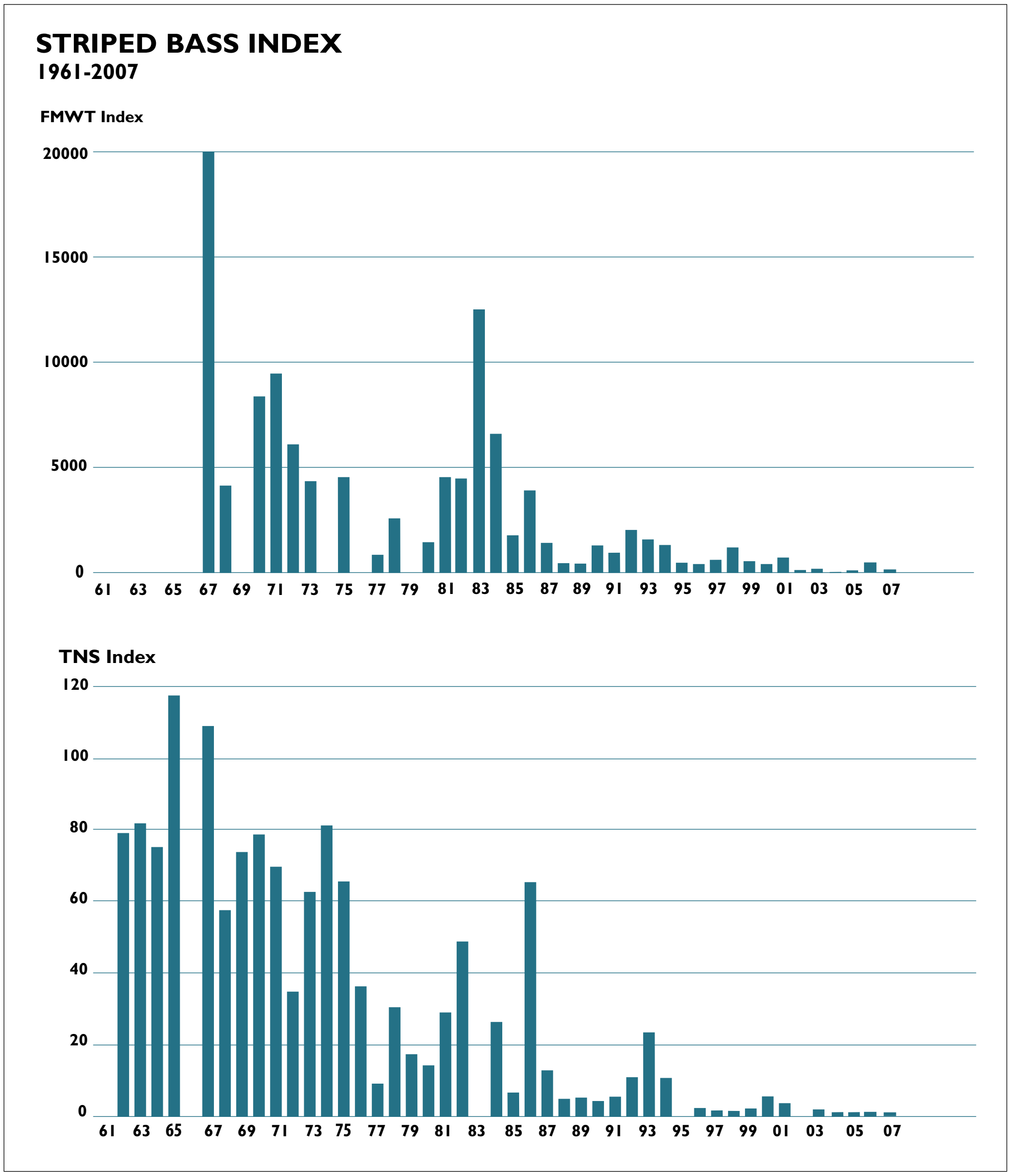
Central Valley Chinook salmon (*Oncorhynchus tshawytscha*) occur in four discrete runs—winter-run, spring-run, fall-run, and late fall-run (run refers to the season in which adults return to their native streams to spawn).

The winter-run Chinook salmon, with the lowest population, has been listed as both a state and federal endangered species since 1994. As a result of more regular interagency scrutiny of operations, a new counting method for Chinook winter-run salmon critical to assessing "incidental take limits" is now in place. Federal incidental take limits for winter-run allow up to 2% of "juvenile production" to be lost at the pumps. The formula for setting take limits combines the number of offspring produced ("juvenile production") with the number of adult fish returning to spawn each year ("adult escapement"). The latter number—based on how many fish passed through the Red Bluff Dam fish ladders—became questionable in recent years as the dam gates remained open for longer periods and fewer fish had to use the ladders. An alternative method, counts of spawned female carcasses upstream, backed up by earlier surveys, revealed a variation up to a factor of five in the total estimates of spawning adults. The new higher estimates of adult escapement translated into a higher estimate of juvenile production and meant that the take limit was never reached in 2001, for example, changing the need to reduce pumping and use EWA resources to protect fish. The winter-run population was 5,299 in 2005; 7,513 in 2006; and 6,144 in 2007.

The next most sensitive stock, the spring-run, was state listed as threatened in 1998 and federally listed in 1999. The method used to estimate the spring Chinook return to the Feather River Hatchery was changed in 2005, with a subset of tagged fish being used for the estimate of spring escapement. The spring-run population was 15,900 in 2005; 12,567 in 2006; and 11,950 in 2007.

Sacramento fall-run have historically been the most abundant Chinook stock. Their population dropped from 839,956 in 2002 (the estimated population for Battle Creek was the highest on record) to 383,500 in 2005 and 270,224 in 2006. The preliminary 2007 estimate of 90,414, second-lowest since 1973, forced curtailment of the 2008 salmon season. The Pacific Fishery Management Council's minimum conservation goal for this run is 122,000. The estimate of 2,021 two-year-old spawners in 2007 was far below the 36-year average of 40,000.





The Sacramento late fall-run (distinct from fall-run) population was 17,035 in 2005; 23,134 in 2006; and 18,593 in 2007.

Returns of the San Joaquin fall-run in 2005, at 23,000 were above the 1967-1999 average annual return of 20,470. However, the return fell to 12,184 in 2006 and 2,572 in 2007. Since 1986, San Joaquin spawner returns have constituted less than 10% of the total Central Valley escapement for fall run Chinook.

MORE INFO? www.pcouncil.org/salmon/salsafe.html

Striped Bass

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

The striped bass is one of the four species involved in the recent Pelagic Organism Decline (POD) phenomenon, along with Delta smelt, longfin smelt, and threadfin shad. See the Delta smelt account for a summary of POD activity to date.

Abundance indices of striped bass in their first year of life (young-of-the-year or YOY) remain at very low levels. On a scale where the peak Midsummer Townet Survey (TNS) index was 117 in 1965, the 2005 index was 0.9. The TNS index of 0.8 in 2004 was the lowest in the 45-year history of the survey. The indices were even lower in 2006 (0.5) and 2007 (0.3). On a scale where the peak Fall Midwater Trawl Survey (FMWT) index was 20,038 in 1967, the 2006 index was 363, up from 121 in 2005. The 2007 index fell to 82.

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Invasives

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. The rate of spread is greatest on mudflats and restored tidal marsh, where soft sediment and quiescent hydrology provide ideal habitat. The invasion no longer consists of the pure parent genotype; many hybrid morphologies have been observed. Hybrids are more vigorous and reproductively fit than either of the parent species. Although genetic tests can be cryptic, UC Davis researchers have developed these tests to distinguish hybrids from natives. In 2005, the previously used herbicide glyphosate (AquamasterR, the aquatic version of RoundupR) was largely replaced by a new agent, imazapyr (HabitatR), only recently registered for use in California. Unlike glyphosate, treatment with imazapyr does not require a 6-to-12-hour post-application period without tidal inundation. Glyphosate also tends to bind to sediment and become inactivated, and requires coating of the entire plant. Human health risks from imazapyr are reported to be low, and the herbicide is less toxic to aquatic organisms than glyphosate; however, there is a high risk of damage to non-target plants if inadvertently applied. Following two years of treatment, the Invasive Spartina Project manager reported excellent control and very little grow-back. In 2006 the control program treated 1,450 acres of *Spartina* (94% of the Bay-wide population, 107 of 134 known locations), reporting 60 to 95% killed. Treatment at two locations was delayed because of the presence of the endangered California clapper rail. Spot treatments will continue from 2009 forward. Meanwhile, the plant has colonized two recent East Bay restoration sites and a small portion of the Petaluma River within the last two years. Barring additional expansion, the Invasive Spartina Project expects to control the invasive *Spartina* by 2011.

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Invasive Hydrozoans

Three species of hydromedusae (popularly known as "jellies") from the Black and Caspian Seas have colonized the brackish waters of the upper San Francisco Estuary: *Maeotias marginata, Moerisia* sp., and *Blackfordia virginica.* They probably reached our area in ships' ballast water. *M. marginata* may have been present since at least 1959, which *Moerisia* sp. was first collected in 1993. All three alternate between a sedentary, asexually reproducing polyp form and a free-swimming, sexually reproducing medusa form. Polyps may produce either medusae or more polyps; medusae produce polyps. *M. marginata* was originally believed to be an all-male population, but females have been detected. A fourth exotic hyrdrozoan, *Cordylophora caspica,* occurs only in the polyp form.

These invasive species have the potential to disrupt estuarine food webs. The exotic shimofuri goby has been reported to feed on *C. caspica*, but the three hydromedusae have no known predators in the Estuary and contribute nothing to the food web until they die off in winter. Their prey, captured with tentacles loaded with stinging nematocysts, includes copepods, barnacle nauplii, crab zoea larvae, and larval fish. Researchers at UC Davis are studying prey selectivity, including selectivity among copepod species, and dietary overlap with POD fish. At this point their potential contribution to the POD phenomenon remains unclear.

The hydromedusae are especially abundant in Suisun Marsh. They also occur in the Napa, Sonoma, and Petaluma Rivers. Overall abundance varies with salinity and temperature; numbers fell in 2005, a low-salinity year, compared with 2004. For all three, catches in Suisun marsh were highest in September. In a recent study, *Moerisia* sp., which can occur in particularly dense concentrations, was shown to have more predatory effect on copepods than the other species (Schroeter 2007). One concern is that swarms of medusae may deter fish from exploiting local prey resources.

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Overbite Clam

The overbite (Asian) clam (*Corbula amurensis,* previously *Potamocorbula amurensis*) continues to be the dominant benthic organism in the North Bay. Seasonal decline of the bivalve occurs 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 during early spring of some years, when *Corbula* biomass is at an annual minimum. These blooms have been earlier and shorter in duration than historic blooms. *Corbula* was first seen in the South Bay in 1988 and had become a dominant bivalve by 1990. Unlike in the North Bay, however, the South Bay phytoplankton bloom has not been depleted by *Corbula* filter-feeding. This is partially due to the seasonal cycle of *Corbula* and other shallow water bivalves 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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Pacific Giant Oyster

Also known as the Japanese or Miyagi oyster, *Crassostrea gigas* is the most common oyster species grown commercially on the West Coast. Farmed in Tomales Bay and Drakes Estero, it was not detected in San Francisco Bay until 2004. In a 2006 survey by SFEI's Biological Invasions Program, over 260 were collected between the Dumbarton Bridge and the San Leandro Marina. No new sites were detected in the 2007 survey.

Several possible sources for the population have been suggested, including an illegal planting near San Rafael, larvae drifting in from rearing sites or arriving in ballast water, and three RMP programs that used this species in bioaccumulation studies. Although they had previously spawned in the Bay, these oysters had not settled in at an effective rate until recently. The higher phytoplankton concentrations reported in the South Bay in recent years may have created more favorable conditions for them.

C. gigas, an efficient filter feeder, has been known to outcompete and overgrow mussels and other bivalve species. Its presence may complicate efforts to restore the native *Ostrea conchaphila.* The major concern, however, is that its impact on estuarine food resources may contribute to the decline of pelagic organisms.

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Green Crab

The European green crab (*Carcinus maenas)* is now established in every significant Bay and estuary between Monterey, California, and Gray's Harbor, Washington. It appeared in South S.F. Bay in the early 1990s and has spread north at least as far as the Carquinez Strait. Salinity limits the crab's distribution: crabs have been collected from water ranging from 5-31 parts per thousand (ppt) salt to water, but few have been collected from water with less than 10 ppt. A 10-year study in Bodega Bay found that in contrast to their slow growth rates in Europe, green crabs here grew rapidly and reached sexual maturity in their first year. Over the course of the study, the green crab severely reduced the abundance of three common invertebrate species, but did not impact the shorebird food web (Grosholz et al. 2000). 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. In Bodega Bay, an intensive sampling and removal effort in 2006 removed over 67% of initially marked green crabs, and appears to have reduced green crab predation on the native shore crab *Hemigrapsus oregonensis* (De Rivera et al. 2007). The results indicate that local eradication may be feasible.

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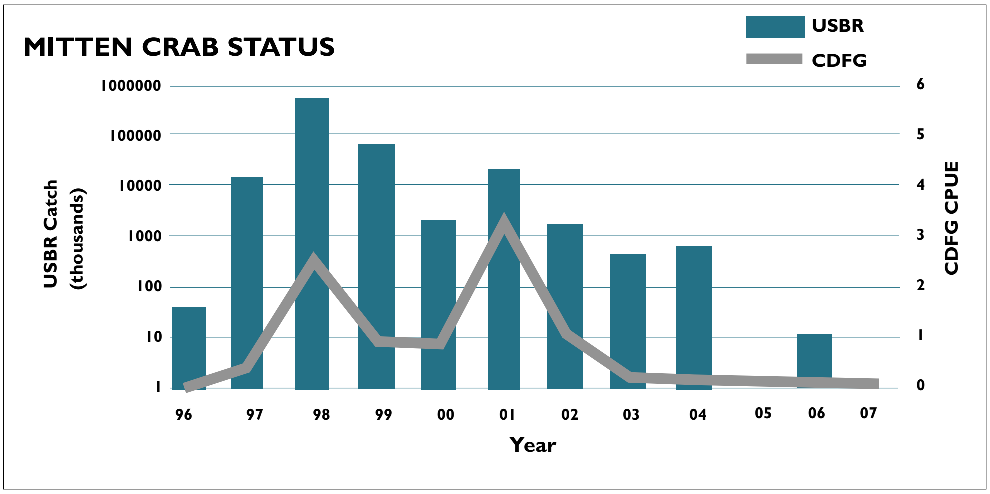
Chinese Mitten Crab

The Chinese mitten crab (*Eriocheir sinensis)* population rapidly increased after it was first reported in the San Francisco Estuary in the early 1990s. Numbers of downstream migrating adult crabs peaked at the USBR fish facility in the south Delta in 1998 and



Total catch of adult mitten crabs at BurRec's fish facility (bars) and catch per unit effort (CPUE) of adult mitten crabs from Cal Fish & Game's S.F. Bay Study otter trawl survey (line), 1996-2007.

1999, in northern Bay (Central Bay to the western Delta) trawls in 1998 and 2001, and in Suisun Marsh trawls in 1999. All data sources support a population decline since 2002, with only a few crabs reported in the northern portion of the Estuary, including the Delta, in 2006 and none in 2007.

U.S. Fish & Wildlife Service monitoring for juvenile mitten crabs in Delta tributaries detected no mitten crabs in 2006 and 2007. No reports of mitten crab sightings or bait stealing were made by the public to the toll-free reporting line in either 2006 or 2007. When numbers are low, the mitten crab's only detectable impact is stealing bait from sport anglers 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 survival and growth of larvae and timing of juvenile settlement. Since larvae hatch in winter in the lower Estuary and have no retention mechanisms, winter ocean conditions may control larval survival in addition to Estuary conditions. A "boom-and-bust" cycle has been reported for some introduced species, although this may not be universally true for all introductions.

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Northern Pike

The voracious Northern pike (*Esox lucius*), native to Canada and the Midwest, was illegally planted in the 85,000-acre-foot Lake Davis reservoir in the early 1990s. In 1997, the California Department of Fish and Game treated the lake with Rotenone to eradicate pike from the lake. The pike were significant predators on rainbow trout and also presented a potential threat to the Delta ecosystem. The treatment temporarily shut the lake to all recreational uses and compromised local water supplies. In May 1999, about a year after more than a million trout were planted and the lake had reopened, the pike reappeared, possibly intentionally reintroduced. With CALFED funding, control efforts resumed. Biologists had pulled approximately 55,000 pike from the lake by September 2005. During the summer of 2007, approximately 2,000 pike were electrofished from the creeks feeding the lake. This was followed in September by a second Rotenone treatment, during which the tributary creeks were screened off. Drinking water for the city of Portola, which now uses wells and springs, was not affected. Nearly 50,000 pounds of dead fish were removed from the lake following treatment, of which over 80% were bullhead and about 6% were pike (Sacramento Bee 2007). Water quality sampling by the California Department of Public Health through December failed to detect Rotenone and its breakdown product. Restocking with trout began in December and will continue in the spring of 2008. DFG is also working with community leaders to prevent another reintroduction, a criminal offense with penalties including a fine of up to $50,000 and up to a year in jail. For current status, visit http://www.dfg.ca.gov/lakedavis.

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Wetlands & Wildlife

Wetlands

Current efforts by San Francisco Bay Joint Venture (SFBJV) partners include restoration projects for the South Bay salt ponds, Petaluma and Triangle marshes, Simmons Slough, Pacheco Marsh, Hamilton Air Force Base–Bel Marin Keys, Napa-Sonoma Marshes, Cullinan Ranch, Napa River Flood Control Project, American Canyon, Dutch Slough, Eden Landing

Ecological Reserve, West Stege Marsh, and Sears Point. Nearly 300 other projects to protect and restore wetlands and riparian habitats are also in progress. SFBJV's habitat goals call for the acquisition of 63,000 acres of Bay habitat, 37,000 acres of seasonal wetland, and 7,000 acres of creeks and lakes, to be followed in most cases by restoration or enhancement.

The Central Valley Joint Venture updated its Implementation Plan in 2006, enlarging its previous focus on waterfowl by adding objectives for shorebirds, non-game waterbirds, and riparian songbirds.

The South Bay Salt Ponds Restoration project, affecting 16,000 acres of former Cargill Salt property, has completed its Initial Stewardship Plan and is moving to implement Phase 1. This will entail six projects totaling 2,800 acres in the Eden Landing, Alviso, and Ravenswood areas, with the breaching of pond levees to restore tidal marsh habitat and the reconfiguration of existing managed ponds. Elsewhere in the South Bay, restoration of the 1,500-acre Bair Island site began in July 2007. The California Coastal Commission provided $1.5 million for restoration of seasonal wetlands at the Berkeley Meadows and the cleanup of the nearby Brickyard, both in Eastshore State Park.

Several North Bay restoration projects also moved forward. At the Hamilton Wetlands site, the US Army Corps of Engineers began pumping sediment from nearby Bel Marin Keys onto the 700-acre former airfield in April 2007. Following a judicial ruling against further dredging, Marin Audubon is soliciting bids for the restoration project while awaiting permits from the Corps of Engineers and the City of Novato for the first phase of restoration of the Bahia Wetland. Marin Audubon has also completed work at Triangle Marsh and breached a levee at Petaluma Marsh.

A final Environmental Impact Report for another former Cargill property, the Napa Plant Site on the Napa River, was issued in 2006. A final preliminary plan for Cullinan Ranch was released in February 2007, calling for tidal marsh restoration south of the railroad line and enhancement of seasonal wetlands north of it. In Suisun Marsh, 507 acres of diked seasonal wetlands near Hill Slough are being restored to tidal habitat.

Over the last decade, state and federal agencies have spent $370.5 million to acquire and/or begin restoration on 13 sites totaling 36,176 acres. A 2007 report by Save the Bay proposed investing $1.43 billion to restore an additional 36,000 acres of wetlands, doubling the extent of San Francisco Bay's tidal marsh.

For a comprehensive list of wetland restoration projects that have been implemented around the Bay, see the database and maps compiled by Wetlands and Water Resources (www.swampthing.org). For wetlands creation, restoration, mitigation, and enhancement projects, see the San Francisco Estuary Institute's Wetland Project Tracker (www.wrmp.org/projectsintro.html), San Francisco Bay Joint Venture (http://www.sfBay.jv.org/), and Central Valley Joint Venture (http://www.centralvalleyjointventure.org). For information about restoration of the Cargill property, see http://www.southBayrestoration.org/.

Suisun Thistle

Suisun thistle (*Cirsium hydrophilum var. hydrophilum*) is an herbaceous, short-lived perennial restricted to moist or wet habitats of the Estuary, specifically salt and brackish marshes of the Suisun Marsh ecosystem. Presumed extinct until it was rediscovered on Grizzly Island in 1989, it was federally listed as endangered in 1997 due to its narrow distribution, low population numbers, and threats to its existence (i.e., altered hydrology, competition from native and non-native plants, seed predation by both the thistle weevil, *Rhinocyllus conicus,* and larvae of the butterfly, *Phyciodes mylitta*).

Prior to extensive surveys at Rush Ranch in 2003, Suisun thistle was known to exist at three locations: less then 10 plants at Grizzly Island Wildlife Area, less than 100 plants at Peytonia Slough Ecological Reserve, and 2,000 to 3,000 plants at Rush Ranch. 2003 surveys across the 1,050 acres of high marsh at Rush Ranch demonstrated a distribution that far exceeded previous estimates; a total of 47 subpopulations were mapped with a total geographic extent of 8.55 acres, all of which belong to a large, single population of approximately 137,500 (22,300 – 873,200) individuals. Preliminary size class distribution data suggested that recruitment of new individuals likely was sufficient to maintain the population size.

Despite these encouraging results, major threats to the short and long term viability were observed, including 1) the pernicious and invasive perennial pepperweed (*Lepidium latifolium;* associated with 85% of subpopulations); 2) presence of a non-native, phytophagous, biocontrol weevil (*Rhinocyllus conicus,* capable of reducing seed set by 86% in other *Cirsium* species); 3) habitat destruction by feral pigs (*Sus scrofa,* damaged 34% of subpopulations); and, 4) potential hybridization with another non-native congener (*Cirsium vulgare,* co-occurred with 45% of subpopulations).

As a consequence of both natural and human influences, the remaining tidal marshes of the Estuary are both degraded and threatened. Current restoration efforts targeting habitat improvement for Suisun thistle and reducing threats to its persistence are in the planning stages, pending funding for Rush Ranch to develop various conceptual restoration plans. Suisun thistle populations currently are protected at Grizzly Island Wildlife Area, Peytonia Slough Ecological Reserve, and Rush Ranch.

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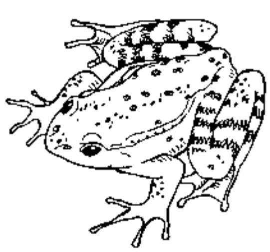
Wildlife

California Red-Legged Frog



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. Range-wide, only four populations contain more than 350 adults. Habitat loss, stream sedimentation, pesticides, and predation all threaten the frog, the largest native to the western United States. In spring 2004, the 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. Following litigation, the Service issued a revised proposal in November 2005 that eliminated 82% of the area in the original proposal, including many of the core areas delineated in the 2002 recovery plan. In the Bay Area, the new proposal eliminates almost all critical habitat in eastern Contra Costa County based on a habitat conservation plan. The revision also exempts routine ranching activities on private land from federal coverage. In 2007, the Service announced it will reverse the final critical habitat decision for the red-legged frog as well as rulings that denied six other endangered species increased protection, after an investigation found the actions were tainted by political pressure from a former senior Interior Department official. Also in 2005, a court decision required the Environmental Protection Agency to consult with U.S. Fish & Wildlife on the registration of 66 pesticides with potential impacts on the frog, and imposed interim restrictions on the use of these 66 pesticides in core frog habitats around the Bay Area and California.

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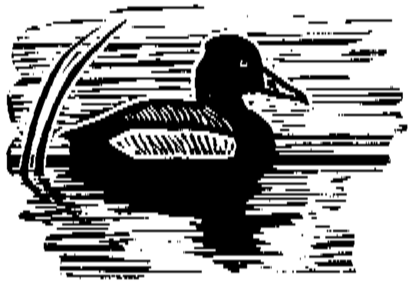
Greater and Lesser Scaup



The greater scaup (*Aythya marila*) and lesser scaup (*A. affinis*) are blue-billed diving ducks that nest in interior wetlands and northern boreal forests, and winter in coastal waters including the San Francisco Estuary. The two species are impossible to distinguish in aerial surveys, so data for both scaup are combined in U.S. Fish & Wildlife Service and US Geological Survey reports. About 45% of scaup in the lower Pacific Flyway winter in the San Francisco Bay. Greater scaup may be more abundant on the Bay itself, and appear to have been more impacted by the Cosco Busan spill. Lesser scaup use salt ponds as winter habitat more than greater.

Midwinter Waterfowl Survey estimates for San Francisco Bay scaup have held largely steady since the 1950s. This database may not capture trends in lesser scaup, many of which appear to move out of the Bay and into the Delta and Central Valley by early January when the survey takes place. Continent-wide, scaup populations have been declining steadily. Afton and Anderson (2001) report this trend may be largely due to reductions in the lesser scaup population.

One hypothesis suggests that female lesser scaup are arriving on their northern breeding grounds in poorer physical condition. They may forego nesting or may nest later in the season than usual, with reduced nestling survival. This is supported by studies showing declines in body mass and lipid reserves in northbound Midwestern lesser scaup since the 1980s (Anteau and Afton 2004). Poor spring condition may result from declining habitat quality and reduced prey base at migratory stopover sites.

Contaminants are also a concern. Both greater and lesser scaup in San Francisco Bay continue to show high selenium concentrations, above levels known to cause reproductive problems in female mallards. Because of their feeding habits, lesser scaup may have greater selenium exposure: overbite clams (*Corbula amurensis*), which bioaccumulate selenium, form a higher proportion of their winter diet in Bay waters. Greater scaup have a more varied diet, including other mollusks and amphipods.

Changes on the breeding grounds may also be contributing to the lesser's decline. A recent study (Corcoran et al 2005) found low duckling survival in Alaska's Yukon Flats, which lost 18% of its wetland area between 1952 and 2000. Lesser scaup nesting on small wetlands and creeks may be hardest hit.

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Northern Harrier

A long-winged hawk of open country, the northern harrier (*Circus cyaneus*) occurs in the Bay-Delta region as a spring breeding species, winter visitor, and migrant. Atypically for hawks, northern harriers are polygamous; males may have two to five mates. Territorial males court females with a spectacular sky-dancing display. Harriers are also unusual in that they nest on the ground. Their prey base consists largely of rodents, especially voles (*Microtus*); birds, mainly passerines and small waterbirds; reptiles; and frogs. A harrier's owl-like facial ruff enables it to locate concealed prey by acoustical cues alone.

A California Species of Special concern, northern harriers are dependent on declining wetland and upland grassland habitats. Requiring ground nest sites safe from humans and predators, they are vulnerable to development and recreational use of these environments. Locally, data from the Golden Gate Raptor Observatory shows an increase in harriers migrating through the Marin Headlands since 1996. From an earlier average of 0.2 hawks per hour, the harrier count has risen to 1.5 hawks per hour in recent years. This may reflect either prey population cycles or a distemper epidemic in the 1990s that eliminated gray foxes and other mammalian competitors for rodent prey (Fish 2008, pers. comm.).

Banding records and radiotracking studies indicate a very sedentary Bay-Delta harrier population that ranges from the coast to the Sacramento River and from Petaluma to Alviso. They are joined in winter by migrants from the far north. One harrier banded on Whidbey Island in Washington was recovered two years later in Petaluma.

Ironically, northern harriers have been identified as a key predator of western snowy plovers in the South San Francisco Bay salt ponds, responsible for record high nest depredation in 2006, and the species has been added to the avian predator management program. Harriers in the South Bay were observed hunting along levees as well as over marsh habitats, suggesting the need to remove linear features from plover nesting ponds (Tucci et al 2007).

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California Black Rail

Tidal marshlands of the S.F. Bay region supports the preponderance of the California black rail (*Laterallus jamaicensis coturniculus*) population in the western United States (Evens et al. 1991, Evens and Nur 2002). State listed as threatened, breeding black rails are confined mostly to remnants of historic tidal marshlands in the Estuary's northern reaches, primarily those associated with San Pablo and Suisun Bays (Manolis 1978, Trulio and Evens 2000, Evens and Nur 2002). 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 (Ainger et al. 1995). 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 (Evens and Nur 2002). Because detection probability is based on a statistical model, and there are many factors that may bias estimates, the true number may be substantially higher or lower; a more reliable estimate may be an average density of 2.13 birds/hectare in high value habitat (Evens and Nur 2002). 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). Other contributing variables 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 bounded 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). Threats to black rail populations within San Francisco Bay include loss of refugial habitat along the marsh upland edge, habitat loss due to rising sea level, predation, and contamination.

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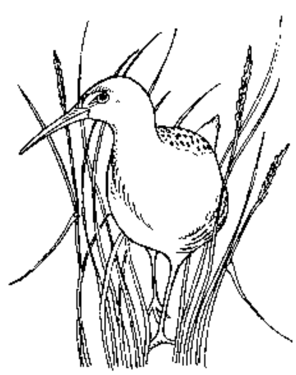
California Clapper Rail



Although small satellite populations of the California clapper rail (*Rallus* *longirostris obsoletus* historically occurred in tidal marshes along the outer coast, (Tomales Bay, Bolinas Lagoon, Elkhorn Slough), the entire population is now restricted to San Francisco Bay. The population estimates within the Bay have fluctuated widely over the last four decades. In the 1970s Gill (1979) estimated 4,200-6,000 birds within the Bay. By the 1980s, the population had plummeted to a low of 300-500 individuals. In the 1990s clapper rail numbers were estimated at 1,040 to 1,264, with up to 564 in Suisun and San Pablo Bays (1992-93 data) and up to 700 in South San Francisco Bay (1997-98 data). The results of more recent Bay-wide surveys, 2004 to 2007, are not yet available, but the consensus among rail researchers is that numbers have remained stable or increased somewhat over the last decade, especially in the South Bay. It is clear, however, that there have been shifts in distribution among the disparate habitat parcels available within the Bay. The recent multiyear study (2005) found that the species had declined or been extirpated in some areas of the North Bay since the early 1990s. In 2005, no clapper rails were detected at any of the nine Suisun Bay sites, or at the mouth of Sonoma Creek where the previous survey found approximately 25 individuals. However, in 2007 rails were again detected at those San Pablo Bay sites, but in lower numbers than in the 1990s. Two former low-density sites, Richardson Bay and Point Pinole, also had no detectable rails in 2005, but low-numbers were detected in 2006/7. The population at White Slough near Vallejo also showed a sharp decline in 2004/5 but a modest rebound in 2006/7. The causes of these declines and rebounds are unclear, although predation by the non-native red fox has been a contributing factor. Numbers have increased in some sites that have been invaded by non-native *Spartina alterniflora.* At Central Bay locations such as Arrowhead Marsh and San Bruno Marsh, there appears to be strong association between increase in vegetation cover provided by *Spartina alterniflora* and increase in clapper rail densities.

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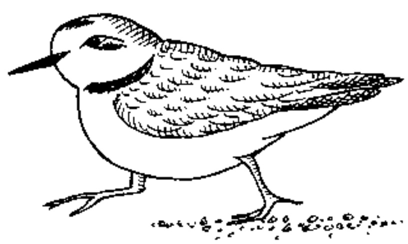
Western Snowy Plover



In the Bay Area, the federally threatened Pacific Coast western snowy plover (*Charadrius alexandrinus nivosus*) is primarily associated with commercial salt evaporation ponds and levees, which means that land managers have not to date been able to actively manage habitat or resources for this species. However, the recent purchase of more than 15,000 acres of salt ponds in south S.F. Bay by U.S. 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 2007 final 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. The recovery plan sets a low bar for recovery and delisting of the species (delisting would occur when 3,000 breeding plovers are maintained over a 10 year period—after an increase of only 510 adult birds in California and less than 50 birds in Oregon and Washington). In April 2006 the Bush administration issued a proposed regulation to allow counties unlimited "take" of all plovers over the county's recovery goal, primarily from development and off-road vehicle impacts. Since some counties are already over their recovery goal, this plan will likely cause a decline in the total plover population in the short-term. It may produce a slight increase in the long-term, but is very unlikely to ever actually recover the species. The recovery plan also relies heavily on volunteer activity and voluntary cooperation of county and state agencies, rather than providing adequate funding for recovery or regulatory protections. While the Bay did not historically support 500 snowy plovers, managing salt evaporation ponds for plovers is an opportunity for it to play a significant role in the recovery of this species, especially because many of the plover's historic coastal breeding and wintering sites have been degraded by human disturbance and urban development. Off-leash dogs also pose a significant threat to snowy plovers at coastal breeding sites. Snowy plovers were among the bird species killed by the November 2007 oil spill in San Francisco Bay.

Based on surveys in May 2006, the breeding population for San Francisco Bay was estimated as 99, a decline from 124 in 2005. Hatching success at two South Bay sites was estimated as 85% in 2005 and 5% in 2006. The decrease was attributed to high nest predation rates at the Eden Landing Ecological Reserve. Common ravens, northern harriers, and California gulls were the predominant nest predators (Robinson et al 2007).

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California Least Tern

California least terns (*Sternula antillarum browni*), state and federally listed as endangered, continue to nest at Alameda Point, formerly the Naval Air Station Alameda. The Alameda Point California least tern colony represents the largest California least tern colony in the San Francisco Bay Area. While disturbances from gulls and raptors have increased, human disturbance from trespassers has decreased to almost none.

The number of tern pairs using the base had been increasing each year, until 2006. It is believed that some of these terns chose one of two more recently established nesting sites close by: Montezuma Slough, east of Suisun Bay or Hayward Shoreline (EBRPD).

As in past breeding seasons, the number of successful fledglings continues to fluctuate. In 2006, 409 breeding pairs produced an average of 79 fledglings, a very poor season due to high avian predation pressure and an inadequate food supply of chick-sized fish in the Bay. In contrast, 2007 had 355 breeding pairs that produced an average of 247 fledglings, very close to the production in 2005 with 260 fledglings from 424 breeding pairs, and down from the previous all-time high of 320 in 2001. Those fledglings represented between 8 and 18% of the state's total fledgling population.

Montezuma Slough, a new north Bay least tern and western snowy plover colony, was discovered last year in Solano County, Suisun Marsh. In 2007, Montezuma Slough biologists observed 32 breeding pairs and at least 5 fledglings. Hayward Regional Shoreline, approximately 20 km south of Alameda Point, had terns for a third year in a row with 35 breeding pairs that produced 49 fledglings. For the first time, least terns were observed nesting at Eden Landing, located just south of Highway 92 on the east shore of San Francisco Bay. Six nesting attempts were observed, but no fledglings produced. The Albany colony on CalTrans property has not hosted least terns since 2001 and CalTrans has stopped monitoring this area indefinitely. Pittsburg Power Plant reported to the California Department of Fish and Game that there were seven least tern nests on the property, but no chicks were observed. Tern numbers have decreased from 13 pairs in 2001 to 4 in 2005, none of which were successful. 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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Least Bell's Vireo

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

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

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

In 2006, despite extensive flooding on the refuge, the banded male vireo returned with a mate; three young were successfully fledged. But no male was detected the following year. A female vireo built a nest and laid 4 eggs, then abandoned the nest; the eggs were apparently removed by a predator, and the female was not observed again. Intensive monitoring will continue during the 2008 nesting season.

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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. Despite this increase, the overall success observed at most marshes (usually only between 15% and 20% of nesting attempts result in any fledged young) may be below the level necessary to ensure a stable population. Reproductive success varies among marshes, with landscape characteristics (such as proximity to the water's edge) being good predictors of nest survival. The greatest cause of nest failure is predation by both native (gopher snake, northern harrier, common raven, American crow, raccoon, river otter) and non-native (house cat, red fox, Norway rat) predator species; rodents are likely the most common predator in most marshes. In addition, about 10% of nests fail each year due to flooding during the highest tides. Nesting success data for 2005 showed an unusually high rate (31%) at Pond 2A (San Pablo Bay) and lower success rates in other San Pablo Bay marshes, and relatively high rates in Suisun Bay. In 2006, nesting success was extremely low at Benicia (Suisun Bay) due to predation and at China Camp (San Pablo Bay) due to flooding. Estimated numbers of breeding Alameda song sparrows (*Melospiza melodia pusillula*), restricted to Central and South S.F. Bays, range from 13,400-20,000 individuals; of Suisun song sparrows (*Melospiza melodia maxillaris*), found in Suisun Bay, from 43,000-66,000; and of San Pablo or Samuel's song sparrows (*Melospiza melodia samuelis*), found in San Pablo Bay, from 81,000-90,000. Population densities of the Alameda subspecies generally increased from 1996-2003, then decreased from 2003 to 2006. Surveys in the Hayward area in 2006 detected very low numbers. Density indices for San Pablo and Suisun song sparrows have been declining since the late 1990s and reached historic lows in 2006. 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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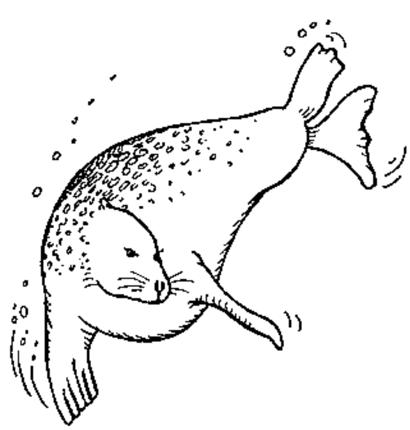
Harbor Seal



San Francisco Bay harbor seal (*Phoca vitulina*) numbers have remained fairly stable over the past decade, and are estimated to be >600. Approximately 15 haul-out sites are known in the Bay, with sporadic reports of additional sites being used. Harbor seals are found in the greatest numbers throughout the year at three sites: Mowry Slough, Yerba Buena Island, and Castro Rocks. Mowry Slough, still the largest pupping site in the Bay, is used predominantly during the pupping (mid-March-May) and molting (June-mid-August) seasons. Since 2000, approximately 300 harbor seals and >100 pups have been counted at Mowry Slough each pupping season. Monitoring of three haulouts on the Don Edwards San Francisco Bay National Wildlife Refuge documents a dramatic upward trend at Coyote Creek (Alviso) due to increased pupping success (Buffa 2007). In the winter (mid-November-mid-March) months, when Pacific herring (*Clupea pallasi)* spawn in the Bay, the number of seals at Yerba Buena Island increases to 200-300 harbor seals (1998-2004). Additionally, the number of seals using Castro Rocks, a chain of rock clusters just south of the Richmond Bridge and the second-largest pupping site in the Bay, has increased greatly during the winter season since 2000, with a maximum of 300-600 seals recorded during recent years. The increase in seals hauling out at Castro Rocks in the winter may be related to shifts or increases in herring spawning closer to Castro Rocks. Castro Rocks is used by an average of 100 seals year-round (2000-2004). Seismic retrofit work began on the Richmond Bridge in early 2001, and researchers from San Francisco State University monitored what effect the construction had on seal numbers and behavior. Despite an early shift in site use to rocks located farther from the bridge when construction was underway in the immediate area, and an increase in disturbances due to construction activity; seals maintained use of the Castro Rocks haul-out site for the duration of construction work (2001-2005).

Contaminant levels in San Francisco Bay harbor seals have been a concern since the 1990s. The authors of a 2005 study reported that polychlorinated biphenyl (PCB) residues in harbor seal blood had decreased during the past decade, but remained at levels great enough that adverse reproductive and immunological effects might be expected. They also reported associations between PBDE (polybrominated diphenyl ether) concentrations, high leukocyte counts, and low red blood cell counts, suggesting that seals with high contaminant burdens might be subject to increased rates of infection and anemia (Neale et al. 2005). An emerging contaminant found circulating in blood samples from harbor seals is perfluorooctane sulfanate (PFOS), a compound used in a variety of stain-resistant and water repellent coatings. These chemicals have been detected in the marine environment worldwide, but preliminary work done by the Marine Mammal Center's Denise Greig in collaboration with San Francisco Estuary Institute suggests that levels in seals from San Francisco Bay may be two to three times higher than levels reported in seals from the Baltic Sea or Norwegian Arctic.

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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. Meanwhile, recent surveys document that there is very little mouse escape cover left in the South Bay, where what was once miles of high marsh vegetation has been reduced to a maximum width of 8 to 9 feet or eliminated completely (Shellhammer, pers. comm. 2005).

Although the mouse has been considered a pickleweed specialist, research on its northern subspecies (*calcoides*) in Suisun Marsh indicates that mixed halophyte growth (rushes, sedges, saltgrass, fat hen) is also used. When tidal habitats were compared, the percentage of females in reproductive condition was higher in the mixed-halophyte zone than in pickleweed. The study also found viable mouse populations in diked as well as tidal wetlands (Sustaita 2004). Other recent studies in the Don Edwards San Francisco Bay National Wildlife Refuge have documented the effect of management activities on the southern subspecies (*raviventris*), documenting that the mice colonize restored habitat quickly and that translocation can be successful in augmenting low population levels (Buffa 2007).

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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 and 194 young rabbits released into the refuge. Overall, since 2002 a total of 671 rabbits have been released from the captive breeding program into the wild, another 62 are currently scheduled for release once they have matured, and 204 wild-born rabbits have been identified through the ongoing studies. The rabbits are not released into the wild until they are large enough to successfully survive the translocation. All rabbits are screened by a veterinarian before being released.

Flooding in 2006 along the San Joaquin River inundated much of the rabbits' habitat, and was a setback for the program. Through an adaptive management process, the federal, state, and private entities involved have learned a great deal about the specific habitat needs in of the species, and have worked extensively to create the habitat structure needed by the rabbit. The risks of flooding, wildfire, and other events can never be entirely eliminated, but actions such as the construction of higher elevation refugia ("bunny mounds"), revegetation of burned areas, and riparian restoration are helping to alleviate the pressures facing the species.

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Delta and Upstream Contaminants

Delta smelt and several other pelagic fish species in the Bay-Delta Estuary have experienced population declines in recent years. The Interagency Ecological Program (IEP) determined that at least three general factors might be acting individually or in concert to lower pelagic productivity: toxic contaminants, exotic species, and water project operations. The State and Regional Water Boards have authority over water pollution and water project operational requirements.

In December 2007 the State Water Resources Control Board and Central Valley Regional Board passed joint resolution No. 2007-0079 to ensure protection of beneficial uses and equitable administration of water rights in the Bay-Delta and its tributaries. The San Francisco Bay Regional Board adopted a similar resolution (No. R2-2008-09) at their January 2008 Board meeting. Among other things the resolution committed Water Board staff to prepare a strategic work plan for joint Board consideration. The plan will describe the scope of individual pollution control actions, relative priorities, timelines, and resources needed to carry them out. Some specific actions that will be addressed by the Strategic plan include:

- Execute a contract to compile and assess available data on contaminant concentrations and toxicity as measured in bioassays for all monitoring programs in the Delta during the last 5 years to determine whether contaminants are a likely contributor to the pelagic organism decline or are impacting aquatic beneficial uses. Contractor will also provide recommendations on integrating and improving ongoing monitoring.
- Propose for Board consideration a comprehensive long-term Delta-wide monitoring program to provide data on contaminants in sediment, water, and aquatic organisms. The monitoring program will be integrated with monitoring already conducted by other groups including the Interagency Ecological Program (IEP.)
- Execute contracts to conduct screening studies of potential inhibition of primary productivity and toxicity to fish associated with ambient ammonia concentrations and, if impairments are found, take appropriate regulatory controls to protect beneficial uses.
- Require characterizations of discharges to and from Delta Islands for water quality purposes.
- Encourage the Department of Pesticide Regulation (DPR) to expedite their pyrethroid pesticide re-registration process and provide Agricultural Commissioners with guidance on pesticide use restrictions that could be implemented in the interim. The Water Boards will work with DPR and Delta county Agricultural Commissioners to consider the feasibility of special restrictions on pesticide use on Delta Islands and lands on the periphery of the Delta.
- Develop and implement regulatory controls in coordination with the State Lands Commission and the U.S. EPA to address the introduction of invasive species in ballast water and hull biofouling.
- Take the following actions to develop or implement TMDLs (Total Daily Maximum Load) or other actions addressing water quality impairments.
    - o To implement the organophosphate (OP) pesticide TMDL, the Water Boards will require management plans to address exceedances of OP pesticide water quality objectives in discharges and

evaluate water quality impacts from replacement products, such as pyrethroid pesticides.

- The Water Boards will continue to negotiate a management agency agreement with the U.S. Bureau of Reclamation to implement a real-time salinity management program by August 2008 as required by the San Joaquin River salt and boron TMDL.
- The Water Boards will develop and adopt salt and boron water quality objectives in the San Joaquin River upstream of Vernalis and an associated TMDL.
- The Water Boards will develop and adopt a selenium TMDL for the Delta and northern San Francisco Bay.
- The Water Boards will adopt a TMDL for mercury in the Delta and begin implementation along with the existing TMDL for mercury in San Francisco Bay.
- Pathogen counts in a number of Delta waterways in the City of Stockton urban area exceed applicable numerical criteria. In March 2008, the Central Valley Regional Board approved a pathogen TMDL for these waterways.

The U.S. EPA approved the Basin Plan amendment for control of mercury in Cache Creek in February 2007, the nutrient Basin Plan amendment for Clearlake in July 2007, and the OP pesticide Basin Plan amendment for the Delta in October 2007. The Sacramento-Feather River OP pesticide Basin Plan amendment was readopted for diazinon in May 2007. The OP amendment now includes water quality objectives for chlorpyrifos.

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Bay Contaminants

The Bay contains a complex soup of pollutants that vary in the severity and types of risks they pose, and in their sources, spatial distributions, and trends over time. Enforcement of the Clean Water Act and other environmental laws over the past 35 years has resulted in tremendous improvements in overall Bay water quality, solving serious problems related to organic waste, nutrients, and silver contamination. Contamination due to toxic chemicals in general has also declined since the 1950s and 1960s.

Several significant water quality threats remain, however, including mercury, PCBs, dioxins, and exotic species. A fish consumption advisory remains in effect due to concentrations of mercury, PCBs, dioxins, and organochlorine pesticides of potential human health concern in Bay sport fish. A duck consumption advisory is also in effect due to selenium concentrations of potential human health concern. There are also indications that current levels of contamination are harming the health of some wildlife species. Mercury concentrations are high enough to reduce the hatching rate of Forster's terns, and also appear to be high enough to cause embryo mortality in clapper rails, an endangered species found in Bay tidal marshes. PCB concentrations may be high enough to also cause low rates of embryo mortality in Bay birds and to affect immune response in harbor seals. Selenium concentrations appear to be high enough to cause abnormalities in early life stages of Sacramento splittail and white sturgeon. Pollutant mixtures appear to similarly affect early life stages of striped bass. Assessments of benthic communities in the Bay indicate that some areas may be impacted by pollutants. The frequent occurrence of sediment toxicity is another indicator of pollutant impacts in Estuary sediments.

The forecast for PCBs and dioxins is for slow progress toward recovery over the next 20 years, with concentrations likely to remain above risk thresholds. The outlook for mercury is unclear, and depends on whether effective management actions can be identified and implemented. For exotic species, the rate of introductions could be reduced significantly through management actions. The future looks brighter for other pollutants (selenium, PAHs, and legacy pesticides) whose concentrations do not exceed risk thresholds by much or at all, or it is not entirely clear if they pose significant risks in the Bay at present concentrations. Concentrations of selenium and PAHs could fall below risk thresholds in 20 years depending on management of sources. For legacy pesticides, concentrations should fall below risk thresholds in 20 years through natural breakdown, with lingering concerns only for effects in combination with other pollutants. For nickel and copper, concentrations are below thresholds and management plans are in place to make sure they stay there.

Concern for another group of pollutants is growing, due to either increasing rates of input into the Bay or advances in scientific understanding of the magnitude of specific water quality threats. For PBDEs and pyrethroids the 20-year outlook is currently unclear, and will depend heavily upon management decisions. Concentrations of both of these pollutants would be expected to drop rapidly in response to reduced inputs to the Bay. If use of these chemicals is curtailed, the Regional Monitoring Program (RMP) should be looking ahead to evaluate the risks associated with the next generation of flame-retardants and insecticides, which hopefully will be less of a threat to Bay water quality. The outlook for sediment toxicity will be unclear until the causes of this toxicity can be identified. Too many unknowns surround the issue of risks due to pollutant mixtures to characterize current status, much less the status in 20 years.

Progress is being made on cleanup plans (TMDLs) for pollutants of concern in the Bay. The San Francisco Bay Regional Water Board has completed TMDL projects addressing mercury in the Bay, pesticides in urban creeks, and pathogens in several Bay tributaries. TMDL projects are scheduled for completion in 2008 for PCBs in the Bay, pathogens in Richardson Bay, nutrients in Napa River and Sonoma Creek, and sediment in Sonoma Creek. Other TMDL projects are planned for selenium and legacy pesticides in the Bay. Information on TMDLs is available at: www.waterboards.ca.gov/sanfransciscoBay/tmdlmain.htm.

Continued monitoring and advances in scientific understanding will be essential in refining the forecasts for the Bay's assortment of pollutants of concern, and in tracking the response of the ecosystem to management actions taken to continue the general trend toward improvement of Bay water quality that has occurred over the past several decades.

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Cosco Busan Spill

The Cosco Busan spill claimed the lives of at least 45 species of birds, ranging from the pelagic northern fulmar and parasitic jaeger to the shorebound fox sparrow. Some were hit harder than others. First impressions that most of the oiled birds were surf scoters are supported by data from the International Bird Rescue Research Center. More surf scoters were collected alive than any other species, followed by western grebe, eared grebe, and greater scaup. The scoters also headed the list of species found dead, followed again by western grebe, common murre, and Brandt's cormorant.

Surf scoters accounted for 36% of birds found alive, 20% of birds found dead, and 26% of all birds collected.

Significant numbers of Clark's grebes, horned grebes, western gulls, northern fulmars, double-crested cormorants, and ruddy ducks were also collected. Except for the gull and fulmar, all these birds forage by diving from the surface of the water. Grebes, cormorants, and murres are fish-eaters, while the three ducks eat benthic mollusks and other aquatic invertebrates. Other foraging guilds—for example, plunge-divers like terns and pelicans—appear to have been less affected.

Photo courtesy of U.S. Coast Guard.

The surf scoter is one of the most abundant birds in San Francisco Bay in fall and winter. But local Audubon Society Christmas Bird Counts report higher totals for greater scaup than for scoter, along with substantial numbers for ruddy duck and bufflehead. Location may account for some apparent patterns. Southern Marin had the highest CBC numbers for western grebe, which ranked second to surf scoter among spill victims; eared grebes, concentrated in the South Bay, had fewer spill casualties.

Other variables may include how susceptible different species are to bunker oil. Compared with crude oil, little is known about the toxicity and persistence of bunker oil, although it has been shown to damage the reproductive systems of laboratory mink. Bunker oil varies chemically from batch to batch, so generalization is difficult. One study found that major oil spills in western Europe doubled the winter mortality of common murres whether the culprit was crude or bunker oil.

Endangered species affected by the spill include marbled murrelet, western snowy plover, and brown pelican. Several Important Bird Areas, including Richardson Bay, East Shore Wetlands, and Brooks Island were impacted; Brooks Island's breeding Caspian terns were not home.

UC Davis researchers headed by Michael Ziccardi and Greg Massey are using the catastrophe to learn more about care and survival of oiled birds. They have analyzed blood samples to determine the best predictors of survival and clarify the causes of anemia in spill victims, and studied infrared scans as indicators of waterproofing. A group of surf scoters had radio transmitters implanted so their travels and survivorship after release could be monitored. Two control groups were also radio-tagged for comparison. There is little existing data on post-spill survivorship of rehabbed waterfowl, most of it from hunters who report the bands of birds they have shot. According to IBRRC Executive Director Jay Holcomb, bands from six of 175 ducks released after a spill on the Santa Clara River were reported over a six-year period.

Susan De La Cruz and other USGS biologists are also looking at over-winter survival of oiled scoters compared to non-oiled birds in a study with UC Davis, DFG, and Humboldt State. Effects on adult survival in a species like surf scoters can have long-term effects on the population. Scoters are a long-lived sea duck species with low reproductive potential, and are particularly sensitive to changes in adult survival. Such species may have the most difficulty recovering from oil spills (Samuels and Ladino 1984). Additionally, many sea ducks show high winter site fidelity and pair on wintering areas; thus, factors that affect survival rates in the Bay could have disproportionate effects on local subpopulations. Since San Francisco Bay supports an average of about 45% of the lower Pacific Flyway surf scoter, the numerous mortalities here could potentially impact the Pacific Coast population. De La Cruz and colleagues are also looking at differences in foraging behavior and movement patterns between oiled and control birds, to determine whether oil exposure has influenced their physiology such that they are not foraging and/or using Estuary habitats in the same manner as non-oiled birds.

There are also long-term, chronic effects to be considered. Scoter and scaup may continue to be exposed to residual oil through their prey in subsequent winters. Studies after the Exxon Valdez have shown that sea duck survival is lower in chronically exposed (nine years after the spill) individuals and that chronic oil exposure affects shorebird reproduction.

In some cases, residual oil may influence the food scaup and scoters eat by eliminating or changing dominant prey species, and thereby changing the energy available to diving ducks. Changes in the amount and type of prey available could potentially influence the number of birds the Estuary can support over winter. There are also indirect effects in which a change in some key organism in the system due to oil exposure can trigger a cascade of delayed long-term ecosystems effects (S. De La Cruz, pers. comm. 2008).

A total of 1,084 oiled birds ware taken to the IBRRC's Cordelia facility in the aftermath of the spill. As of January 2008, 421 rehabilitated birds

Photo courtesy of Ron Sullivan.

had been returned to oil-free shorelines in San Mateo and Marin Counties. The IBRRC said 1,858 had been found dead in the field (939 visibly oiled); another 653 had died or been euthanized at the rescue center. Many others may have sunk in the Bay or the ocean, or been eaten by predators and scavengers. If, as is likely, only one of every ten casualties is being retrieved, deaths resulting from the spill could exceed 22,000.

Marine mammals appear to have been less impacted. The deaths of two northern fur seals and a harbor seal were attributed to the spill.

MORE INFO?
www.ibrcc.org/Cosco_Busan_spill_2007.htm;
www/vetmed.ucdavis.edu/owcr

Important Changes

IN THE STATE OF THE ESTUARY

The State of the Estuary as Reflected in the 2007 CCMP

THOMAS E. MUMLEY
San Francisco Bay Regional Water Quality Control Board

The newly revised Comprehensive Conservation and Management Plan (2007 CCMP) of the San Francisco Estuary Project is a reflection of the current state of the Estuary and provides a vision for the future of the Estuary. This is the first review and revision of the original CCMP established in 1993. Over the past two years, over 80 stakeholders reviewed the 1993 CCMP actions and accomplishments, identified current and future challenges, revised 70 of the 145 actions, and developed 61 new actions.

Although much has been accomplished, we still have far to go. We have one of the best pollution monitoring programs in the world in San Francisco Bay and TMDLs for salt, pesticides, oxygen, mercury, selenium, and PCBs. Yet new contaminants are emerging all the time, including personal care products and pharmaceuticals, and flame-retardants, some of which have been banned. Marine debris is a huge problem in the Bay and the ocean.

We have made huge strides in restoring habitat for salmon on Battle, Butte, and Deer Creeks, and also in wetlands acquisition and restoration throughout the Estuary, yet we continue to lose seasonal and riparian wetlands to poorly planned development. The Estuary remains a major coastal wintering and migratory stopover for waterfowl; yet mercury in the Bay food chain is contaminating some species of birds and their eggs, possibly affecting reproduction. We have a Long Term Management Strategy for Dredged Materials that has reduced in-Bay disposal of dredged sediments by 50%. Over 9 million cubic yards has been "beneficially" re-used in wetland and upland restoration projects, levee rehabilitation, and landfill cover. Yet there are long-lived "legacy" contaminants that will take decades to clean up. And while we have come a long way in conserving water supply, we need to do more, and to diversify sources of supply and take regional approaches to water management.

One of our biggest challenges is land use—to better manage watersheds at local levels and multiple watershed scales. And to address all of these issues, we must do a better job of getting scientists and resource managers to communicate, and a better job of educating the public about the Estuary.

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Watersheds and Land Use: Trends and Implications for the Estuary

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The biggest change in land use in northern California is urbanization: of upland watersheds from which runoff is generated, and of low-lying lands that receive floodwaters from the watersheds. There is now greater awareness of the hydrologic effects of urbanization on watersheds, and stormwater management for new urban developments has greatly improved. Nonetheless, the rapid pace of continued urbanization tends to counteract the reduction in impact of each new development. When prime agricultural lands become urbanized, some components of water quality (such as nutrient loading) may improve locally, but loads of pesticides and automobile-related contaminants can be higher. When urbanization displaces agriculture from prime farmland to marginal lands, water quality impacts increase on a regional scale because marginal lands typically require more fertilizers and have steeper slopes and more erodible soils, thus yielding more sediment.

With intense population growth pressure in urban areas, urban growth has spilled into low-lying areas such as the Sacramento-San Joaquin Delta. Although the Delta Protection Act has prevented urbanization of deeply-subsided central parts of the Delta, outside of this core, thousands of houses are now being built in deep floodplains—lands that lie below sea level or more than 10 feet below the level of the 100-year flood. Ironically, federal flood control policies conspire with financial pressures on local jurisdictions to encourage development on these deep floodplains. However, even if they are "protected" by 100-year levees, the residual risk of flooding from larger floods remains surprisingly high: more than 25% over the life of a 30-year mortgage. The water quality implications of levee failure and inundation of vast areas of the Delta are sobering to contemplate. Management of the Delta for water supply and ecosystem has been hotly debated for over three decades, but options to address these resources are rapidly being foreclosed by uncontrolled urbanization.

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Climate Adaptation Strategies for Urban Water Management

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Historically, Bay Area water management agencies have worked together on integrated water issues in an attempt to diversify water supplies, reduce wastewater discharges, and protect the health of ecosystems. More recent integrated and regional water management initiatives include the Bay Area Integrated Regional Water Management Plan, inter-ties among Bay Area water agencies, recycled water efforts, regional desalination projects, and watershed management plans.

While water supply diversification has been a goal of many water supply agencies throughout the Bay Area and the state, diversification becomes increasingly important as the region's population continues to grow and supplies are stretched thinner. The Department of Water Resources California Water Plan involves meeting statewide goals for groundwater development, water recycling, and conservation. Local urban water management plans involve water agencies continuing to pursue local projects to meet the state's and their own supply diversification goals. San Francisco Public Utilities Commission has its own diversification plan that includes investigation of potential options such as desalination and recycled water use, as well as increased groundwater use and conservation. The Bay Area Integrated Regional Water Management Plan provides a regional context for water supply diversification.

As our understanding of the effects of global climate change evolves, water, wastewater, and flood protection agencies are faced with additional challenges. Future challenges that may need to be considered by water management agencies include reduced snow pack, precipitation and temperature changes, localized flooding, sea level rise, and more frequent droughts. In San Francisco, wastewater treatment facilities are at risk from sea level rise, and we will need to decide whether to move or protect them.

The effects of climate change inspire integrated urban water management and a renewed interest in reducing demand, diversifying water supply, and changing the way communities are designed and developed. More robust tools to understand temperature and precipitation effects are needed, as are better data on stream flow and snow pack. Providing for more regional coordination among land use agencies is necessary to meet future growth and prepare for the effects of global climate change.

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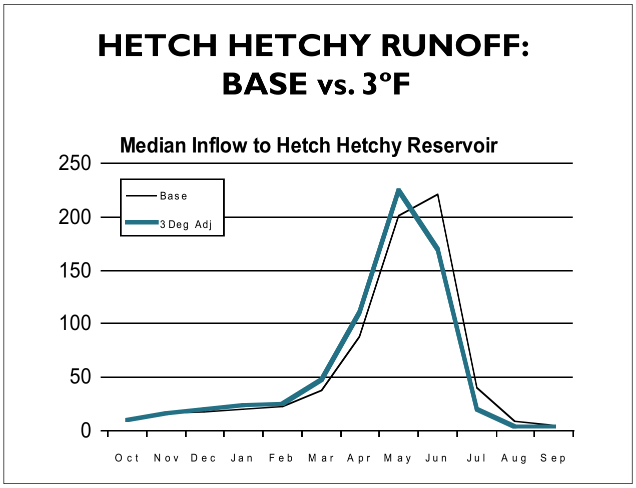

The black line shows the current runoff pattern. The teal line shows the predicted runoff pattern with a 3˚ Fahrenheit warming. The results in terms of water supply are that peak runoff moves up 1 month; there will be less snowpack later in the season and reduced carryover storage at the end of the drawdown period (May-October). The greatest danger to supply will be early runoff coupled with below normal precipitation the following year. These effects will be common to all snow-fed systems in the West.

SFPUC EARLY ADAPTATION TO CLIMATE CHANGE STRATEGIES:

- Develop local water supplies to rely less on imported snow-dependent supplies.
- Explore desalination—the SFPUC is part of the Bay Area Regional Desalination Project.
- Diversify water sources, including the use of groundwater.
- Use graywater to flush toilets.
- Learn from other water agencies.
- Engage ratepayers: In the summer of 2007, SFPUC customers were able to reduce water use by 12% through voluntary conservation measures. People can reduce their water use, and continue to do so.
- Develop better science and technical tools.
- Focus on adaptation while leading in mitigation.
- Strengthen communication with regulatory agencies.
- Interact with wastewater agencies.
- Provide opportunities to reduce wastewater and flooding while offsetting potable demand through water recycling, stormwater capture.
- Support local/state regulatory reform that encourages new development standards that reduce resource needs.
- Update local and state planning, plumbing and building codes to support the use of greywater, stormwater, rainwater, and recycled water.

Pollution Prevention and Reduction: Familiar Foes and Emerging Enemies

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San Francisco Bay Regional Water Quality Control Board

Water quality managers have had modest success over the last decade in gaining an understanding of the sources of a number of pollutants, such as copper, fats/oils/grease, and some forms of mercury. In fact, because of long experience working on some of these issues, source control has become routine and commonplace. However, even some commonplace pollutants (like trash) continue to be serious water quality concerns. While new chemicals and products usually benefit society, there is almost always an associated environmental impact.

New products and chemicals enter the market at a very fast pace, and there is not an infallible process in place for determining the ultimate environmental fate of active ingredients or degradation products. Moreover, improved analytical techniques allow us to detect the presence of chemicals at very low concentrations so we know about the presence (in water, sediments, and biota) of many potential chemical hazards, but we may know very little of the consequent biological risk. These pollutants of concern for which we do not have enough historical monitoring information to assess trends and are not captured within existing water quality regulatory frameworks are called emerging contaminants. They include polybrominated diphenyl ethers (PBDEs), used as flame-retardants in many consumer products, and perfluorinated chemicals, used in non-stick or stain-resistant coatings. The challenge of the next decade is to continue learning about the sources and pathways of both familiar and emerging pollutants so that managers can develop and employ effective control strategies.

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TAKE HOME POINTS

- We must have better leadership and more protective product legislation at the national and state levels.
- Citizens need to be educated to not misuse or abuse products that could result in the discharge of pollutants.
- Local agencies must provide the "last line of defense" by enacting appropriate policies and through intelligent design and operation of wastewater and stormwater infrastructure.

EVERYTHING vs. THE ENVIRONMENT

Pest Control/Nuisance on Land and Water (Pesticides)	vs.	Aquatic Toxicity
Preventing fires (PBDEs)	vs.	PBDEs in our water, sediment, and tissues, resulting in possible harm
Health and beauty (Pharmaceuticals and personal care products)	vs.	Endocrine disruption in wildlife and possibly humans, other health effects
Economic health (PCBs, Mercury)	vs.	Legacy Contamination
Air quality (MTBE)	vs.	Groundwater contamination

Wetlands: Links Between Watersheds and the Bay

JOSH COLLINS
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Much is being done to protect wetlands around the Bay. The Baylands Goals are being met by many efforts that are more adaptive, collaborative, and better coordinated than ever before. This will help us meet the challenge of protecting these lands, so dangerously situated between rising Bay waters and widening cities. Saving the Bay in the new world might mean doing things we've never done before, like filling the Bay to give it places to grow new marsh if the old washes away, or moving people out of the Bay's way. But in the meantime, we can't neglect the other wetlands, the ponds and wet meadows, springs and seeps, and lakeshores and riparian areas that dot and cross the landscape from the Bay's shore to the ridge tops. These wetlands help protect the Bay by providing nutrients, filtering pollutants, and lessening floods. They link the terrestrial and aquatic worlds together, sharing attributes of both worlds while being worlds unto themselves. Most of the wildlife in the Bay Area relies on these wetlands, which have more indigenous biological diversity than any other habitat type. They are also the celebrated centerpieces of the local aesthetic. They are the shady creek, the song sparrow by the frog pond, the dragonflies on the lakeshore. And they are vulnerable to many of the same kinds of problems that threaten the Baylands: pollution, climate change, habitat fragmentation. Protecting these wetlands will require no less effort than protecting the Baylands and the Bay. A regional approach is needed. New efforts are underway to map the wetlands and riparian habitats past and present, assess their status, track the progress of programs and projects designed to protect all wetlands, and set wetland goals at the watershed scale. The needed coordination among public and private interests is possible with a growing capacity to commonly visualize local wetlands and related projects in the context of all the others in the region, and to assess the effects of our cumulative efforts to assure healthy wetlands for the future. The developing plans envision our lakes and streams, coastline and Bay, hillsides and valleys, and the wetlands between as one integrated circuitry of physical and biological processes essential to our survival. And the vision has to accommodate change. Given all of the economic and ecological uncertainties before us, protecting ourselves requires forecasting the consequences of alternative plans. Watersheds are natural templates for comprehensive protection of the Bay, the Bay Area, and the life they should support.

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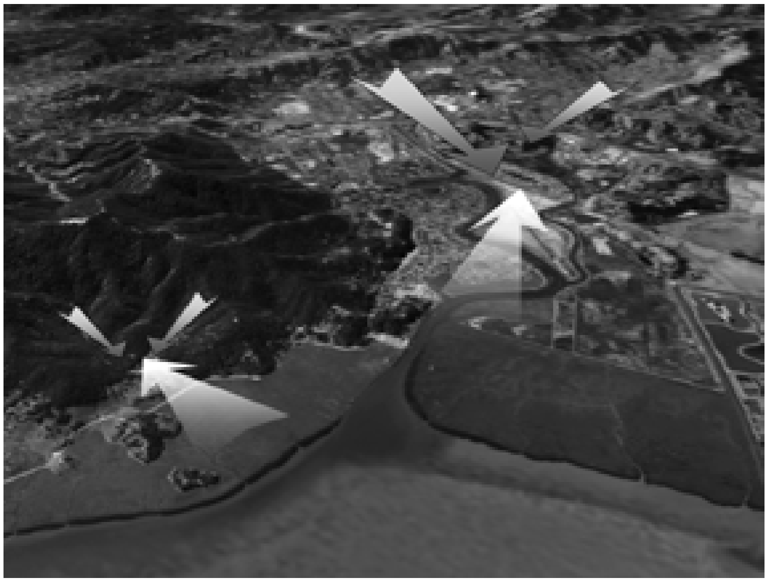
TAKE HOME POINTS

- We need to "give way" to the Bay. The Bay will continue to grow into local watersheds.
- Climate change will affect local runoff and erosion (sediment and freshwater supplies), not just sea level rise.
- While we can't manage sea level rise, we can manage runoff and erosion.
- Given the uncertainties of the future, wetland protection means going beyond static habitat goals with a set of tools for simulating habitat response to land use and climate change and for exploring alternative management scenarios.
- Watersheds are natural templates for comprehensive protection of wetlands and related habitats.



How far inland will the Bay shore migrate? The answer depends on the rate of sea level rise (white arrows pointing inland), existing topography (the inland migration will be shorter in steeper areas), and the amount of sediment provided by local watersheds (the outlined arrows pointing Bay-ward). As the watersheds erode, they build new topography by raising streambeds, floodplains, and tidal marshes that slow the upstream migration of the Bay.

From Spoils to Beneficial Reuse

STEVE GOLDBECK
San Francisco Bay Conservation and Development Commission

BRIAN ROSS
U.S. Environmental Protection Agency

When the original CCMP was signed in 1993, almost all dredged material was disposed of in the Bay. There were no multi-user ocean or upland disposal sites, and the main disposal site near Alcatraz was filling up. Disposal in the Bay was highly controversial and opposed by fishermen and environmentalists; dredged material was widely considered to be useless, toxic spoil. There was little coordination of permits, dredging projects were often delayed, and the Port of Oakland's 42-foot deepening project had taken 20 years to get underway, with no dredging in sight. The Dredging and Waterway Modification section of the CCMP called for actions to address and resolve these issues.

Since then, the Long Term Management Strategy (LTMS) for the placement of dredged material in the San Francisco Bay region was developed and implemented. Today we are halfway through the transition to low in-Bay disposal volumes and significant beneficial reuse. There is a designated deep-ocean disposal site. The Sonoma Baylands project was constructed using dredged material, the Montezuma Wetlands project is accepting material, the Hamilton Wetlands project is coming online, and dredged sand is being used to directly nourish Ocean Beach. There is a comprehensive testing program for dredged material, and an interagency Dredged Material Management Office coordinates permit applications. The LTMS agencies meet regularly with stakeholders and support an ongoing science program. Environmental work windows help protect sensitive species. The Port of Oakland completed its 42-foot project and is now dredging to 50 feet.

Hurdles remain to completing the transition to beneficial reuse, including maintaining staffing, funding, and the support of stakeholders. New listings of sensitive species like the green sturgeon present ongoing challenges. The use of multiple reuse sites around the Bay must be coordinated. Impacts of sand mining need to be assessed. Sea level rise and changes in Bay sediment dynamics must be taken into account.

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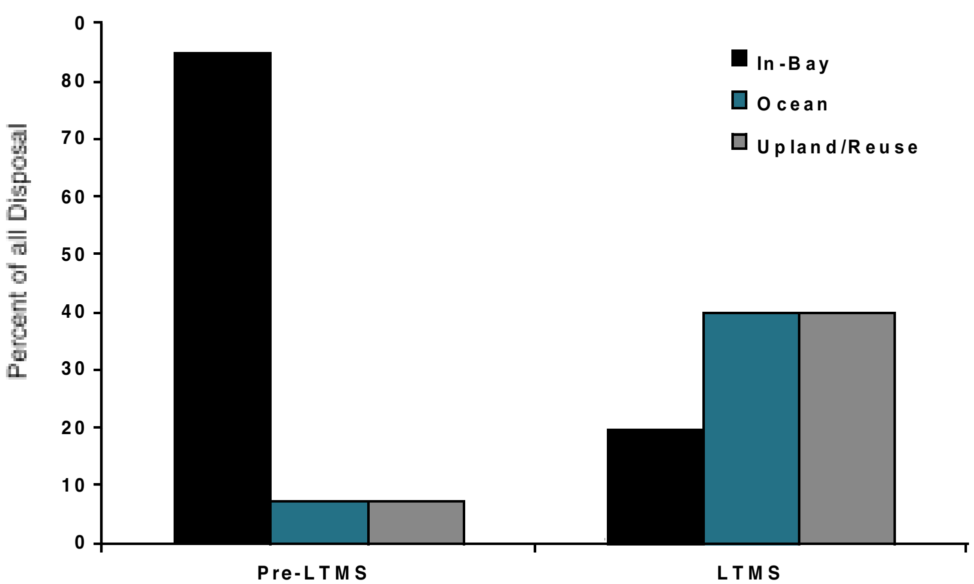
THE PLAN: MINIMIZE IN-BAY DISPOSAL MAXIMIZE BENEFICIAL REUSE



BENEFICIAL RE-USE PROJECTS

- Sonoma Baylands: 322 acres, reused over 2.5 million cubic yards.
- Carneros River Ranch (agricultural reuse): 540 acres, reused 0.7 million cubic yards to date, 2 million cubic yard capacity for ongoing reuse.
- Middle Harbor Habitat Area (subtidal habitat, including eelgrass): 180 acres, reused 6 million cubic yards.
- Montezuma Wetlands: 1,800 acres, capacity 12 million cubic yards; has already reused over 3 million cubic yards.
- Hamilton Wetlands: 700+ acres, capacity over 8 million cubic yards, will have reused over 3 million cubic yards by the time the Oakland -50 foot Deepening Project is completed in 2008.
- BMK "Unit V" will expand Hamilton to 2,000+ acres, 25 million cubic yards capacity.
- Ocean Beach: ~1 million cubic yards sand placed near shore for beach nourishment.
- South Bay Salt Ponds represent a potential for additional reuse opportunities in the future.

The Collapse of Pelagic Fishes in the Upper San Francisco Estuary: An Update

TED SOMMER ET AL.
California Department of Water Resources

Although the pelagic fish community of the upper San Francisco Estuary historically has showed substantial variability, a recent collapse of pelagic fishes has captured the attention of resource managers, scientists, legislators, and the general public. The consequences of the decline are most serious for Delta smelt (*Hypomesus transpacificus*), a threatened species whose relatively narrow range overlaps with large water diversions that supply water to over 25 million people and a multi-billion dollar agricultural industry. Other pelagic fishes showing a similar decline include the native longfin smelt (*Spirinchus thaleichthys*), and two introduced species, striped bass (*Morone saxatilis*) and threadfin shad (*Dorosoma petenense*). The declines occurred despite recent moderate hydrology, which typically results in at least modest recruitment, and investments of hundreds of millions of dollars in habitat restoration and environmental water allocations to support native fishes. Moreover, initial results suggest that fishes in upstream, downstream, and littoral habitats are not in a similar state of decline. In response to the pelagic fish collapse, an ambitious multi-agency research team has been working since 2005 to evaluate the causes of the decline, which likely include a combination of factors: stock-recruitment effects; a decline in habitat quality; increased mortality rates; and reduced food availability due to invasive species. The three big questions questions we are looking at are:

1. Did anything change at the same time as the Pelagic Organism Decline?
2. How and why did these factors change?
3. Did these factors affect populations of pelagic organisms?

Preliminary, unpublished results are shown above.

Quick Answers

	Change with POD?	Mechanism?	Population Impact?
Stock	Yes	Yes	Yes
Habitat	Yes	Yes	Yes
Food	Some	Yes	Yes
Mortality	Yes	Yes	Yes

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The Collapse of Pelagic Fishes in the San Francisco Estuary: What Does the Future Hold?

BRUCE HERBOLD ET AL.
U.S. Environmental Protection Agency

In the early 1990s Delta smelt and winter-run salmon were listed under the California and Federal Endangered Species acts. Biological Opinions to protect these species prompted the adoption of new water quality standards. These regulatory efforts focused on flow and habitat conditions in the Delta from February through June. These new regulations and other restoration efforts appear to have greatly benefited salmon. Radical declines in both Delta and longfin smelt abundances in recent years led to petitions to list longfin smelt as threatened and to downgrade the status of Delta smelt to endangered, to court orders to limit water project operations, to forced re-consultations under the Endangered Species Act, and to heightened concern among many groups and agencies. This high level of concern has led to intense scientific work in contaminants, disease, entrainment, habitat loss, trophic effects of introduced species, and many other factors.

This broader ecosystem approach in science is being reflected in real-time operations and in the re-consultations for water project operations. Evidence suggests that sensitivity of these species involves year-round conditions and a number of interacting, human-induced stressors. Fall Delta smelt habitat has shrunk and moved eastward. Flows in the Delta have stabilized, whereas they used to be variable in all but drought years. This may have helped the overbite claim to become established farther upstream, and possibly contributed to less nutritious phytoplankton, particularly the spread of the toxic blue-green algae *Microcystis*. It is possible that the pelagic organism decline could represent a tipping point from a variable estuarine system to more of a steady lake/lagoon system.

Simultaneous with the current concern for pelagic fish is widespread concern about the stability of the structure of the Delta and the likely impacts of climate change. Under the governor's direction this is leading to grand re-envisioning of how this engineered ecosystem will look in the future. Short-term protective measures for pelagic fishes are being included in the work of several groups charged with determining the long-term needs of the Delta. Understanding management and protection of our native fish in the short-term is an essential element in the future restoration of a sustainable Delta.

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Aquatic Invasive Species: Planning and Implementation

SUSAN ELLIS and
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California Department of Fish and Game

Over the past five years, the California Department of Fish and Game has worked with other agencies and stakeholder groups to develop an Aquatic Invasive Plan that includes over 160 actions for addressing aquatic invasive species issues in the state. The vectors for introduction highlighted in the plan include commercial shipping, commercial fishing, recreational equipment and activities, trade in live organisms, construction in aquatic environments, and water delivery and diversion systems. The objectives for the Plan that were identified during stakeholder meetings are as follows: coordination and collaboration, prevention, early detection and monitoring, rapid response and eradication, long-term control and management, education and outreach, research, and laws and regulations. The Plan identifies lead and cooperating agencies for each action within these objectives and sets up a timeline for completing actions and revising the Plan. The Plan also includes a draft Rapid Response Plan that provides generic guidance for agencies responding to suspect infestations. Using a Rapid Response Plan and an Incident Command system, the recent quagga mussel invasion has been contained in southern California.

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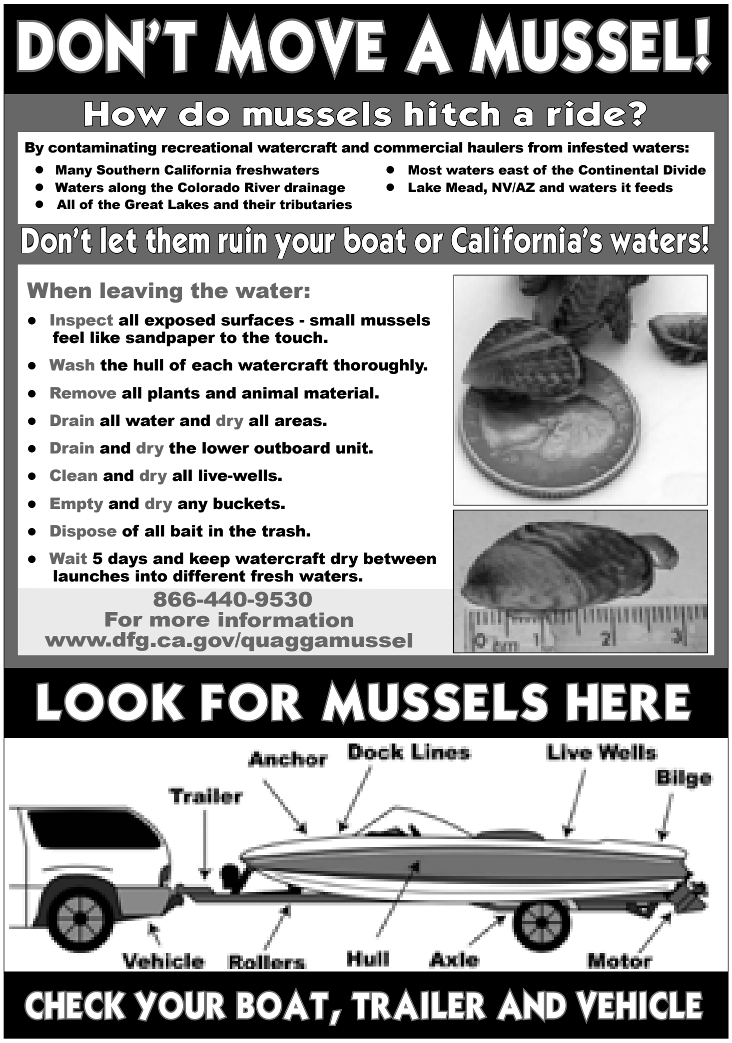

Fish and Game efforts to control new invaders include public outreach.

AQUATIC NON-NATIVES IN S.F. BAY

In 2005, we sampled 70 sites in S.F. Bay for non-native aquatic species. Target habitat types were intertidal rocky, intertidal sandy, subtidal fouling, and subtidal infaunal communities. 514 total species were identified:

- 103 non-natives (20% of all identified species)
- 81 cryptogenic (neither demonstrably native nor non-native)
- 330 native to California
- 285 unresolved taxa (could not be identified to species level)

Supplemental zooplankton sampling in 2006-2007 revealed an additional 10 non-native and 4 cryptogenic species.

- At one site—Port Sonoma in the Petaluma River—76% of all species identified were non-native.
- Three species are probable new invaders to S.F. Bay.
- Another two species are probable new invaders to California waters.

Response of the Estuary's Aquatic Biota to Changing Ocean Conditions

KATHY HIEB ET AL.
California Department of Fish and Game

Many biological and physical factors influence the abundance, distribution, and community composition of the Estuary's aquatic biota. For species that reproduce and rear in the upper Estuary, the importance of water exports, food supply, contaminants, and invasive species has been the focus of recent directed studies. However, species that reproduce in the nearshore ocean and rear in the Estuary are subject to a different suite of factors in early life, including ocean temperature, nearshore surface currents, and upwelling. Important ocean factors that affect biota include temperature, strength and onset of coastal upwelling, strength of the wintertime Davidson Current, and productivity.

The San Francisco Estuary is situated in a transitional zone between two ocean faunas: a cold-temperate fauna to the north and warm-subtropical fauna to the south. In this zone, we have observed relatively rapid responses of some nearshore species to changes in ocean conditions. Ocean temperature is a leading indicator of ocean conditions; warm-water and cold-water periods can be relatively short in duration, such as El Niño and La Niña events, or on longer multi-decadal or century time scales. During warm-water periods, warm-subtropical species such as the California halibut, white croaker, California tonguefish, and white seabass increase in abundance or make an appearance here after many years of absence. During cold-water periods, common cold-temperate species, including the Dungeness crab, English sole, speckled sanddab, and several rockfishes, increase in abundance while less common cold-temperate species reappear.

The frequency and duration of warm and cold-water events and the associated changes in ocean conditions are well documented in the eastern Pacific over the last century, but human-mediated changes on a global scale may result in new trajectories. Most ocean scientists predict that the physical environment will be more variable and change at an unprecedented rate in the near future. There are several scenarios or predictions of future changes in ocean climate, but all agree that there will be increased variability on the interannual (1-3 year) scale. Although we cannot predict the precise changes in ocean conditions, we can hypothesize how the Estuary's biota would respond to certain types of short and long-term changes. Marine species here have a wide range of responses to changes in ocean conditions.

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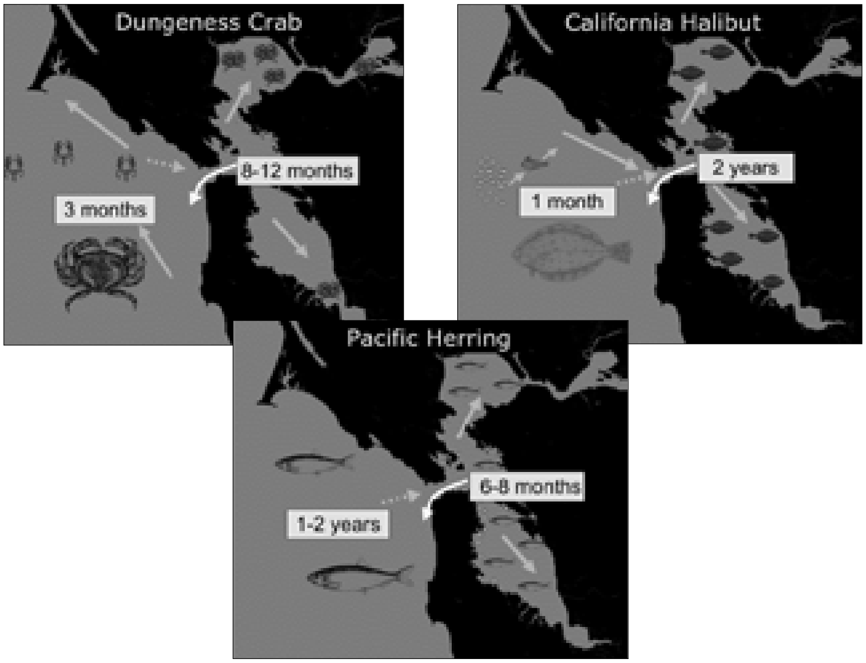
LIKELY CHANGES WITH GLOBAL CLIMATE CHANGE

- Ocean temperatures will increase.
- Summer upwelling could increase.
- There will be a deeper thermocline and upwelling of nutrient-poor water.
- The Davidson Current will increase with more frequent storms.
- Variation in temperature will increase with shorter regimes and more frequent El Niño events.
- There will be poor recruitment of cold-temperate species; adults will migrate north.
- More warm-subtropical species will migrate here with local recruitment of warm-subtropical species.
- There may be more dead zones (as in Oregon 2002-2006) and toxic algal blooms.



Response of Two Estuarine Mammals to Natural Events and Management Activities

JOELLE BUFFA, NORTON W. BELL, and WILLIAM PURCELL
San Francisco Bay National Wildlife Refuge Complex

The San Francisco Bay National Wildlife Refuge Complex (the Refuge) manages habitat for two estuarine mammals: harbor seal (*Phoca vitulina*) and salt marsh harvest mouse (*Reithrodontomys raviventris*). Harbor seal monitoring has been conducted weekly since 1998 at Mowry Slough, which is the largest of the three major haul-out sites in San Francisco Bay, and also the largest pupping site in the Bay. Monthly monitoring has also been conducted since 1999, weather permitting, at Alviso Slough, which is a smaller haul-out and pupping site located in the South Bay. Our data show daily, seasonal, and annual patterns in seals using these haul-out areas. Two seasonal peaks in harbor seal numbers have been well documented: April, which coincides with peak pupping, and June, which coincides with the molting season. The number of seals at Mowry Slough haul-out increased during the earlier portion of the survey period and has remained stable more recently. The Alviso site has experienced a steady increase in total numbers and number of pups. Explanations for these patterns include tidal cycle, physiological needs of the seals, and other natural and anthropogenic factors. The Refuge is also cooperating with San Jose State University on a study of recreational boating impacts to the harbor seal haul-out on Bair Island.

Most investigations of salt marsh harvest mouse population numbers in the Estuary have been conducted in response to proposed development projects or changes in land use that threaten mice. In contrast, small mammal studies conducted on the Refuge have focused on monitoring the effects of management actions undertaken to increase the amount of available habitat or improve habitat conditions for the mice. The establishment of Don Edwards S.F. Bay National Wildlife Refuge (NWR) in the South Bay and San Pablo Bay NWR in the North Bay included specific objectives to protect and contribute to the recovery of this federally listed (endangered) species. Management actions undertaken in seven marshes (Mayhew's Landing, La Riviere Marsh, Entry Triangle Marsh, New Chicago Marsh, Mouse Pasture, Tubbs Island Setback, and Tolay Creek) have included land acquisition, removal of fill, reintroduction of tidal and muted tidal action, other water management activities, and, in one case, the translocation of a population of salt marsh harvest mice from an area slated for development. While numbers of mice have generally increased following management actions, there have been setbacks caused by design flaws, lack of staff/funding causing inconsistent plan implementation, and natural events. Still, adaptive management, and resiliency in the rodent population indicate that this story is headed toward a happy ending. The Refuge, in cooperation with many other partners, is implementing the initial phases of the South Bay Salt Pond Restoration Project. Results of our monitoring are being used to design project components to benefit harbor seals and mice.

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TAKE HOME POINTS

- Salt marsh harvest mice colonize newly restored habitat relatively quickly.
- Translocating mice can be successful in augmenting low mouse populations (where habitat is below carrying capacity).
- Water management in diked pickleweed marshes is important.
- Salinity of pickleweed marshes is important.
- Natural events can have unexpected effects on mouse recovery efforts.
- Restoration sites need to include high tide refugia for mice.

Challenges in Conserving Migratory Birds as Estuary-wide Restoration Takes Place

JOHN TAKEKAWA ET AL.
USGS Western Ecological Research Center

NILS WARNOCK
PRBO Conservation Science

San Francisco Bay has become a focus for wetland restoration on the Pacific Coast. Multiple restoration projects are taking place throughout the Estuary, but there has been little effort to look at the impact of all of these projects together.

The goal of most Bay restoration projects has been to return tidal flow to diked baylands and to restore vegetated marshes for endemic tidal marsh species. Shallow open bays and ponds in the Estuary support a large number of migratory birds in the Pacific Flyway. Migratory birds respond quickly to changes in habitat, yet without long-term data it can be difficult to make sense of complex phenomena. By summarizing population information and movement studies of selected migratory and endemic birds, we demonstrate how individual restoration projects, large restoration programs within subregions, and overall Estuary restoration changes may affect avian communities. Our avian movement studies have shown that most species exhibit strong site fidelity to local areas. For example, species such as California clapper and black rails have very small home ranges of less than a hectare during the breeding season, but they also may move among subregions. We also discovered that one of the most important Clapper rail sites in the whole Bay—Colma Creek—is surrounded by industry.

Ground-nesting birds like Forster's and Caspian terns may be negatively affected by avian predators, such as California gulls, that can unexpectedly increase as a result of restoration actions. This raises difficult management issues.

Diving ducks and shorebirds are found in most subregions, but the South Bay is especially important for shorebirds, while the North and Central Bays support large numbers of waterfowl. Within the flyway, the Bay is the wintering refuge for clapper rails and black rails. The majority of lesser and greater scaup, canvasback, and surf scoters counted on the Pacific coast occur in the Bay during the midwinter. Western sandpipers spend more time staging at the Bay during the spring migration than at any other site along the Pacific coast. Mudflats and shoals are especially important habitats used for foraging by waterfowl and shorebirds, but these areas may decrease with restoration and sea level rise. The Estuary plays a critical and complex role in conservation of waterbirds from local to Estuary scales that must be considered for all levels of restoration planning.

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SHOREBIRD RESPONSE TO EBB AND FLOOD TIDES

Species	EBB (%)	FLOOD (%)
dunlin	90.2	59.6
least sandpiper	83.8	54.1
western sandpiper	67.6	35.9
American avocet	84.2	76.8
black-bellied plover	40.6	56.6
dowitcher spp.	69.3	78.0
long-billed curlew	75.4	77.6
marbled godwit	92.7	96.1
willet	95.1	95.3

USGS

Small shorebirds stayed <100 m of tideline. Their large populations may be most affected by changes in mudflat elevations with restoration.

SCIENCE QUESTIONS:

- Bird numbers have increased at the South Bay Salt Ponds. But will mudflat values decrease in response to restoration? A small change in the elevation of mudflats could make a difference to shorebirds as sea level rises: their time for foraging could be decreased—and their populations could decrease.
- Have dunlin decreased because of changes in the South Bay? Can we look at the effects of restoration and see if restoration activities affect bird use of the Flyway?
- How does the Estuary relate to nesting areas in the Northwest Territories? There is a direct link between remote areas and other areas in the south.
- Can we use the movements of migratory birds as a proxy to understanding restoration?

TAKE HOME POINTS

- To understand changes in migratory birds caused by local restoration, regular adaptive monitoring must be conducted through transitional stages.
- Determining species' carrying capacity would help to assess restoration success regionally.
- Effects of Estuary changes may be evident in redistribution of populations.
- For migratory bird populations, broad scale restoration effects should be evaluated at a flyway level with calibration to other coastal sites.

An example of rare remnant brackish tidal marsh with large pans, grading into lowland native wet rush-sedge meadow, grassland, and oak woodland, China Camp. Photo and caption courtesy of Peter Baye.

The Delta

The Changing Delta: What it Means for Californians

ELLEN HANAK
Public Policy Institute of California

The Sacramento-San Joaquin Delta has long been an important resource for California, providing agricultural and recreational uses, wildlife habitat, infrastructure pathways, and water supply services throughout the state. The Delta is in poor health today. Its levee system is fragile, many of its native species are declining, and it lacks strong governing institutions.

Sea-level rise, increased floods associated with warmer winters, seismicity, and continued land subsidence are increasing the pressures on Delta levees. One recent study put the risk of a catastrophic levee failure—multiple failures on multiple islands—at roughly two-thirds over the next 50 years. Such a failure would cause massive flooding and salt water intrusion into the Delta, disrupting key infrastructure, including the pumps that deliver water supplies to urban and agricultural users from the Bay Area to the Mexican border.

Meanwhile, an ecological crisis is brewing, with precipitous declines in the endemic Delta smelt, a protected species. As the summer of 2007 demonstrated, failure to resolve this crisis is also a threat to the state's water supplies. State Water Project pumps were temporarily shut down, and both federal and state pumps operated at reduced capacity to limit harm to the smelt.

In our Envisioning Futures report,* we suggest the need for a new long-term management system for the Delta, because the system's increasing fragility makes current practices unsustainable. We consider the consequences of changing—or failing to change—on the range of Californians who depend on the Delta. Most stakeholders have considerable ability to adapt to a changing Delta. Mitigation is appropriate for those likely to lose ground in the Delta of the future.

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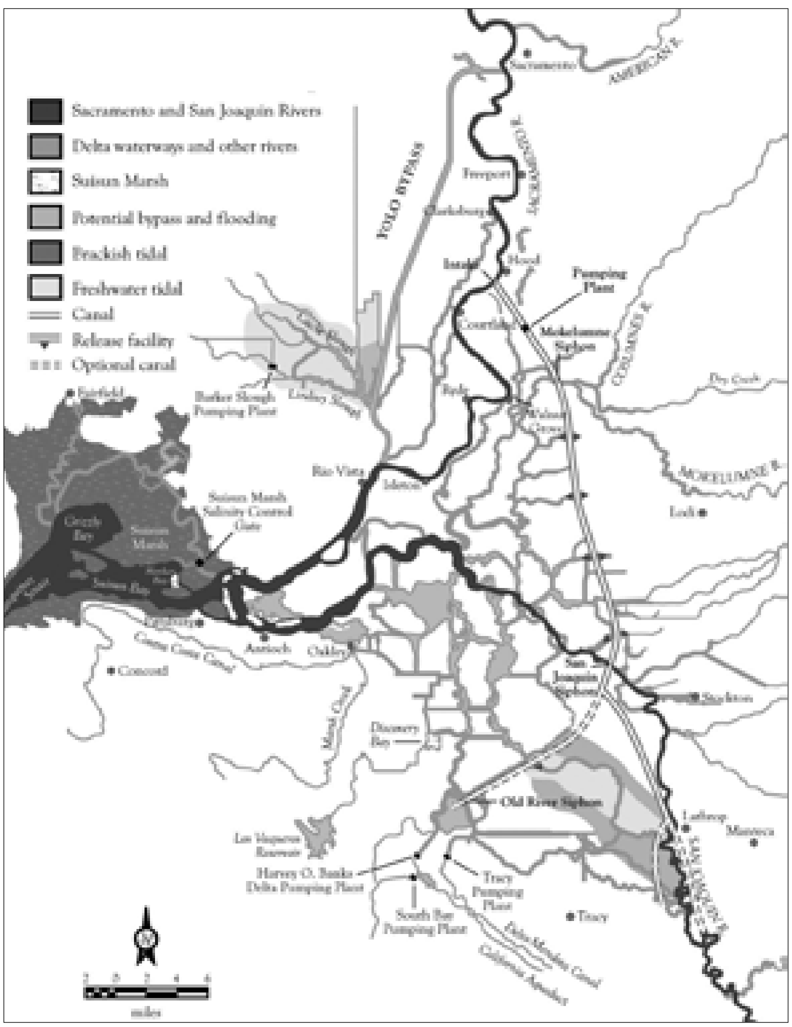
* Jay Lund, Ellen Hanak, William Fleenor, Richard Howitt, Jeffrey Mount, and Peter Moyle, 2007. *Envisioning Futures for the Sacramento-San Joaquin Delta,* Public Policy Institute of California, San Francisco, California. www.ppic.org

DELTA MANAGEMENT ALTERNATIVE #5: SOUTH DELTA RESTORATION AQUEDUCT



TAKE HOME POINTS

- The Delta could experience a catastrophic failure of its levee system as a result of a large earthquake or higher flood flows before a new management system is put in place.
- Demand to build housing in the Delta is great due to the Delta's proximity to several metropolitan areas, and its relatively inexpensive land. The recent housing market slowdown offers a window of opportunity to make changes in the system.
- The Delta's fragility is California's central water management challenge.
- We can try to work with the forces of nature pushing on the Delta and foster habitat for desirable species.
- Adaptation will have to occur one way or another. The question is whether we choose to work with the system or not.

Old Uses for a New Delta

MICHAEL HEALEY
CALFED Science Program

The established principles of water and environmental management in California are being restructured, and an important focus is the Sacramento-San Joaquin Delta. Multiple listings of Delta species as endangered or threatened have highlighted the failure of the established principles to protect ecological integrity. In 2007, the governor appointed a high level task force to develop a sustainable vision for the Delta; their Vision Plan was released and is available at www.deltavision.ca.gov. Now the Vision must be implemented. Since the Vision places significant emphasis on biodiversity conservation, greater land and water allocation for environmental purposes will be needed, as well as the restoration of some critical habitat types and ecological processes that have been lost over the past 150 years. Habitat types that need to be expanded include saltwater and freshwater tidal marsh and seasonally inundated floodplain, as well as the hydraulic and morphodynamic processes that sustain these habitats. Also necessary will be changes in Delta geometry and flow patterns to increase variation in water residence time and heterogeneity in open water habitat.

In anticipation of sea level rise, development needs to be directed away from the margins of the Delta so that habitat types on the margin can advance upslope as sea level rises. While these changes reflect a reestablishment of habitats and processes that were more typical of the Delta prior to 1850, the new Delta will also sustain a broad spectrum of social and economic services that were not part of the historic Delta, including water supply, agriculture, urban development, recreation, and transportation. The Delta of the future is not going to be the same as today. We need to plan and design for a Delta that will deliver the services we value.

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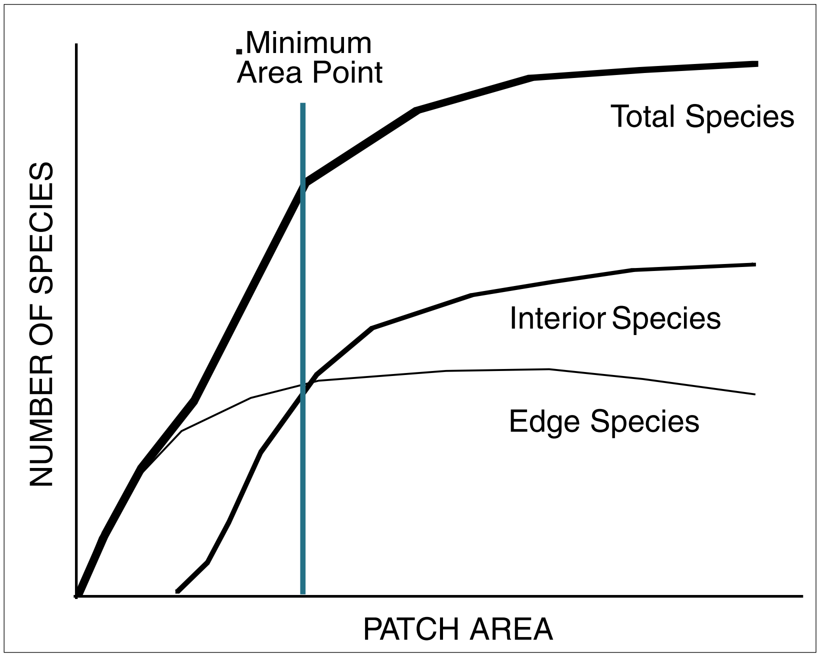

The nature, size, and arrangement of habitat or ecosystem patches is very important to how the Delta functions. Large patches support more species. Adjacent patches exchange materials and organisms easily; distant patches do not. In thinking about a sustainable Delta environment we need to think about how it is structured in terms of ecosystem patches. Different kinds of species respond differently to different sizes and shapes of land and water patches. Connectivity between the Delta and upland habitats is also important.

TAKE HOME POINTS

- Environmental management in the Delta is a wicked problem.
- Sustainable management of the Delta is a complex, ever changing problem. There is no one-shot fix.
- All solutions are temporary.
- Every solution creates new conditions and problems.
- There are no right or wrong solutions, only better or worse solutions.
- Management never ends: the future is uncertain but changing.
- We need to choose solutions for the Delta that are robust to change: today's solutions will soon be obsolete.
- The Delta is a landscape and should be managed as such. As sea level rises, land in the Delta has the potential to be inundated. Protecting infrastructure raises questions about where to put new development to reduce the risks of flooding.
- The size and arrangement of land and water types defines the ecosystem.
- Drivers of change impose a new standard of adaptability on managers.
- Society and economy are not on hold.

Assessing Scenarios of Change in the Delta Ecosystem

DAN CAYAN
Scripps Institution of Oceanography & U.S. Geological Survey

JIM CLOERN
U.S. Geological Survey

California's Delta is the interface between the largest estuary on North America's west coast and a vast watershed that produces runoff from winter storms and spring snowmelt. It is the hub of California's water-delivery system, a region of rapid population growth, a subsided landscape protected by fragile levees, and habitat for endemic species of plankton, smelt, and salmon whose populations are at risk of extinction. The challenge of sustaining native biological communities demands innovative approaches for assessing how habitats and their life-supporting functions will be altered by global change. With support from CALFED and USGS, we have launched a three-year research project (CASCADE) to assess how the Delta ecosystem might evolve into the 21st century in response to prescribed scenarios of climate, sea level rise, levee failures, and water operations. The project uses outputs from global climate models to compute, through a cascading series of linked models, precipitation, runoff, river discharge, temperature, salinity, sediment transport, geomorphology, primary production, incorporation of contaminants into food webs, expansion of invasive species, and habitat quality for native fishes. CASCADE is still a work in progress; however, it can help provide visions of the future Delta across a range of plausible scenarios. Early predictions are that we can expect a saltier Bay-Delta environment compared to that of the past, and a lack of sediment supply will probably be a critical part of the Delta's future. In terms of climate change, for some species of fish, a couple of degrees increase in temperature could be catastrophic.

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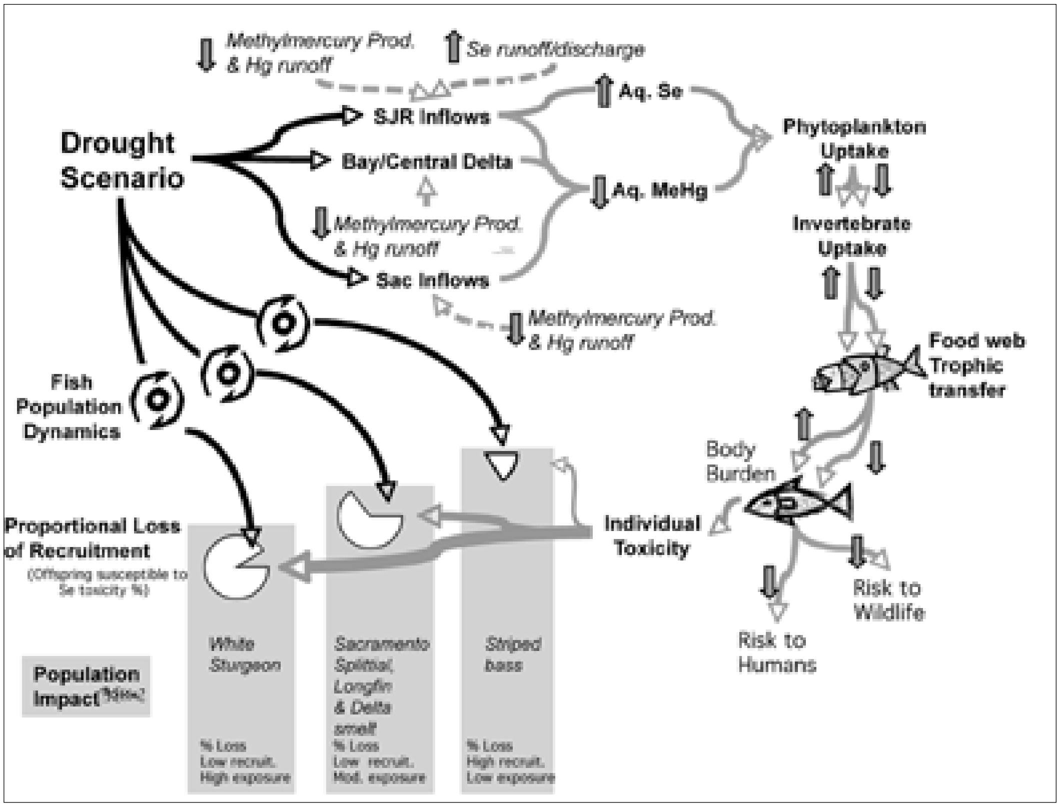
CASCADE CHALLENGES

- Working across and amongst disparate disciplines
- Downscaling global to regional-local scales
- Climate uncertainties: e.g., sea level rise and precipitation
- Constructing realistic biological models
- Uncertain social, regulatory, operational environment
- Non-linearities: invasives, levee breaks

CONTAMINANT CONCEPTUAL MODEL (STEWART AND LUOMA, USGS)



This contaminant conceptual model describes the critical physical, chemical, and biological processes and their interactions that determine the fate and effects of contaminants in the San Francisco Bay and Delta. Outputs from submodels that characterize individual processes are incorporated in successive submodels to determine bioaccumulation and effects in different levels of the food web.

The Fragility of Levees in the Delta

LES HARDER
California Department of Water Resources

California's water supply is dependent upon water conveyance across the Delta and by water exports from the Delta. In recent years, many researchers have become concerned about the vulnerability of local levees in the central Delta to both sea level rise and earthquake shaking. Such concerns have called into question the long term sustainability of the levee system and current water conveyance approaches. Future levee failures, particularly during the dry season, have the potential of drawing saltwater into the Delta from San Francisco Bay. If a future earthquake caused a large number of islands to suddenly flood during the dry season, water export could be significantly curtailed, perhaps for years. There would also be major impacts to the Bay-Delta highway and rail transportation systems, and unknown impacts to Delta habitats and fisheries.

To better define such risks, the Delta Risk Management Strategy (DRMS) is being carried out. The Phase 1 portion of DRMS is a risk management study that examines both the current and future risk of levee failure, and considers the effects of climate change and other stressors on the system. A draft Phase 1 report has been completed and is now under review. It shows that Delta levees will be at significantly higher risks in the future from both flood and seismic events. The Phase 2 portion is beginning and is intended to examine alternative risk reduction measures. Several separate measures, or building blocks (e.g. improved levees, emergency preparedness and response, and alternative conveyance approaches) are being evaluated for their potential to reduce risk of levee failure. In addition, three trial scenarios have been developed that would include different combinations of risk reduction building blocks.

Recently, Governor Schwarzenegger called for the Department of Water Resources to carry out $120 million in immediate actions to improve conditions in the Delta. Part of this effort is intended to help restore the Delta's natural habitat. Other actions are related to improving emergency preparedness and planning. The Governor's actions represent some of the very first steps towards risk reduction.

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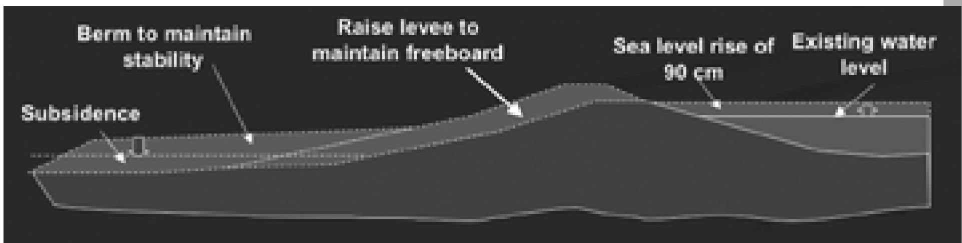
COSTS TO MAINTAIN CURRENT LEVEL OF LEVEE PERFORMANCE OVER THE NEXT 100 YEARS (TO ~2100)



	Per mile cost	Total Cost for 500 miles upgrade
On Island fill	$ 8.8 million	$ 4.4 Billion
Imported fill	$ 23.5 million	$ 11.8 Billion

Suisun Marsh: The Forgotten Link Between the Bay and Delta

STEVE CHAPPELL
Suisun Resource Conservation District

The Suisun Marsh is the largest brackish wetland in the western United States, situated between the freshwater ecosystem of the Sacramento-San Joaquin Delta and the saline ecosystem of greater San Francisco Bay. Suisun Marsh's water quality affects and is affected by diversions that supply water to 23 million Americans and to farms and businesses accounting for over $500 billion in economic benefits. The marsh is home to a wide variety of plants, fish, and wildlife that depend upon balancing of fresh and saline waters for their survival.

Historical land uses have reduced Suisun's tidal wetlands by 90%. Now the primary type of wetland is seasonal wetland managed for resident and migratory wildlife under the auspices of 158 private owners and numerous public agencies. A charter group of seven local, state, and federal entities came together to develop a long term approach for tidal restoration and managed marsh enhancements that balances the recovery of listed species with maintaining the marsh and levees for waterfowl and to meet water quality objectives. The traditional NEPA/CEQA planning process has been expanded to include a Science Integration Strategy, conceptual models, enhanced public involvement, and a science-based adaptive management program for implementation that will address multiple objectives of the CALFED Program and guide Delta Vision considerations for Suisun Marsh.

MORE INFO?
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HISTORY OF PROTECTION & PRESERVATION ACTIONS

1963
Suisun Soil Conservation District formed by landowners

1970
Suisun Resource Conservation District (SRCD) formed

1974
Suisun Marsh Preservation Act passed by California Legislature

1976
Suisun Marsh Protection Plan completed by DFG and BCDC

1977
Assembly Bill 1717 passes the Suisun Marsh Preservation Act

1978
Water Rights Decision 1485

1987
Suisun Marsh Preservation Agreement signed by SRCD, DWR, USBR, DFG

2000
Suisun Marsh Habitat Management, Preservation, and Restoration Plan (PEIR/EIS) begins

SUISUN MARSH HABITAT MANAGEMENT, PRESERVATION, AND RESTORATION PLAN PROGRAMMATIC EIR/EIS

***Draft* Tidal Restoration Targets**

	REGIONS			
	1	2	3	4
Alternative A 2,000 – 4,000 acres	500–1,000	460–920	860–1,720	180-360
Alternative B 4,000 – 6,000 acres	1,000–1,500	920–1,380	1,720–2,580	360-540
Alternative C 6,000 – 9,000 acres	1,500–2,250	1,380–2,070	2,580–3,870	540-810

Subsidence Reversal through Wetland Restoration and Carbon Sequestration in the Delta

ROGER FUJII, ROBIN MILLER, and KIM TAYLOR
U.S. Geological Survey

A serious threat to the Sacramento-San Joaquin River Delta is the deeply subsided central and western islands. These islands' land surface elevations have subsided by as much as 8 meters since the late 1800s, and continue to subside 2 centimeters per year due to microbial oxidation of peat soils. As subsidence progresses, drainage ditches are deepened, increasing the hydraulic head between the channel water surface and the island's shallow groundwater table. This increases seepage of water under and through the levees, making them more vulnerable to failure. Many of the desired functions of the Delta will be lost during a catastrophic levee failure, and overcoming ongoing subsidence and increasing risk ultimately requires raising land surfaces.

One effective approach to increasing land-surface elevation, while sequestering greenhouse gases, is establishing shallow wetlands on these subsided islands. Using our knowledge that keeping fields under water will mitigate the oxygen-driven decomposition of peat soil and that consistent shallow water depths spur the growth of emergent marsh vegetation, in 1997 we established two wetlands (25- and 55-centimeters deep) on Twitchell Island. Average land-surface elevation gains across both wetlands were approximately 4 centimeters per year from 1997 to 2005; however, different conditions within the wetlands led to as much as 9.2 centimeters per year gain in some locations.

This rate of carbon sequestration is much greater than published rates for many other land uses, suggesting that permanently flooded, shallow wetlands may meet criteria for greenhouse gas emission credits. Pinning down precisely why some areas gained nearly 10 centimeters per year, more thoroughly assessing greenhouse gas fluxes, developing carbon accounting methods, and evaluating the potential for mercury methylation and production of dissolved organic carbon are needed to further test the viability of this approach. If this evidence bears up under further scrutiny, managed wetland systems show promise as an alternative farming practice in the Delta.

MORE INFO?
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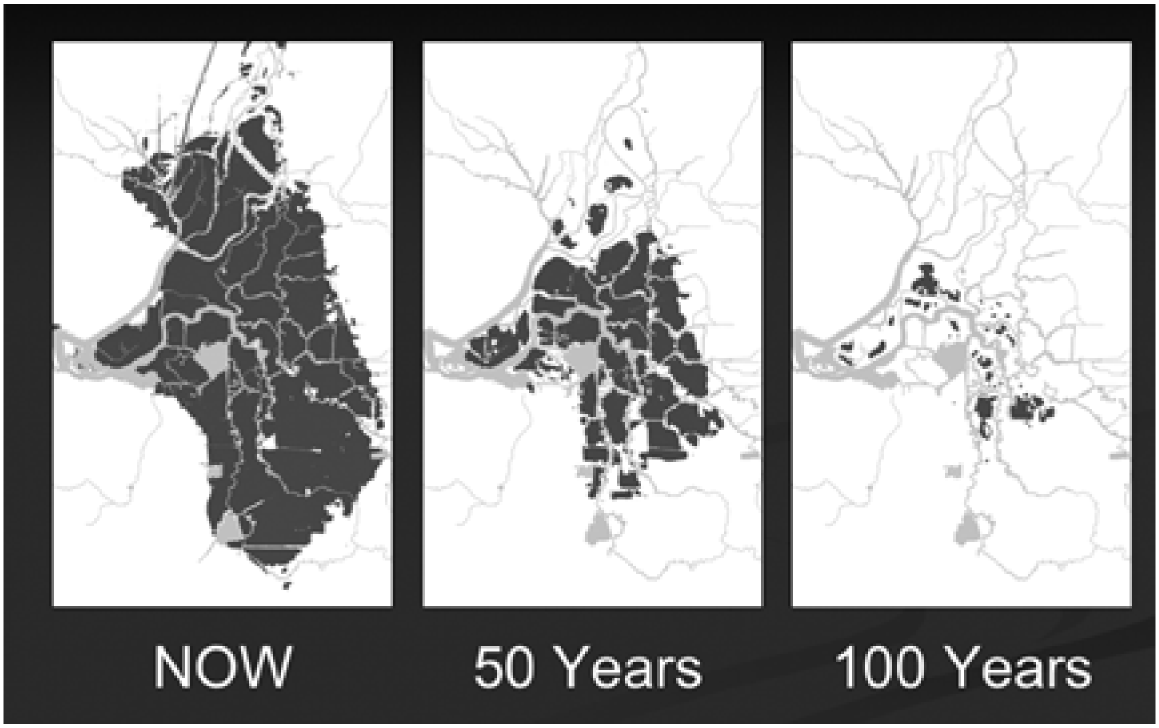
POTENTIAL CHANGE IN DELTA ACCOMODATION SPACE THROUGH CARBON SEQUESTRATION



Dark gray indicates land below sea level.

How Delta Decisions Affect San Francisco Bay

PHIL WILLIAMS and
DAVID BREW
PWA Ltd.

The San Francisco Estuary is artificially divided into two geographic parts, the Delta, and San Francisco Bay. These parts are managed by different government entities, located in different cities, addressing different management questions. Since the Katrina disaster, the impossibility of continuing "business as usual" policies in the Delta in the face of continued land subsidence and the impacts of global warming has become generally recognized. Now, state and local governments are actively considering an array of more sustainable future scenarios for Delta management. The most feasible scenarios include returning tidal action to significant portions of the Delta, with consequent increases in the tidal prism and tidal volume of the entire Estuary. These increases could have significant implications for the future evolution and functioning of San Francisco Bay, as they could induce major changes in the hydrology, hydrodynamics, estuarine circulation, salinity distribution, sediment budget, sediment dynamics, and geomorphic evolution of the Bay's bathymetry. Over the next 50 years these changes would coincide with other man-made and natural physical changes occurring in San Francisco Bay, including sea level rise, shoreline erosion, habitat restoration, and dredging. The cumulative effect of these changes will in turn affect ecosystem processes and habitat distribution throughout the entire Estuary. At present, because of the institutional isolation of the two parts of the Estuary, these cumulative Estuary-wide impacts are not being systematically considered. However, over the last 20 years we have significantly advanced our understanding of how the physical Estuary functions and evolves. We have the tools available to generate projections of what the whole Estuary will look like in 50 or 100 years to help inform Delta and San Francisco Bay decisions.

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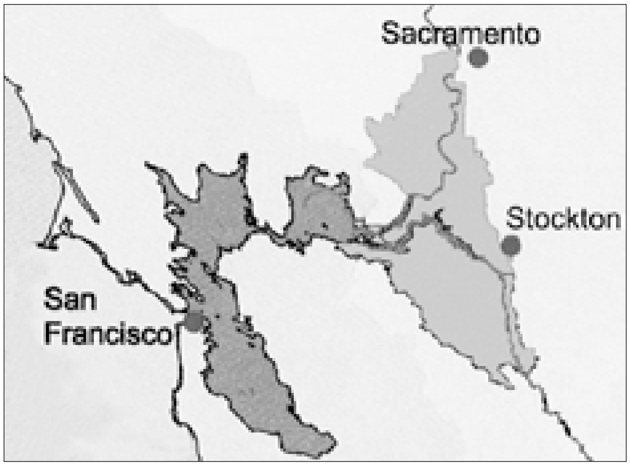
THE DOOMSDAY SCENARIO: AN ESTUARY TWICE AS BIG



TAKE HOME POINTS

- We have created a massive hole in the Delta, up to 25' below sea level, as a result of agricultural practices that have induced subsidence.
- In a "Doomsday" scenario, with a complete levee failure, the Estuary would double in area; the volume of water in the Delta would increase by four times what it is now, and the volume of the whole San Francisco Estuary would increase by 50%.
- The tidal prism of the Delta could increase by six times what it is now.
- We have not fully grasped—or analyzed—how this will affect physical processes and habitats in the rest of the Estuary.
- As saltwater moves upstream, Suisun Bay could become more like San Pablo Bay, and San Pablo Bay more like the Central Bay.
- There will be significant impacts on San Francisco Bay marshes with sea level rise and saltwater intrusion: marshes will be saltier, brackish marsh and mudflats could be lost.
- A higher low tide would decrease mudflat area.
- Less mud in circulation will make tidal marshes harder to restore.
- There could be increased shoreline erosion with a higher mean tide; and an increase in the tidal prism will increase channel scour.
- We need to recognize that there will be significant changes in the physical system when we abandon Delta islands.

Integrating Ecological Restoration

INTO WATERSHED MANAGEMENT

The Connection Between Estuary and Perimeter Habitats: Implications for Tidal Marsh Restoration

MARK STACEY and LISSA MACVEAN
University of California, Berkeley

The to-be-restored South Bay salt ponds represent a surface area comparable to the adjoining far South Bay, and the nature and magnitude of the connection between them is critical for both the Estuary itself and the restored habitats. Through a combination of analytic approaches and the analysis of observations collected adjacent to breached ponds along Coyote Creek, we examined the details of exchange between Coyote Creek and the "Island Ponds" and identified several important features of the exchange.

First, flow into the restored habitats appears to be from waters sourced along the margins of the Estuary, with dominant sediment inflows occurring late in the flood tide. Secondly, the outflow from the restored sites is scouring a subtidal channel through the intertidal zone that adds vertical variability to the exchange flow. From these results, it appears that sediment flowing into the ponds will be sourced from along the perimeter of the Estuary down-estuary from the restoration site. Finally, the outflow from the restored habitats creates a large pool of relatively saline waters sitting adjacent to the restored ponds at the end of the ebb tide. During the ensuing flood, these waters are swept upstream in Coyote Creek, with an abrupt frontal transition evident between the pond waters and the ambient creek waters. During the following ebb tide, at a station across Coyote Creek from the ponds, the salinity variation is altered from the expected, with a slightly elevated salinity near the end of the ebb. These results quantify the effects of "tidal trapping" on the ambient salinity for this site, with an increase in the average salinity intrusion into the creek.

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The scale of the restoration area (light gray) is comparable to the surface area of the far South Bay (the region south of the Dumbarton Bridge, dark gray), which will modify tidally-driven currents locally as the restored regions fill and drain, and has the potential to modify tidal dynamics more broadly due to the interaction of the tidal wave with the perimeter of the Bay.

Wetlands Restoration in the North Bay

WENDY ELIOT and
JOHN BROSNAN
Sonoma Land Trust

Historically, nearly 80,000 acres of tidal marshes and mudflats fringed San Pablo Bay. Most of these tidal marshes were diked for agricultural reclamation during the 1890s, resulting in the loss of over 82% of the North Bay's historic tidal wetlands and dramatic reductions in the wildlife populations that depended on the marshes. Over the past 20 years, conservationists, landowners, and agency managers from the region have set ambitious goals for restoring the North Bay's wetlands. The efforts, including the San Francisco Estuary Project's Comprehensive Conservation and Management Plan and the Baylands Ecosystem Habitat Goals Report, provide the consensus for supporting grand-scale restoration and offer roadmaps to achieving restoration goals. Since the early 1990s, wetlands restoration has occurred in significant individual and collective projects across the watershed. In 1996, the Sonoma Baylands Wetlands Restoration Project was completed. At 289 acres in size, Sonoma Baylands was the largest planned tidal wetlands restoration project at the time construction was completed. Progress since then has been steady, and projects continue to expand in scope and size, totaling thousands of acres that have been restored or are on track to restoration, including Hamilton, Bel Marin Keys, Bahia, Carl's Marsh, the Sears Point Restoration Project, Tolay Creek, Cullinan Ranch, the Napa Plant Site, and the Napa-Sonoma Marshes, which includes restoration of almost 10,000 acres alone. Partners are looking ahead to additional wetland and upland restoration projects, including the 1,737-acre Tolay Lake Regional Park and the 1,600-acre Roche Ranch acquisition, which will preserve and restore nearly all of the Tolay Creek watershed. Together, numerous private and public partners are restoring large landscapes within the 50,000 acres of restorable tidal wetlands across the San Pablo Bay watershed.

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***Castilleja ambigua* from Point Pinole, extirpated in SF Bay tidal marshes, and nearly extirpated in the North Bay as well. Photo courtesy of Peter Baye.**

TAKE HOME POINTS

Constraints to integrating wetlands and tidal wetlands include:

- The need for flood protection
- Invasives control
- Remediation
- Multiple users of the site
- Sea level rise
- Physical infrastructure

Biota Without Borders

LETITIA GRENIER and JOSH COLLINS
San Francisco Estuary Institute

Boundaries and barriers that humans place on the landscape are new in evolutionary time. Most wildlife have not evolved to recognize the boundaries or pass the barriers that we create. The landscape as viewed through the human perspective is very different from that which wildlife experience. Wildlife need to link uplands, baylands, and the Bay through their movements each day, by season, and for juvenile dispersal. As wildlife move through the landscape according to the rhythm of the natural history that has evolved for each species, they encounter resistance (and sometimes assistance) from human endeavors. Similarly, as we try to understand and conserve wildlife, we may also be thwarted by human constructions. Barriers to wildlife movement can be apparent, such as a busy freeway, but there are other barriers that are subtle to human perception: loss and degradation of habitat and change in the configuration of habitat patches. The structure of human institutions, which often divide watersheds from Bay wetlands, can hinder wildlife conservation as well. Changes in the connectivity of the landscape for wildlife will continue as the Bay Area urbanizes further and sea level rises. We will better conserve our natural heritage if we predict and prepare for these changes by imagining them through the perspective of wildlife.

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TAKE HOME POINTS

- One of the goals of the Comprehensive Conservation and Management Plan for the Estuary is to restore the physical, biological, and chemical integrity of the Estuary. This means that clean water, water supply, flood protection, and wildlife conservation all have to be part of the same goal.
- Our modern landscape shows a huge loss of habitat connectivity from what was here historically.
- We need a common vision of how to restore and be stewards of wildlife on a landscape scale, and to invest early in conserving landscapes for wildlife. Since we haven't yet specified what our wildlife goals are, we are stuck waiting for a crisis.

Native Plant Diversity In Restored North Bay Tidal Marshes

PETER BAYE
Coastal Plant Ecologist

Most of the North Bay's tidal marshes are young (post-reclamation era) and deficient in native estuarine plant species diversity. Areas rich in uncommon or rare native tidal marsh and ecotone plant species are widely scattered in the region. Many are associated with pre-reclamation marsh remnants or unusual soil conditions. Diked, non-tidal marshes in some cases harbor species-rich refuges of tidal marsh ecotone species. Some uncommon to rare plants are capable of long-distance dispersal into restored tidal marshes, but most have rather weak colonizing and dispersal ability, and are usually overwhelmed by native or non-native dominant tidal marsh pioneer plants when new tidal marshes are restored. Recovery of the North Bay's estuarine plant species diversity will require (a) identification and protection of existing unstable refuges of high native marsh species richness; (b) linking restoration with protection of native plant population "capital" in species-rich refuges; and (c) active adaptation of marsh restoration and management to recover viable populations of non-dominant native plants in restored tidal marshes.

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TAKE HOME POINTS

- In constructing wetlands, avoid homogeneity. Embrace heterogeneity in substrates and topography, and work with designers to allow for it.
- Accidents often deliver biodiversity—uncommon and rare species often become established along the edges of restored tidal marshes. Give less common natives a chance and introduce them early on when they still have a chance.
- All remnant populations of rare tidal marsh species that do not have legal protection should be identified and saved.

***Symphiotrichum subulatum* (*Aster subulatus*), locally abundant in Suisun Marsh (mostly in diked marshes now), rare in South and North Bay tidal marsh edges. Photo courtesy of Peter Baye.**

Putting it Back Together: Are We Leaving out Essential Pieces of Ecosystem Restoration?

ARTHUR FEINSTEIN
Citizens Committee to Complete the Refuge

The San Francisco Bay Area is one of the most exciting places to be if you are interested in wetland and riparian habitat restoration. Nowhere else in the country are wetland and riparian restoration projects taking place with the size, complexity, and variety of those in the Bay Area.

But what does wetland/riparian restoration mean (and in this context I include the restoration that results from mitigation projects)? For pure, non-regulatory, restoration projects, is it simply recreating the specific footprint and hydrology of an historic marsh, or for a mitigation project creating a wetland of some specific acreage, or for a riparian area simply digging a channel and lining it with native plants? Or do the ecological functions we hope to replicate in such a restoration project require landscape components that go beyond the wetland or streambed itself? Do wetland and riparian ecosystems also require transition zones and adjacent uplands if we are to replicate the full suite of ecological functions present in natural aquatic systems? Recent science indicates that the answer is yes.

But how do we achieve these holistic, multi-habitat projects when undertaking pure restoration projects? What are the hurdles such restoration projects face? In the regulatory world, can we preserve such existing habitats when they are threatened by development or demand such expansive habitats when imposing mitigation on developments that destroy streams and other wetlands? When we are fortunate enough to undertake restoration projects that incorporate a full range of habitats, there other issues that must be addressed to ensure that the restoration provides all the desired functions. Those issues include restricting human access to protect wildlife.

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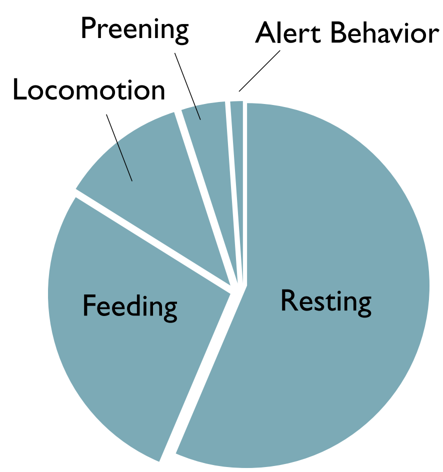
TAKE HOME POINTS

- Once you allow humans into an restored area, even an urban area, species diversity gets diminished. If full environmental restoration with large diverse habitats is the goal, people must be controlled. If *we* are everywhere, then the wildlife species we are restoring habitats for won't be.
- We need to provide for quality public access—not quantity.
- The larger, and the more varied the habitat, the better it is for sustaining biodiversity (although small habitats aimed at specific species can be very valuable).



During the day, a typical duck may spend 57% of its time resting, 28% of its time feeding, 11% in locomotion, 4% preening, and 1% in alert behavior. What is the impact of human recreation if it increases a duck's locomotion or alert time? Energy reserves for migration are particularly important for waterfowl. Pacific populations of brant lose one-third of their body weight (about 1.87 lb. of fat) in just a few days during their 3,000-mile journey from Alaska to Mexico.

Photo courtesy of Jean Matuska.

A Living River Case Study

RICHARD THOMASSER
Napa County Flood Control and Water Conservation District

The Napa County Flood Control and Water Conservation District and the U.S. Army Corps of Engineers are implementing the Napa River/Napa Creek Flood Protection Project along approximately 7 miles of the Napa River and approximately 1/2 mile of Napa Creek in the city of Napa. The objective of the project is to provide an economically-feasible and environmentally-sensitive method of protecting the city of Napa from 100-year storm events.

The project will achieve flood protection and habitat enhancement by using environmentally beneficial methods such as the creation of wetlands, marshplain, and floodplain terraces, selective removal of existing levees, use of open space as the floodway, construction of setback levees, floodwalls, and bypass channels, and biotechnical bank stabilization. Environmentally damaging measures such as deepening the river by excessive dredging will be avoided.

The project was developed through a two-year community-wide coalition process, which was coordinated by the District. The Community Coalition has been a cooperative process among a wide ranging group of stakeholders with diverse interests. The Community Coalition, with the assistance of the Corps, resource agencies staff, and outside consultants, developed the major concepts in the project to meet the dual objectives of reducing flood damage and maintaining and enhancing environmental quality. Through the Community Coalition, the "Living River Guidelines" were created, which is the design guide for the project.

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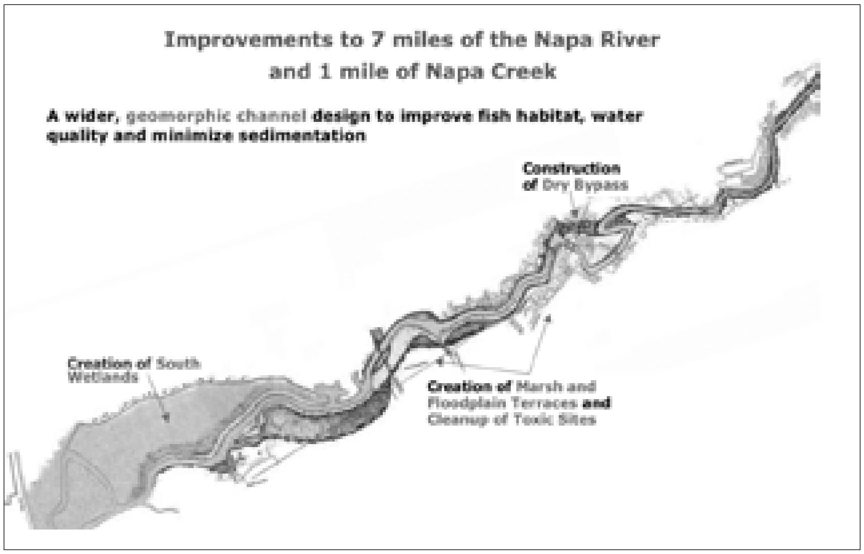
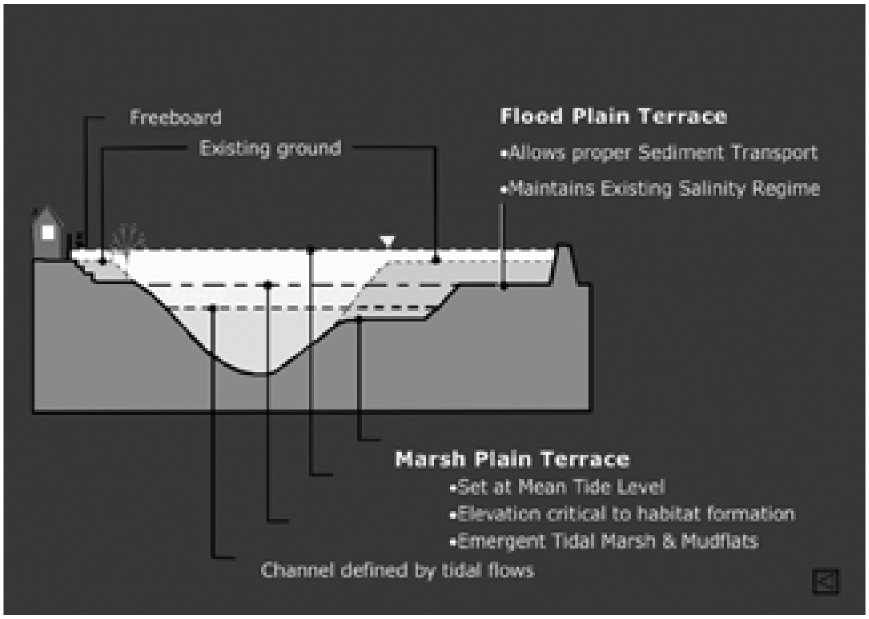
THE LIVING RIVER DESIGN



Key elements of the design include reconnecting the river to its natural floodplain and restoring the significant wetlands in the southern reach of the project. The plan called for cleaning up contaminated sites rather than avoiding them. One of the key flood protection elements is a dry bypass which will stop flooding in the downtown reach but not cut off the river's natural flow through its downtown oxbow.

GEOMORPHIC CHANNEL DESIGN



The project includes a geomorphic channel design, which creates marsh and floodplain terraces, and is designed to maintain more natural sediment transport, while creating significant additional emergent marsh and riparian habitat along the river, right into the downtown reach.

Controlling Pollution to Protect Water Quality

BRUCE WOLFE
San Francisco Bay Regional Water Quality Control Board

The San Francisco Bay Water Board continues to move beyond the classic pollutant-by-pollutant approach to water quality protection that was our agency's initial focus after adoption of the federal Clean Water Act in 1972. Our regulatory efforts are now designed to not only protect, but also restore water quality through collaboration with other agencies and stakeholders, as we try to accomplish multiple goals, such as providing increased flood protection, habitat, and recreational opportunities while protecting water quality and preventing pollution on a watershed basis. Key Water Board programs and projects designed to integrate and support multiple uses include the Total Maximum Daily Load (TMDL) program; a Wetland and Stream Policy currently being developed; the Surface Water Ambient Monitoring Program; the Regional Monitoring Program; beneficial reuse of dredged materials through the Long Term Management Strategy; and large scale wetland restoration projects.

We are learning that we need to better regulate development of upland areas, and in some cases, to treat "flow" as a pollutant—i.e., where developments cause change in runoff patterns. We also want to begin to recognize the social and economic benefits of restoration projects and to include all of the regulated community. We are now addressing pollutants on a statewide and Baylands basis: TMDLs are really watershed plans. We are trying to recognize the many benefits of riparian zones that haven't been spelled out yet, and have begun to view wetlands and streams as a physical unit. To quote Josh Collins, "wetlands are really the deltas of riparian systems." In the future, we will look more closely at flood attenuation and storage when projects are permitted, as well as cumulative impacts, and ways in which we can provide incentives for watershed-based planning.

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Integrating Wastewater, Stormwater, Floodwaters, and Restoration

STEVE RITCHIE
South Bay Salt Pond Restoration Project

The systems developed around San Francisco Bay to manage wastewater, stormwater, and flooding have been largely independent activities driven by a variety of laws and regulations as well as funding considerations. The resulting municipal plumbing is not being used optimally for the benefit of the community and the Bay. With the increasing investment in habitat restoration both in creeks and around the margins of the Bay, new opportunities present themselves for re-management of these systems to provide multiple benefits and guide investment in the future. We need to think about the Bay differently—it's a big estuary with myriad challenges. Natural plumbing—i.e., watersheds—can work, but is sometimes too limiting for good decision-making. Using unnatural plumbing as an organizational framework—i.e., a county, city, or special district—can sometimes work. We don't have to use the same approach everywhere. Here are some examples.

Lake Merritt and Channel

This project restores a flood control basin and has good public access. Yet is important to connect to the Estuary. The lake and upper channel restoration is funded, and the interest in restoring the lower channel is there: this should be approached in conjunction with Sewer District 1 Clean Water Act compliance.

Damon Slough

The recent Damon Slough project is a nice piece of work: it has good public access to the tidal fringe, but controlling trash upstream is essential to achieving the full value of the project. The project should be approached via stormwater permit compliance in conjunction with Sewer District 1 Clean Water Act compliance.

Salt Pond Restoration

A five-year planning process is nearing completion. The plan integrates habitat restoration, flood protection, and public access. But what about the connection to adjacent areas and local watersheds? We need to reinforce watershed connections, particularly steelhead restoration, mercury TMDL decisions, and stormwater management.

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TAKE HOME POINTS

- We need to always think about restoration/integration of wastewater, stormwater, and floodwaters control from financial, scientific, and regulatory standpoints.
- We should do these things in chunks that make sense to manage.

Salmon and Steelhead Recovery, North Central California Coast

MAURA EAGAN MOODY
NOAA Fisheries

NOAA Fisheries (NOAA) aka the National Marine Fisheries Service is the federal agency with regulatory jurisdiction over anadromous salmonids listed under the Endangered Species Act. NOAA is responsible for developing recovery plans for these species. The North Central California Coast Recovery Domain includes salmon and steelhead from several populations—Central California Coast coho salmon, Central California Coast steelhead, California Coastal Chinook, and North Central California steelhead. Key components of the recovery plan include: (1) developing criteria for population/species viability; (2) assessing population and habitat-based threats; (3) developing recovery criteria and site-specific management actions that will reduce or eliminate identified threats; and (4) assessing costs of implementation. Beginning with Central California Coast coho salmon, NOAA hopes to complete draft recovery plans for these salmonids in 2008. In addition to developing numerous technical documents that form the foundation of the plan, multiple public workshops will be held across the north coast of California to facilitate public involvement in the process. Draft materials are available at http://swr.nmfs.noaa.gov/recovery/index.htm. NOAA is currently requesting review and comment on draft materials and a variety of data as background for the draft recovery plans, which will present a blend of scientific and policy/management recommendations for recovering these listed fish.

THE NORTH CENTRAL CALIFORNIA COAST RECOVERY DOMAIN (showing northern and southern boundaries)

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A Sample Recovery Strategy For Alameda Creek Steelhead

Our analysis ranks channel modification as a high or very high threat in the Alameda Creek watershed. Strategies to address this threat could include:

- Providing fish passage over the BART weir
- Installing fish screens at key diversions
- Enhancing the riparian corridor
- Providing adequate bypass flows
- Developing partnerships for implementation of fish passage measures

The Bottleneck in the Alameda Creek Flood Control Channel

ERIC CARTWRIGHT
Alameda County Water District

With a drainage area of almost 700 square miles, Alameda Creek has the largest watershed draining to San Francisco Bay aside from the Sacramento-San Joaquin River Delta. The size of the drainage, the pristine habitat, the protected status of large portions of the upper basin areas, and the presence of native rainbow trout make the watershed a high priority area for restoration of steelhead trout.

Although the upper Alameda Creek watershed contains an estimated 15 miles of steelhead trout spawning and rearing habitat, like many Bay Area watersheds this one has passage barriers that must be addressed to restore the fishery. These barriers have all been assessed as part of watershed planning efforts, and the owners of all the barriers are working cooperatively with the Alameda Creek Fisheries Work Group to make them passable to steelhead trout. Some barriers have already been removed, will be removed soon, or have modifications in the planning process.

Barriers remain in the lower 12-mile portion of Alameda Creek that was channelized by the U.S. Army Corps of Engineers as part of a flood control project in the 1960s and 1970s. These barriers include the Alameda County Water District's (ACWD) groundwater management facilities (three inflatable rubber dams, and unscreened diversions) and a drop structure owned by the Alameda County Flood Control and Water Conservation District (ACFC&WCD).

ACWD and ACFC&WCD have been working cooperatively to address these barriers. Fish screens are under construction for a portion of the unscreened diversions, and plans are underway for the removal of one of the inflatable dams. Conceptual designs have been developed for fish ladders past the remaining barriers, and a recent agreement between ACFC&WCD and ACWD provides for a cooperative approach to address passage past the flood control drop structure and the middle inflatable dam.

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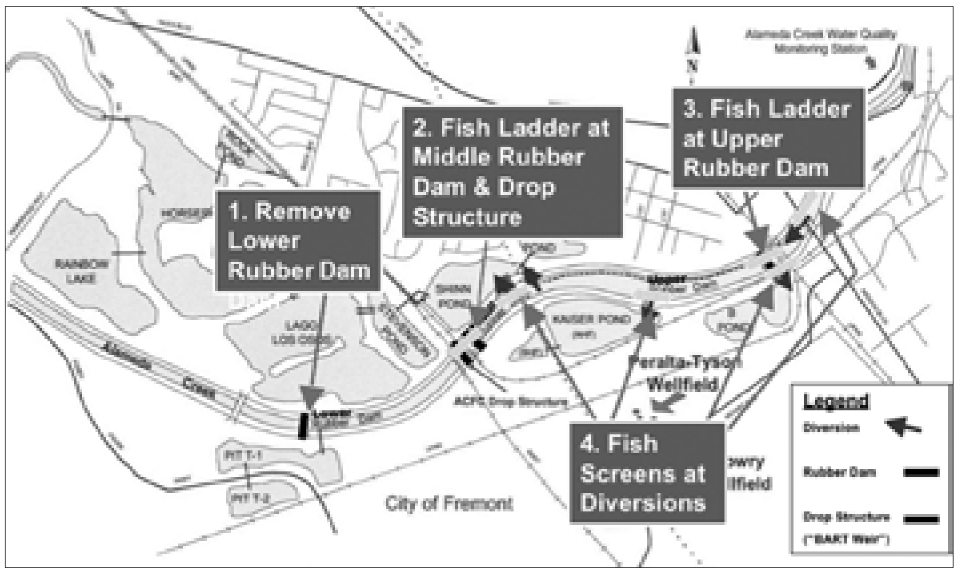
CONCEPT FOR FISH PASSAGE IMPROVEMENTS



SUBSTANTIAL PROGRESS IS BEING MADE

Year	Barrier	Action
2007	Diversion at Alameda Creek Pipeline	Install Fish Screens - $500K Award (NFWF) - Operational Dec 2007
2008	Lower Inflatable Dam	Remove Dam and Foundation - $500K Award (NFWF)
2009	Diversion at Bunting Pond	Install Fish Screen - $600K Grant (Prop 50)
2010	Middle Inflatable Dam/ BART Weir	Install Fish Ladder - 2007 Water District/Flood Control District Agreement
2010 & Beyond	Upper Rubber Dam & Diversions (2)	Install Fish Ladder and Fish Screens (2)

TOTAL ESTIMATED COST: Approx. $12 M

Restoring Steelhead Trout to Alameda Creek

ANDY GUNTHER
Center For Ecosystem Management and Restoration

Alameda Creek is the largest watershed draining to San Francisco Bay, and with large tracts of protected habitat containing healthy rainbow trout populations has long been of interest for steelhead restoration. The most recent effort began in 1999 with the formation of the Alameda Creek Fisheries Restoration Work Group, the first effort since the fish were listed as threatened pursuant to the Federal Endangered Species Act.

Restoring anadromous fish to a significantly urbanized watershed is an exceedingly complicated task that will require the coordinated, sustained action of local, state, and federal agencies, working cooperatively with landowners and other concerned citizens. These interested parties must define a vision of restoration, determine the necessary actions and their sequence of implementation (including provision of in-stream flows), and a mechanism for monitoring success and adjusting future activities to better achieve restoration goals in the light of urban development, climate change, and other unforeseen future environmental perturbations. These activities must be integrated with existing public and private activities, including flood control and water supply projects.

The Work Group prepared a peer-reviewed assessment of the potential to restore steelhead (2000), and a draft Restoration Action Plan (2003). These efforts have helped build solid working relationships and engendered trust among parties and institutions that was previously scarce. Working together with professional support, participants have attracted several million dollars for high priority projects to remove barriers to migration and screen a key water diversion.

One the most important aspects of restoration is deciding the magnitude, timing, location, and source of water flows in the creek to support restoration while minimizing the impacts on water supply operations. Stakeholders have recently signed a Memorandum of Understanding to address this issue, and have pledged funds to conduct the joint fact-finding required for credible and legitimate restoration plans.

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TAKE HOME POINTS

- The creeks that connect to the Bay are under increasing pressure. Yet steelhead, which use the entire watershed during their lifecycle, can drive ecosystem management and be the impetus for preserving landscapes for future generations.
- Restoration is a choice and requires conducting experiments on how to best restore steelhead trout. It gives us a chance to "think globally, act locally."
- The upstream fight of steelhead is both mysterious and inspiring. The return of these wild creatures restores something in us as well.

Alameda Creek Steelhead

Photos courtesy of Jeff Miller, Alameda Creek Alliance.

When Will Steelhead Return to Alameda Creek?

JEFF MILLER
Alameda Creek Alliance

After an absence of almost half a century, salmonids are poised for a comeback in Alameda Creek. Volunteers rescuing fish below barriers in lower Alameda Creek during the past decade have documented at least 100-150 wild adult steelhead. The persistence of these fish offers a glimmer of hope and has galvanized public support for restoring Alameda Creek and its native fishes. The restoration is gaining momentum with over a dozen local, state, and federal agencies working cooperatively on planned fish passage projects and a draft restoration plan. Three dams have been removed with a fourth dam coming out in 2008. Two fish ladders have been built and three more major fish passage projects are in the planning stages.

The biggest unanswered question is whether sufficient water will be available to provide suitable habitat, water temperatures, and out-migration flows to sustain a viable steelhead run. Adequate stream flows are needed to allow steelhead to again thrive in the creek, particularly late-summer cold water rearing flows and flows for out-migration of steelhead smolts to reach the Bay. Eighty-six percent of the stream flows of upper Alameda Creek above the Sunol Valley are currently diverted for water supply demand, and none of the watershed's reservoirs release any minimum flows for fish. With efforts to provide fish passage underway, much of the hope for restoring Alameda Creek's anadromous fish runs now hinges on the city of San Francisco's project to replace the seismically challenged Calaveras Dam.

Discussions have begun over required water flows and potential habitat enhancement projects in the watershed. All of the watershed stakeholders recently agreed to jointly conduct studies to estimate the range, magnitude, timing, duration, frequency, and location of stream flows necessary to restore steelhead trout to the Alameda Creek watershed.

MORE INFO?
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TAKE HOME POINTS

- The visibility and persistence of these fish in showing up every year has galvanized the Alameda Creek Alliance.
- We now have over 1,500 members in the watershed, and over 15 agencies cooperating.
- Genetic analysis of steelhead trout below the dams shows their genes to be most closely matched to resident fish of Alameda Creek.
- Landlocked trout can be a source population for restoring steelhead below the dam.
- The biggest question is whether the SFPUC will leave enough water in the stream.
- We hope the restored South Bay salt ponds can provide improved rearing habitat for steelhead at the mouth of Alameda Creek.
- The potential for steelhead restoration has captured the imagination of Bay Area residents. Restoring steelhead to Alameda Creek could be a model for successful urban stream restoration.

Photos courtesy of Jeff Miller, Alameda Creek Alliance.

Volunteers carry fish past barriers on Alameda Creek.

Eastern Petaluma Marsh shoreline along Lakeville Highway, south of Papas Taverna, where the high marsh has a rare connection to the natural old alluvial fans of Sonoma Mountain, washing terrestrial sediments over the upper edge of brackish marsh. This spot has a rare display of salt marsh annual wildflowers—particularly smooth goldfields (*Lasthenia glabrata*)—that are now better known from vernal pools, but which co-dominate with pickleweed and toad rush at the high marsh edge here. Photo and caption courtesy of Peter Baye.

Land Use

California Water Plan Update 2009

KAMYAR GUIVETCHI
California Department of Water Resources

The California Water Plan is a strategic plan for managing California's water resources and systems, and is a key element in the Governor's Strategic Growth Plan. It is required by the California Water Code and is updated every five years.

Water Plan Update 2005 took a substantially new approach by describing short and long-term actions that can be implemented at the state and regional levels, and identifying a portfolio of 25 resource management strategies to sustain California's communities, economy, and environment.

Water Plan Update 2009 will build on Update 2005 by emphasizing comprehensive and integrated regional management of water resources and flood management systems. Update 2009 will integrate information about California's water uses and supplies, conservation, water quality, environmental stewardship, and flood management; and it will lay the groundwork for addressing climate change impacts on California's water resources and systems.

Water Plan Update 2009 will be developed in a collaborative process with broad public input and multiple opportunities for participation. Annual plenary meetings will bring all participants together.

- A steering committee composed of 18 state government agencies is guiding plan development. The steering committee is coordinating with federal agencies, consulting with tribal governments, and engaging statewide and local agencies and organizations, technical experts, and the public.
- An advisory committee of about 38 statewide organizations representing a spectrum of interests will provide input on statewide policy issues and initiatives.
- Regional workshops and multi-region forums will focus on regional water issues and management strategies with an emphasis on integrated regional water management.
- Through the extended review forum, people can follow the Water Plan process without direct involvement in work activities. Members will receive regular information updates and public meeting notices.
- The Statewide Water Analysis Network (SWAN), a voluntary network of scientists and engineers from the public, private, and non-governmental sectors, will hold public workshops on technical topics.

More information is available at www.waterplan.water.ca.gov

MORE INFO?
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EFFICIENT CITIES: Easy on the CO_2 and H_2O

It is politically impossible to jump directly to 2050 sustainability, but we can progress through three "change stages" to get there: populist, fundamental (2020), and profound (2050). The Bay Area has too many people consuming too much land. Our suburbs are the world's least sustainable places. How do we create efficient human settlement patterns, minimizing the distance between work, home, and activities? The solution: pioneer green settlements and use the capitalist imperative to spread them like a virus:

- change the culture (via sociological persuasion);
- new and better transit technology (PRT);
- comprehensive door-to-door mobility using GPS cell phones;
- move people closer to their jobs;
- develop "auto hostility" by charging for parking;
- grow walkable places.

—Steve Raney, Cities21
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Photo courtesy of Heidi Perryman (www.martinezbeavers.org).

Cost-effective Strategies to Ensure Long-term Water Supply Reliability

KRISTINA ORTEZ
Natural Resources Defense Council

The Bay-Delta Estuary is facing a crisis. Numerous species are listed as threatened or endangered, or proposed for listing. The Delta smelt is on the verge of extinction. The status quo is not sustainable for any of the Delta's users, including farmers, commercial and sport fishermen, Delta residents, and the 23 million Californians who rely on the Delta for a portion of their water supply. Investments to improve water supply reliability must also improve conditions in the Delta. Despite proposed spending to build two new surface storage projects in California—Sites and Temperance Flat dams—in virtually every area, alternative water management tools provide superior performance and broader benefits when compared with proposed surface storage projects. The 2005 California Water Plan Update contains extensive, detailed estimates of the water supply potential of a range of proven water supply tools. The bar chart presents many of those totals, ranging from low to high yield estimates. We believe that the more ambitious estimates are realistic, and that aggressive targets and ambitious programs will assure Californians a reliable water future.

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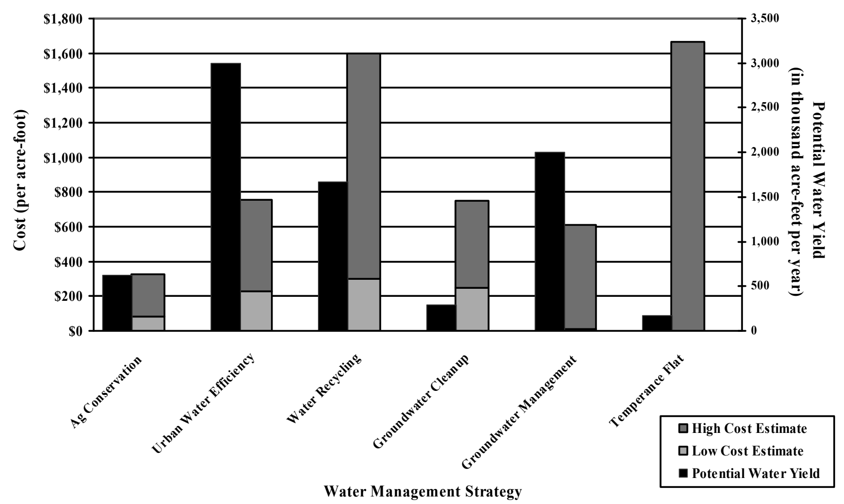
Benefits of Alternative Water Management Strategies

- Investments in alternative strategies produce water at approximately one fifth the cost of water from Temperance Flat.
- Almost 20% of California's electricity use, and over 30% of its natural gas use, are associated with the use of water. Water use efficiency and recycling can generate substantial energy savings and reductions in greenhouse gas emissions.
- Investing in water efficiency and groundwater cleanup will improve water quality by reducing urban runoff from lawns and gardens and by delaying or reducing the size of water system expansions.
- Investments in surface storage could harm the Bay-Delta ecosystem by reducing flows to the Delta and increasing diversions from the Delta. In contrast, alternative water management tools would decrease our reliance on the Delta.
- A massive levee failure in the Delta could jeopardize the water supply for 23 million Californians. Investments in alternative water management tools will reduce reliance on Delta diversions, thereby decreasing the risk to California's economy from potential Delta levee failures. In contrast, Sites Reservoir would increase our reliance on the Delta, and increase risks to the state's economy.
- Alternative water management tools can deliver benefits far faster than dam projects that can take more than a decade to build.
- Climate change is likely to reduce the potential yields of Temperance Flat and Sites Reservoirs. In contrast, many alternative water management tools will be as effective, or even more effective, in the future.
- State investments in alternative water management strategies will be far more effective in attracting water user matching funds. Water users are eager to invest in conservation, reclamation, integrated regional plans, and other tools—but not new dam projects.
- Temperance Flat is designed to provide water to a small number of farmers near the San Joaquin River. In contrast, investments in conservation and reclamation would produce benefits for the taxpayers who pay for state bonds.

COST AND POTENTIAL YIELDS FROM SELECTED WATER SOURCES



Sources:
Department of Water Resources, California Water Plan Update, Bulletin 160-05, Vol. 2, Chapter 3, p. 7.
Department of Water Resources, California Water Plan Update, Bulletin 160-05, Vol. 2, Chapter 22, p. 5.
Water Recycling 2030 Recommendations of California's Recycled Water Task Force, June 2003.
DWR Water Desalination – Findings and Recommendations.
This is an average cost according to Bulletin 160-05.
Department of Water Resources, Role of Surface Storage in the Governor's Comprehensive Water Plan, September 2007.

New Conservation Trends and Possibilities For Water Savings

RICHARD HARRIS
East Bay Municipal Utility District

Resource efficiency has been a growing area of interest for utilities, resource management agencies, non-governmental organizations, and the development community for many years. Water supply reliability, energy consumption, environmental stewardship, sustainable development, and economic viability all have played a strategic role in helping shape past, present, and future communities.

EBMUD's new water efficient service requirements went into effect July 1, 2007. They promote the rewards and benefits of water efficiency, and apply to all new water services and meter upsizing. Recommended water-efficient products have been performance rated by a third party, have been proven to achieve measurable water savings, and are readily available at a reasonable cost to consumers.

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INDOOR WATER EFFICIENCY REQUIREMENTS

Item	Residential	Non-Residential
Toilets	1.28 gal dual flush (HET)	1.28 gal dual flush (HET)
Urinals	---	0.5 gal per flush
Showerheads	2.5 gpm; individually plumbed; one head per 2,500 sq. in stall	2.5 gpm; individually plumbed; one head per 2,500 sq. in stall
Faucet Aerators	1.5 gpm bath; 2.2 gpm kitchen	1.5 gpm bath; 2.2 gpm kitchen
Clotheswasher	7.5 gal per cubic foot of laundry	7.5 gal per cubic foot of laundry
Pre-Rinse Spray Valves	---	1.6 gal. per minute
Ice Machines	---	Air cooled or ≤ 25 gal/100 lbs
Food Steamers	---	Boiler-less; self contained*
Cooling Towers	---	≥ 5 cycle recirculating

* *Where applicable*

OUTDOOR WATER EFFICIENCY REQUIREMENTS

Item	Water Efficiency Requirement
✓ Landscape Plan	detailed plan review; check List <5,000 ft²
✓ Turf Areas	< 25% of area; turf and sprinklers/spray heads not allowed in medians <8 ft.
✓ Dedicated Irrigation Meter	> 5,000 sq. ft. of landscape
✓ Irrigation Efficiency	80% of evapotranspiration; no runoff
✓ Irrigation Controller	weather-based self adjusting model
Plants	80% low water use; 20% other
Non-Turf Areas	drip, sub-surface and bubblers; no runoff
Valves and circuits	separately zoned by plants and water use

✓Exception for: (a) <5,000 ft² of irrigated landscaping and (b) < 3 residential properties

AVERAGE CUSTOMER COSTS AND BENEFITS

Product	Usage	Avg. Unit Cost Incr.	Projected 5-Year Water Savings (gal)	Projected 5-Yr Cost Savings	Estimated Payback Period
Food Steamers	2 gal/hr	$0	675,000	$26,000	Immed.
Pre-rinse Valves	1.6 gpm; 6 hrs/day	$50	325,000	$5,000	2.6 weeks
Ice Machines	Per 100 lbs ice	$1,000	1,000,000	$5,720	< 1 year
HET Toilets	1.28 gpf	$150	5,000-90,000	$50 - $750	1-5 years
Irrig. Controller	10,000 Sq ft.	$400	125,000	$400	5 years
Clothes washer	5 loads/wk	$450	34,500	$450	1 – 5 yrs

The Importance of Recycled Water to the San Francisco Bay Area

MICHELLE PLA
Bay Area Clean Water Agencies

Population growth and climate change are predicted to reduce the reliability and sustainability of the water supply for the Bay Area. Communicating the growing importance of recycled water to the Bay Area, its role in regional water management objectives, the regional economic benefits of recycled water, and ways to ensure its safety and allay public concern is an important task for Bay Area water resource managers. The Bay Area Clean Water Agencies recently commissioned a White Paper on the "The Importance of Recycled Water to the San Francisco Bay Area," the purpose of which was to provide a digest of factual information about water recycling, including specific information developed over many years through many studies. Three main topic areas were covered: (1) the importance of recycled water to regional water management; (2) economic considerations of recycled water; and (3) recycled water implementation opportunities and challenges. The paper asserts that recycled water:

- Helps address growing water demands and dependence on vulnerable imported water supplies;
- Helps mitigate risks of long-term climate change;
- Has a smaller energy footprint than most other water supply options;
- Can be used to simultaneously address multiple regional water management objectives.

Using recycled water can also reduce mass loadings of pollutants into the Estuary.

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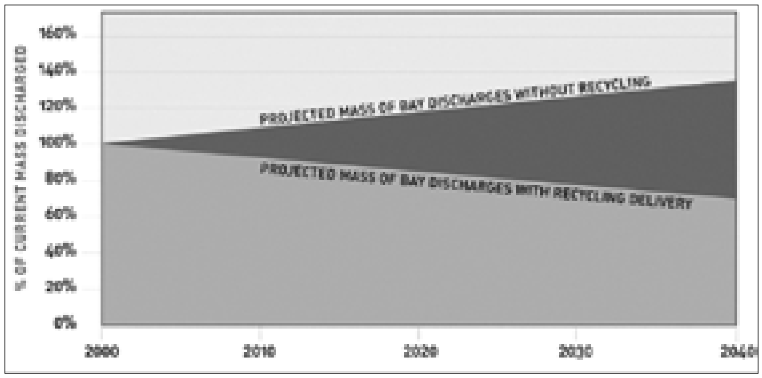
RECYCLED WATER CAN REDUCE BAY DISCHARGES



HOW CAN BETTER LAND USE PLANNING HELP THE ESTUARY?
(What Does Smart Growth Have To Do With Water?)

- Compact urban form means a smaller footprint for population and, in theory, more protected watershed lands, recharge areas, natural drainages, and less impervious surface.
- Higher density (especially residential use) means less landscaping per capita and therefore significantly less water use (and pollutants) per capita.
- Public open spaces, parks, and plazas offer opportunities for large landscape water conserving design and space for innovative surface runoff management.
- Narrower streets and less surface parking lots result in less impervious cover per capita; less vehicle miles traveled should result in less pollutants per capita.

—Jeff Loux, U.C. Davis

Linking the Ahwahnee Principles to Cities' General Plans

ELIZABETH PATTERSON
City of Benicia

Sustaining the long-term viability of our communities begins with a vision of stewardship actions to preserve all of our resources, including precious water resources. Cities currently face major challenges with water pollution, stormwater, flood damages, and ensuring a reliable water supply for current residents and new developments. In response to these challenges and the impacts that local land use decisions can have, the Ahwahnee Principles for Resource Efficient Land use were developed by the Local Government Commission, with a grant from the State Water Resources Control Board, to provide opportunities to reduce costs and improve the reliability and quality of our water resources.

The Ahwahnee Principles establish specific guidelines for communities to create a sustainable built environment. A sustainable community protects natural resources and open space, balances housing and jobs, and provides many transit alternatives. The Ahwahnee Water Principles ensure the protection of water resources by maintaining natural floodplains, encouraging open space and pervious surfaces, and employing water conservation and recycled water technologies. The Principles, when incorporated into city and county general plans, encourage and help facilitate "smart growth" land use development by arming planners, planning councils, and decision makers with tools to control and shape growth in the community. The Principles link livability with resource conservation that enables a built environment to be designed at the human scale while not at the expense of natural communities.

Many communities within the Bay Area have adopted the Principles as part of their General Plans. In addition, the Association of Bay Area Governments, the Bay Area Water Forum, and the League of California Cities have endorsed the principles. Adopting the principles shows a community's commitment to sustainable growth and responsible water stewardship.

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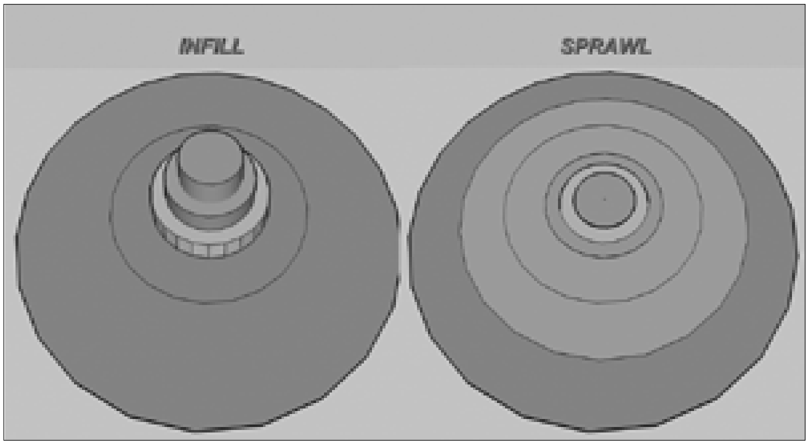
Ahwahnee Water Principles

- Start with the watershed.
- Use a systems-based approach.
- Utilize and protect natural infrastructure.
- Use resources—land and water—efficiently.
- Use integrated, multi-purpose solutions.
- Solve root causes of problems, not just symptoms.

A WATERSHED PERSPECTIVE ON DEVELOPMENT



This conceptual drawing illustrates how much open space or watershed land is left if compact development is used instead of sprawl, and the difference between permeable and impermeable surface. Permeable surfaces allow water to infiltrate; impermeable surfaces promote rapid runoff, increasing the volume and velocity of stormwater and the amount of pollutants flowing into the Estuary or other receiving water bodies.

The Convergence of Urban and Rural Land Uses in the Delta

LINDA FIACK
Delta Protection Commission

The Delta Protection Act was enacted pursuant to legislative action and the signature of the Governor in 1992 (subsequently amended, most recently in 2007). The Act states that the Sacramento-San Joaquin Delta is a natural resource of statewide, national, and international significance, containing irreplaceable resources, and that it is the policy of the state to recognize, preserve, and protect those resources of the Delta for the use and enjoyment of current and future generations.

The Act further states that the basic goals of the state for the Delta are to protect, maintain, and where possible, enhance and restore the overall quality of the Delta environment, including, but not limited to, agriculture, wildlife habitat, and recreational activities; assure orderly, balanced conservation and development of Delta land resources; and improve flood protection by structural and nonstructural means to ensure an increased level of public health and safety.

The 23-member Delta Protection Commission (Commission) was created under the Act to complete and implement a Land Use and Resource Management Plan for the Primary Zone of the Delta (Management Plan). The Management Plan, completed and adopted in 1995, contains findings, policies, and recommendations in the areas of environment, utilities and infrastructure, land use, agriculture, water, levees, recreation and access, and boating. The Management Plan has been adopted in Delta local government general plans, and consistency with the Management Plan in land use planning approvals is subject to appeal relative to projects in the Primary Zone.

The Act and the Management Plan have significant influence over land use and water management in the Delta. These documents, and additional information about the Commission, can be viewed at delta.ca.gov.

MORE INFO?
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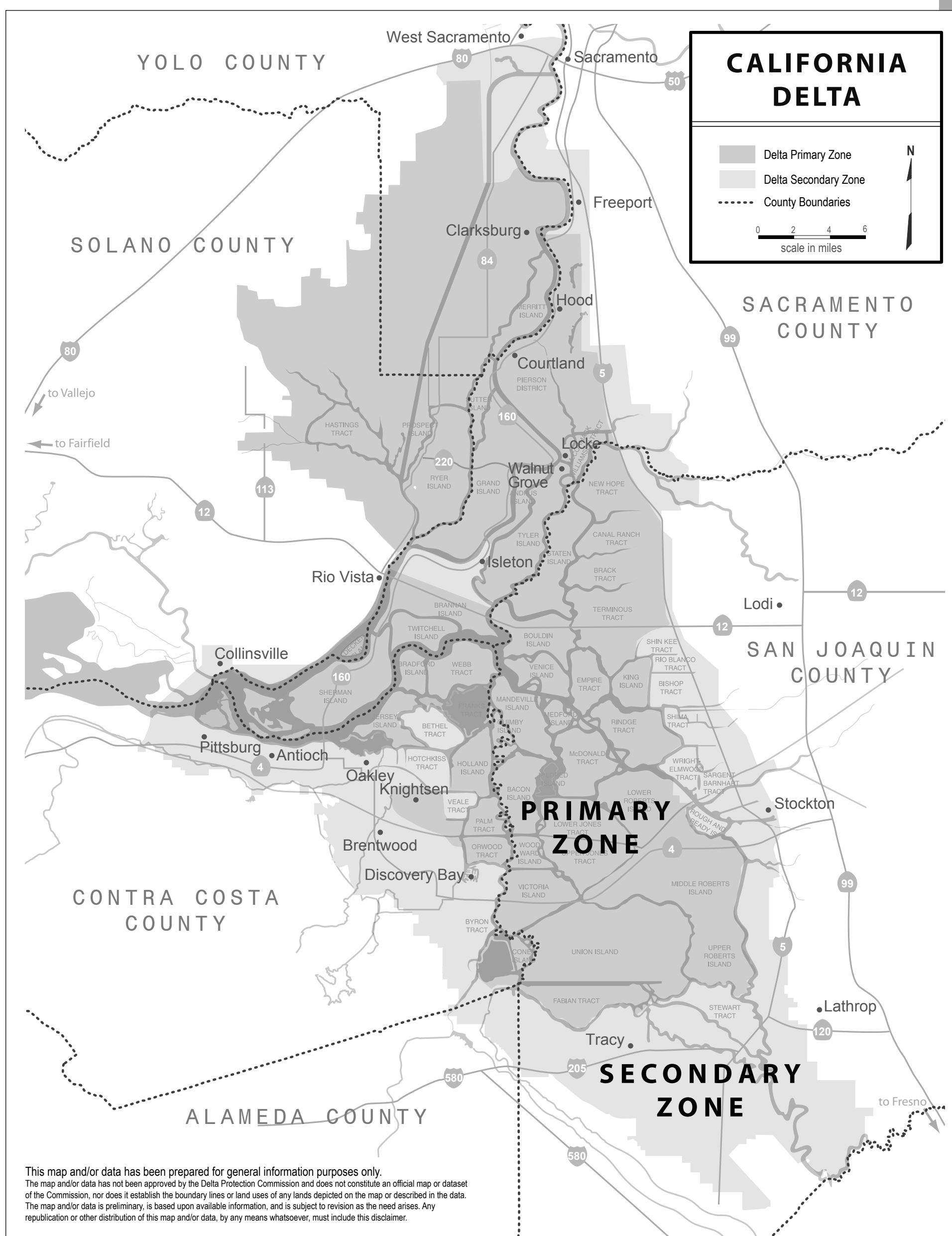


Linking Air Quality, Water Quality, Land Use, and Transportation

DAVE BURCH
Bay Area Air Quality Management District

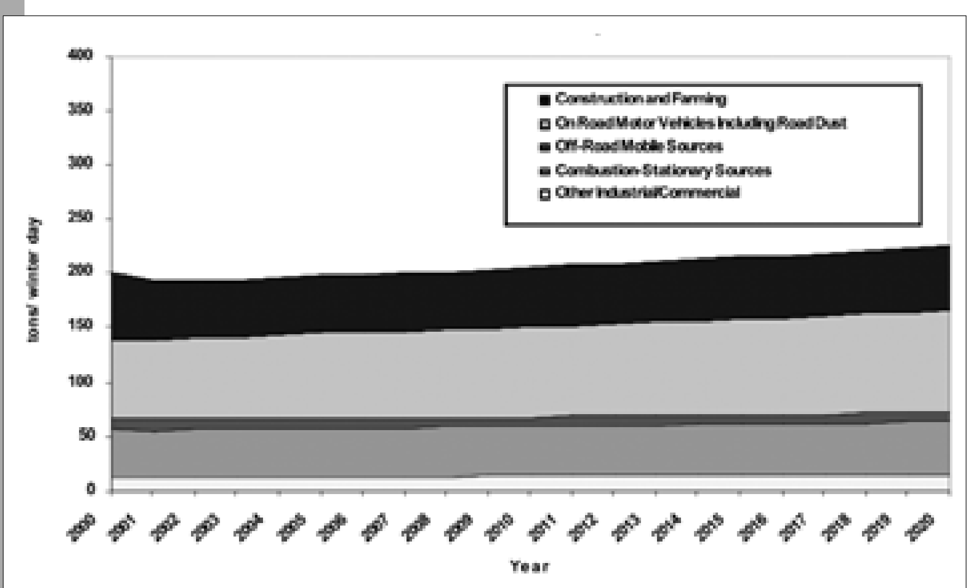
Problem air pollutants in the Estuary watershed include:

- ozone or smog, formed via photochemical interaction of volatile organic compounds and nitrous oxide compounds.
- particulate matter, composed of ultrafine, fine, and coarse particles from wood smoke, fossil fuel combustion, and geologic dust
- air toxics, including diesel particulate matter, benzene, 1,3 butadiene, and
- greenhouse gases such as carbon dioxide and methane.

Air pollution contributes to asthma, lung disease such as emphysema, and risk of cancer. Poor air quality also impedes children's lung growth. Air pollution can also negatively affect water quality and plant growth via acid rain and deposition of pollutants. Other impacts from poor air quality include reduced visibility, wear and tear on buildings, odors, and economic damages.

Motor vehicles are the major source of air pollution in the Bay Area. Vehicles also contribute to water pollution through deposition of tailpipe emissions; road runoff from tire and brake particles (polyaromatic hydrocarbons from tires and copper from brake pads are a major concern); fuel and oil spills and improper disposal of oil, brake fluid, antifreeze, and transmission fluid; as well as nutrients and pollutants from on-street car washing. Tailpipe emissions have been greatly reduced on a per-mile basis in recent decades, due to cleaner fuels and stringent vehicle emission standards. However, a rapid increase in total vehicle miles of travel has eroded progress from technological improvements. Vehicle miles traveled (VMT) are projected to continue increasing twice as fast as population growth in the Bay Area.

PM10 EMISSIONS INVENTORY TREND 2000-2020



Petroleum refining is responsible for less than 0.5% of PM10 emissions in the Bay Area, and therefore does not show up at the scale used. Refineries do produce ozone-precursor emissions but not a lot of PM10.

The Bay Area has made great progress in improving air quality over the past 50 years—but we still face major challenges. These include reducing traditional air pollutants such as particulate matter, ozone, and toxic air emissions, as well as greatly reducing emissions of carbon dioxide and other greenhouse gases that contribute to global warming. Improved emission control systems, more fuel efficient vehicles, and alternative fuels will all play key roles in confronting these challenges. However, it will also be important to constrain the rapid growth in motor vehicle use (VMT). Reducing VMT will require changes in land use patterns, which dictate travel choices. We need to better integrate land use and transportation planning, to rely more on "smart growth" principles such as infill and transit-oriented development, to encourage more walking, biking, and public transit use. Fewer vehicle miles traveled per household will reduce emissions of serious air pollutants and greenhouse gases, and can help us to improve air quality and water quality, protect our climate, preserve open space, and create and maintain healthy communities, all of which contribute to our high quality of life in the Bay Area. The Association of Bay Area Governments, the Metropolitan Transportation Commission, the Bay Area Air Quality Management District, and the Bay Conservation and Development Commission are partnering with cities to try to strengthen existing city centers, locate housing near transit, encourage more compact and walkable suburbs, and protect regional open space. We need to continue to expand and strengthen our partnerships, to encourage greener building, water conservation, and energy efficiency, and mitigate urban heat islands with activities like tree planting.

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Pollutants

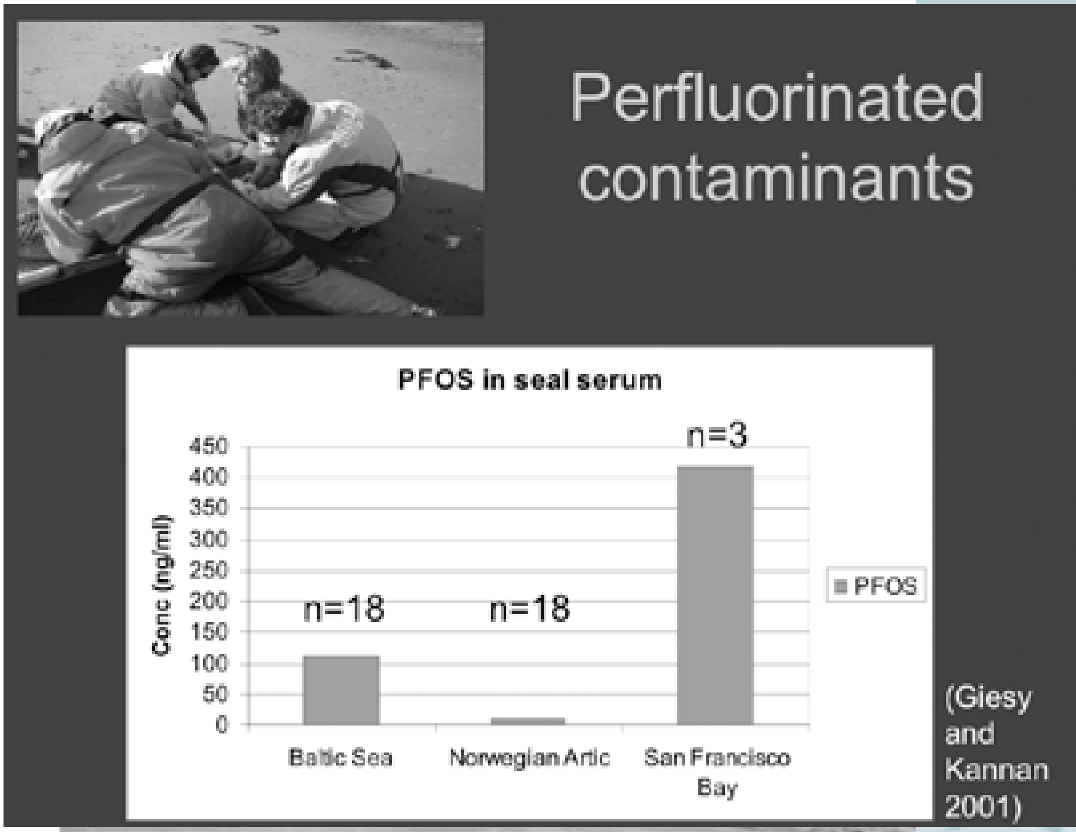
San Francisco Bay Harbor Seal Health

DENISE GREIG and
FRANCES GULLAND
The Marine Mammal Center

MEG SEDLAK
San Francisco Estuary Institute

A.J. HALL
University of St Andrews, Scotland

Harbor seals have lived in the San Francisco Estuary for thousands of years. They rest, give birth, and feed within the Bay and consequently are exposed to a variety of anthropogenic and terrestrial sources of contamination. As long-lived Estuary residents feeding at the same trophic level as humans, they are ideal for monitoring the effects of emerging marine contaminants on mammalian physiology, and hence humans. Their use of an accessible subcutaneous blubber layer to store energy further enhances their utility for monitoring persistent lipophilic compounds in their environment. Previous studies of contaminants in harbor seal tissue have reported varying levels of PCBs, DDTs, and PBDEs, but few have been able to link their results to harbor seal health or mortality. We are investigating the effects of these contaminants on harbor seal health by analyzing the blood and blubber of harbor seals for PCBs, DDTs, PBDEs, and perfluorinated compounds, while simultaneously developing health profiles for these individuals using hematology, morphometrics, prevalence of fecal pathogens, and indicators of infectious disease exposure. In 2007, blood and blubber samples for contaminant analysis were collected from live and dead stranded harbor seals admitted to The Marine Mammal Center, as well as from seals from Castro Rocks under the Richmond Bridge. Preliminary data on levels of perfluorooctane sulfonate (PFOS) compounds in serum were greater than previously reported for marine mammals in other locations. We plan to further analyze blubber samples for PCBs, DDTs, and PBDEs and evaluate the levels in conjunction with measures of health, immunity, and disease exposure. This will provide data on the effects of the contaminants, rather than levels alone, on the health of this sentinel of estuarine health, the harbor seal.



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Investigation of Non-PBDE Flame Retardants in San Francisco Bay

Polybrominated diphenyl ethers (PBDEs) are chemicals used as flame retardants that are incorporated into a variety of consumer products to comply with fire safety regulations. Restrictions on the use of PBDEs due to environmental and human health concerns has resulted in an increase in the use of other chemicals to meet the flammability standards still in effect. Compared to the PBDEs, however, much less is known regarding the toxicity and fate of these alternative flame retardant chemicals, and information on their use (e.g., volume and sources) is generally not available. Examples of chemicals that have reportedly been used to replace PBDEs include hexabromocyclododecane (HBCD), a ubiquitous contaminant that biomagnifies in food webs, and tris (1,3-dichloro-2-propyl) phosphate, a probable human carcinogen. A pilot study will be conducted in 2008 to assess the extent of contamination of several potential PBDE replacement chemicals in the San Francisco Estuary ecosystem. Sport fish, bird eggs, and harbor seal blubber, and surface water collected from the Bay will be analyzed for 15 flame retardant chemicals suspected to be in use in the U.S. Results from this study will allow us to determine the risk of exposure of these chemicals to the estuarine food web and to humans consuming sport fish.

Investigation of Perfluorinated Compounds in San Francisco Bay Harbor Seals

In 2007, the Regional Monitoring Program began collaborating with the Marine Mammal Center to monitor perfluorinated compounds in Pacific harbor seals. This study is part of a larger three-year study of the health and well being of harbor seals. Harbor seals are an ideal indicator species for persistent bioaccumulative contaminants in the Estuary because they are apex predators, eating a diet consisting primarily of fish. Perfluorinated compounds are of particular concern because they are very stable compounds that have been identified in foodwebs throughout the world and have been associated with deleterious health effects. Preliminary data from the first year of the study of seals suggests that the concentrations of perfluorinated compounds, particularly PFOS, are elevated in seals relative to concentrations observed in pristine environments.

—Meg Sedlak, SFEI

Mercury Risk to Birds in the San Francisco Estuary

COLLIN EAGLES-SMITH, ET AL.
U.S. Geological Survey

SUSAN DE LA CRUZ AND JOHN TAKEKAWA
U.S. Fish & Wildlife Service

The San Francisco Estuary is a site of hemispheric importance for waterbird populations. It is also a site of high mercury concentrations in sediments and biota. The risks of methyl mercury bioaccumulation and its toxic effects on avian reproduction may be greater in waterbirds than other wildlife in San Francisco Bay. We examined mercury concentrations in five species of waterbirds common in San Francisco Bay: American avocets, black-necked stilts, Forster's terns, Caspian terns, and surf scoters. Using telemetry, diet, and stable isotope analyses, we quantified key habitats, locations, and prey items utilized by pre-breeding and breeding waterbirds. We examined mercury concentrations in adults, chicks, and eggs, and concentrations in their prey. We also monitored nest success and chick survival of three of the locally breeding species (avocets, stilts, and Forster's terns) at several colonies throughout the Estuary. We found that in general, mercury concentrations were highest in Forster's terns, followed by stilts, Caspian terns, avocets, and surf scoters. Using a risk factor analysis, we estimated that 58% of breeding Forster's tern adults and 46% of eggs exceeded toxicity thresholds established for other avian taxa. We also found evidence of mercury-related effects in both eggs and chicks. Mercury concentrations in failed-to-hatch and abandoned Forster's tern eggs were significantly higher than mercury concentrations in randomly collected, apparently healthy tern eggs. Further, we found a 32% reduction in tern hatching success over the observed range of egg mercury concentrations. We also found that mercury concentrations in down feathers of stilt chicks found dead on colony were significantly higher than in randomly-sampled, apparently healthy chicks of similar age. These results indicate that mercury may be impairing reproduction in both Forster's terns and black-necked stilts, and potentially other breeding waterbirds, in San Francisco Bay. We recommend that an expanded waterbird monitoring program be established in the Estuary to more thoroughly assess mercury risk, and suggest using eggs as an ideal bio-indicator of risk to multiple avian lifestages.

MORE INFO?
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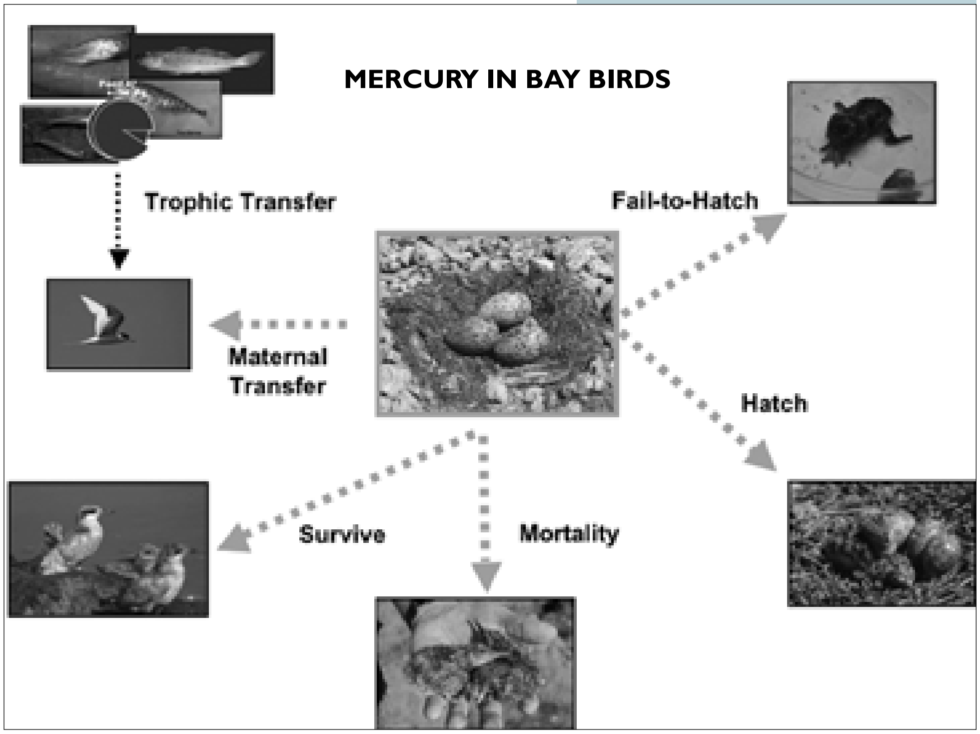
TAKE HOME POINTS

- Mercury bioaccumulates to levels of concern in several waterbird species nesting in the San Francisco Bay Estuary, suggesting that populations may be at risk.
- Mercury levels are not only elevated in high trophic level, fish eating birds, (such as Forster's terns) but also in some birds that eat invertebrates (such as black-necked stilts) in marsh and salt pond habitats.
- Both hatching success and chick mortality may be currently being impaired by mercury exposure, suggesting that a more thorough assessment of mercury effects on waterbird reproduction is warranted.
- Waterbird eggs have been developed as a sensitive bio-indicator of mercury risk, and we suggest that a region-wide monitoring program be established.



Environmental Endocrine Disruption in Bay Shiner Perch and Pacific Staghorn Sculpin

KEVIN KELLEY, ET AL.
California State University,
Long Beach, CA

Our studies have been aimed at characterizing the incidence and potential magnitude of environmental endocrine disruption occurring in native fishes resident in the San Francisco Bay Estuary. There is at present ample evidence that many locations in the Bay are significantly contaminated with continuing and legacy pollutants of several kinds. Because endocrine systems are highly sensitive and typically respond to presence of environmental stressors to a degree commensurate with the need to maintain homeostasis, they are increasingly being used as effective bio-indicators of the effects of pollution and other anthropomorphic stressors. In addition, since different types of contaminants affect different endocrine axes via distinct mechanisms, the kinds of endocrine disturbances observed are typically highly reflective of the kind of pollutant present. We have targeted two indigenous fish species, the shiner perch (*Cymatogaster aggregata*) and the Pacific staghorn sculpin (*Leptocottus armatus*), to assess the degree to which they are experiencing environmental endocrine disruption in association with different regional locations, including Regional Monitoring Program study areas.

Data emerging from these studies indicate that both species are accumulating a variety of contaminants in their livers, including chlorinated pesticides, PCBs, and PAHs. The same animals also exhibit distinct types of endocrine-disrupted states, with location-associated differences in the functions of endocrine systems regulating thyroid hormones, somatic growth, stress responses, and metabolism.

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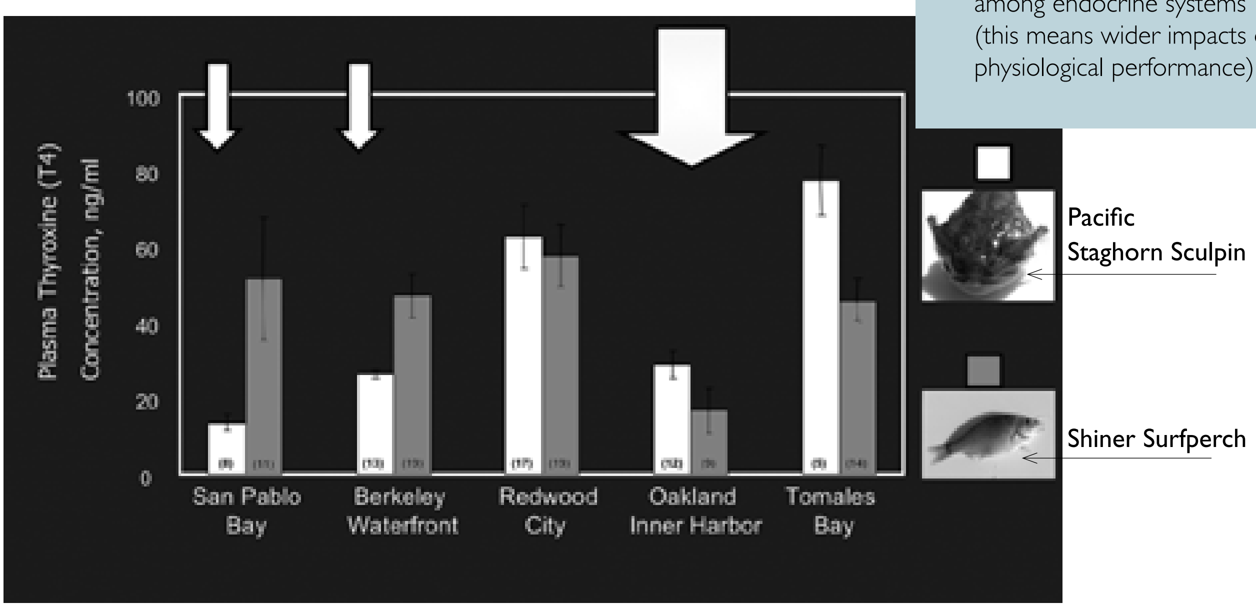
TAKE HOME POINTS

- Endocrine responses/endocrine disruption serve as sensitive bio-markers of environmental perturbations.
- Endocrine systems:
    - o are highly responsive to environmental stressors
    - o respond proportionally to the need to maintain homeostasis
    - o show alterations reflecting the kind of stressor(s) present (different endocrine-disrupting compounds affect different endocrine axes via distinct underlying mechanisms).
- Endocrine-disrupted conditions are observed in SF Bay fish (particularly in urban, industrial, boat marina areas).
- Endocrine disruption is evident in different fish species.
- Endocrine disruption is occurring in different endocrine systems (stress, thyroid, reproduction, growth and repair, defense, metabolism).
- There may be interactions among endocrine systems (this means wider impacts on physiological performance).

THYROXINE (T4) LEVELS IN SF BAY FISH



Protecting Estuaries from Toxic Contaminants: The Role of Biological Observing Systems

TRACY COLLIER
NOAA Fisheries

SANDIE O'NEILL
Washington Department of Fish and Wildlife

Our nation's estuaries are recipients of a wide range of toxic chemical contaminants resulting from human activities, which has led to the implementation of monitoring programs in most major estuaries. Much of this monitoring is focused on abiotic matrices, primarily water and sediments, with sediments viewed as repositories for many toxics entering aquatic ecosystems. However, we are increasingly aware that we have underestimated the ecological ramifications of toxic releases: toxics affect biota throughout the ecosystem, including humans, and not just the benthos. As a result, biologically-based monitoring is increasingly recognized as an important component of efforts to protect estuaries from toxics. We recommend that biologically-based monitoring be incorporated into a broader ecosystem context, which we call a biological observing system (BiOS). A BiOS for toxic contaminants should enhance our ability to protect estuarine ecosystems, and would include:

1. A conceptual (or numerical) model detailing the understanding of current loadings and the fate and transport of toxics within the estuary. Understanding the relative importance of contaminant reservoirs in water, sediments, and biota, and the fluxes among these compartments, will allow managers to focus on appropriate toxics management actions that maximize benefit to biota.
2. A biologically-based monitoring program, assessing exposure and effects of chemical contaminants in biota, integrated across ecologically relevant habitats and food webs. These data provide environmental indicators of trends in estuary health, serve as performance measures for management actions, and give early warning of unanticipated exposures or biological effects (e.g. red flags).
3. Funding for ancillary studies that piggyback on the monitoring framework to follow up on "red flags." Such investigations should provide causality links on which to base further actions.

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TAKE HOME POINT

- Compared to monitoring sediment and water, monitoring animals can tell you more.

American avocet by Bob Lewis

Statewide Assessment of Embayment Sediment Quality Using Multiple Lines of Evidence

STEVE WEISBERG
Southern California Coastal Water Research Project Authority

Numerous surveys have been conducted to study sediment chemistry, but few link contaminants with biological effects. We used a multiple lines of evidence approach to integrate chemistry, toxicity, and benthic infauna data to provide an overall assessment of sediment conditions in California. We used five probability-based data sets collected over the last seven years, and data were integrated using the state's draft sediment quality objectives. Seventeen percent of California estuaries and embayments, or 217 square kilometers, was found to be unimpacted, but this was unevenly distributed. More than 70% of sediments outside of San Francisco Bay were found to be unimpacted, while only 4% of the area within the Bay was unimpacted. The draft sediment quality objectives include three classifications for impacted sediments (possibly, likely, and clearly), and most Bay sediments were in the lowest of those categories (possibly impacted). The high level of mixing within the Bay may be redistributing contaminants and producing a low level impact to sediments over a wider area, in contrast to the more localized hot spots in smaller, hydrologically-isolated embayments of other regions.

MORE INFO?
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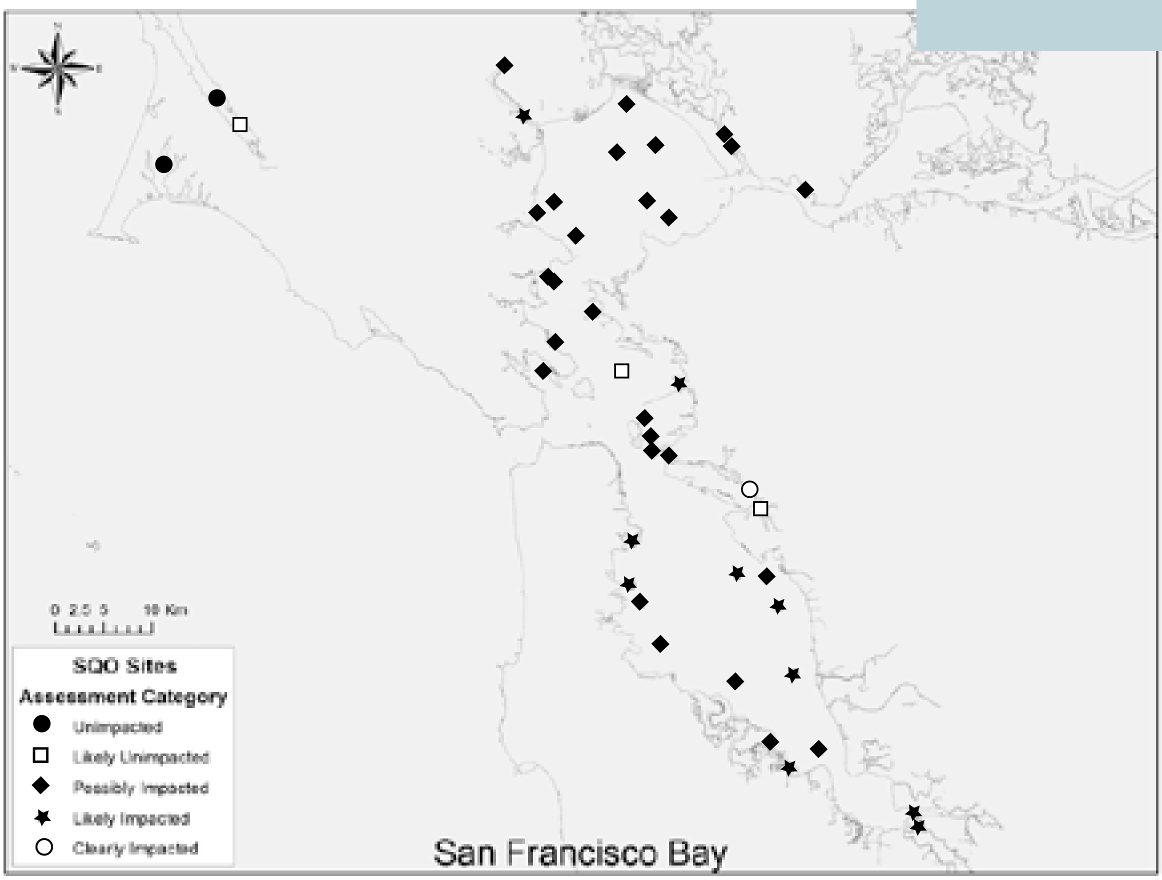
TAKE HOME POINTS

- A sediment quality objectives assessment framework was successfully applied throughout the state, and data from 6 surveys and 381 stations integrated.
- Regional differences in sediment condition were observed: there was a greater area of impacts in San Francisco Bay due to higher prevalence of both sediment toxicity and benthic community disturbance. The cause of the impacts is uncertain.
- These results provide a focus for research and management actions, including stressor identification studies in San Francisco Bay and other areas; increased monitoring in the San Francisco Bay with multiple lines of evidence indicators; and improved chemistry evaluation tools.



Most sites are "possibly impacted" although impacts are greater near ports and commercial areas.

Targeting Trash: Time for Action

DAVID LEWIS
Save The Bay

Walnut Creek

Trash and plastic debris pollution is a serious water quality problem in the Bay and its creeks. The California Ocean Protection Council has made reducing and preventing marine debris a top state priority. A San Francisco Bay Regional Water Quality Control Board study found that on average there are three pieces of trash along every foot of streams leading to the Bay. Save The Bay members and other citizens have collected extensive photo documentation of Bay shoreline trash, and last year volunteers removed 686,000 pieces of trash from the Bay on just one day.

Like other TMDL pollutants, trash and plastic debris is a hazard with serious impacts: harming fish and wildlife that ingest it or become entangled; smothering wetland habitat and jeopardizing priority restoration projects; releasing phthalates and other toxins into the water; deterring recreation; and reducing how much the public values the Bay.

Stormwater runoff is a major source of Bay trash that has received minimal attention until recently. The Los Angeles region is far ahead of the San Francisco region on this issue, with a strong trash TMDL, extensive trash screening and capture devices in place, and locally-generated funding to reduce runoff pollution. The new Bay Area Municipal Regional Permit for stormwater could require significant reductions in Bay trash over the next several years—adoption and enforcement of such reductions is a top priority for improved Bay health. To implement a stronger regulatory regime, new infrastructure to remove trash from the stormwater system could prove a cost-effective strategy.

Save The Bay has launched a major public education campaign on preventing trash pollution, and some Bay cities are pioneering source reduction of non-biodegradable trash components. These efforts must be accelerated throughout the region to achieve significant reductions in trash and marine debris.

Guadalupe River in the South Bay

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Sources, Amounts, and Patterns of Trash in Bay Area Streams

STEVE MOORE
Nute Engineering

In 2002, the Surface Water Ambient Monitoring Program (SWAMP) of the Regional Water Board developed a rapid trash assessment methodology. The study report was scientifically peer reviewed, and finalized by SWAMP in 2007, and documents sources, amounts, and patterns of trash in creeks from five Bay Area counties that drain to the Estuary. At selected sites trash was removed, counted, and categorized along a land-marked 100-foot section of stream. These sites were re-visited two or three times in the following months to document trash deposition rates in pieces per 100-ft per day in both dry and wet seasons. Twenty-four regional sites were visited at least three times between spring 2003 and summer 2005. By documenting return rates of trash, the method helps to evaluate the effectiveness of trash cleanup and current management approaches at a specific site.

All watersheds studied had high levels of trash, regardless of demographics. Lower watershed sites had higher densities of trash due to their position in the landscape. Most of the trash items are not deposited locally but are conveyed from various storm drains and roads throughout the watershed. Trash source hotspots, usually associated with parks, schools, roads, or poorly kept commercial facilities near creek channels appear to contribute a significant portion of the trash at lower watershed sites. There is significant dry season deposition of trash associated with wind and dry season runoff. The majority of trash at lower watershed sites where trash accumulates in the wet season is disposable plastic. This suggests that urban runoff is a major source of floatable plastic found in the Estuary, the ocean. and on beaches as marine debris. Parks with management of trash by city staffs and local volunteers, including cleanup within the creek channels, had measurably less trash pieces and deposition rates.

MORE INFO?

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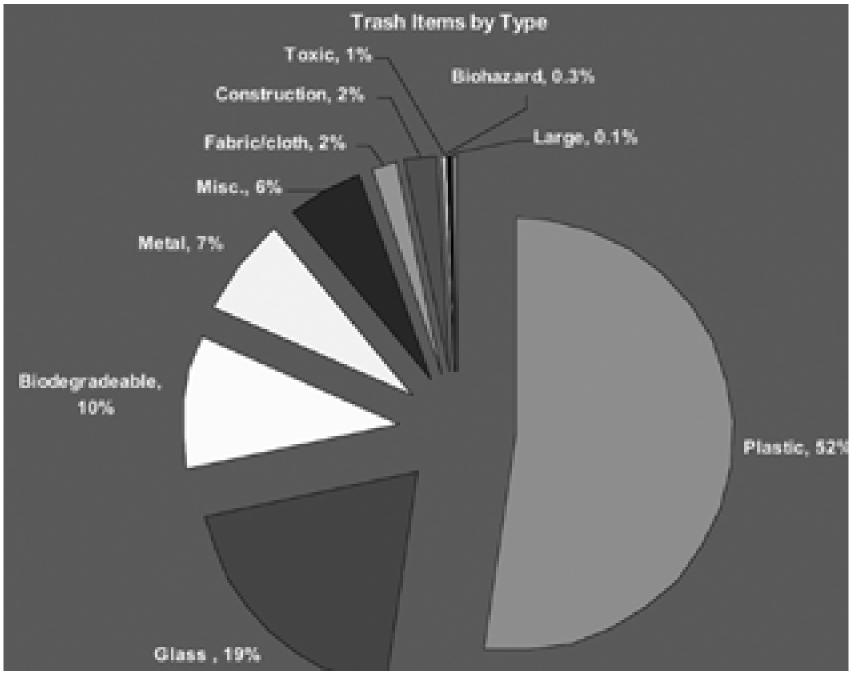
TAKE HOME POINTS

- All watersheds are trashed, regardless of socioeconomic status or population density.
- Lower watersheds are more heavily trashed, due to their position in the landscape.
- Streams are likely the main pathway of floatable plastic to marine waters.
- Trash levels are not improving and may be getting worse.

TRASH RAPID ASSESSMENT RESULTS




Coyote Creek, San Jose


Laurel Creek, San Mateo

Oakland's Programs to Reduce Trash in Bay Waters

LESLEY ESTES
City of Oakland

Lake Merritt is one of the city of Oakland's finest attractions and is home to boaters, rowing clubs, pedestrians, runners, Children's Fairyland, garden clubs, outdoor nature programs, and an array of wildlife. In fact, Lake Merritt is the first wildlife refuge established under the California Wildlife Act of 1870, and is home to thousands of migratory and resident birds. However, the lake sits in the middle of a highly urbanized, mostly paved 4,000-acre watershed and is beleaguered by trash. Between 1998 and 2006 an average of 45,000 pounds (or 22.6 tons) of trash per year has been removed from the lake. Trash degrades water quality by interfering with growth of aquatic vegetation, decreasing spawning and foraging habitat for fish and other living organisms, harming wildlife when they ingest it or become entangled in it, and by contaminating bottom sediments. Along with the impacts of altered hydrology from urbanization, an abundance of trash degrades wildlife habitat and water quality in Lake Merritt. Beyond habitat degradation, trash accumulation in the lake is unsightly to visitors and residents and impacts the recreational and aesthetic experience of Lake Merritt. In 1999, the U.S. EPA included Lake Merritt on its 303(d) list for water quality impairment due to trash. In 2001 the City of Oakland established the Lake Merritt Water Quality Committee consisting of city engineers, naturalists, parks and recreation and watershed program staff, Alameda County Flood Control and city of Piedmont staff, community experts, and the Lake Merritt Institute. The committee developed an evolving, multifaceted approach to improving the Lake Merritt environment. The approach has included piloting and constructing new structural stormwater trash technologies, adopting new anti-trash regulations, including bans on Styrofoam take-out containers and plastic bags, altering street sweeping and maintenance schedules, and funding a large volunteer-based outreach and trash pickup program. Though there are many technical and societal challenges that face an urbanized lake like Lake Merritt, the city of Oakland is committed to the challenge and will continue to experiment with and implement new strategies and technologies.

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Damon Slough, Oakland, with trash boom

TAKE HOME POINTS

- Structural trash removal devices (stormwater separators) have been very successful in a select few locations; however, they require significant capital expenditure.
- Stormwater separators require regular maintenance several times a year, especially during the storm season.
- In an older, built-out city like Oakland there are significant infrastructure challenges and barriers to installing stormwater separators.
- Trash solutions need to be multi-pronged: In addition to structural solutions, Oakland uses bans on Stryofoam take-out containers and plastic bags, anti-littering programs in schools, "adopt a spot" cleanup programs with citizens, clean creeks campaigns, and targeted street sweeping, and employs youth to pick up trash. The city also enforces penalties for illegal dumping.

Structural Trash Removal In Southern California

MARK CUNEO
City of Santa Monica

The city of Santa Monica is a vibrant beach community adjacent to Santa Monica Bay in the Los Angeles Basin, where Ballona Creek and the Los Angeles River have been put on the 303(d) list of impaired waterways due to trash, and a trash TMDL has been put in place. The Santa Monica community has a reputation as a leader in the implementation of sustainable practices; it has a goal of protecting and enhancing environmental health, and improving water quality for residents and visitors. The local economy depends on tourism that may be negatively affected by failure to make the beaches and ocean cleaner and safer. Santa Monica operates and maintains 20 miles of storm drains, 650 catch basins, and various other storm drain facilities. Over the past 10 years, the city has spent $120 million implementing many structural best-management practices to reduce the discharge of trash and debris from the municipal storm drain system. The city uses a combination of structural controls in catch basins and at the end of pipes to reduce discharge of trash to local receiving waters. In dry years, it "boards over" storm drain inlets to keep trash out.

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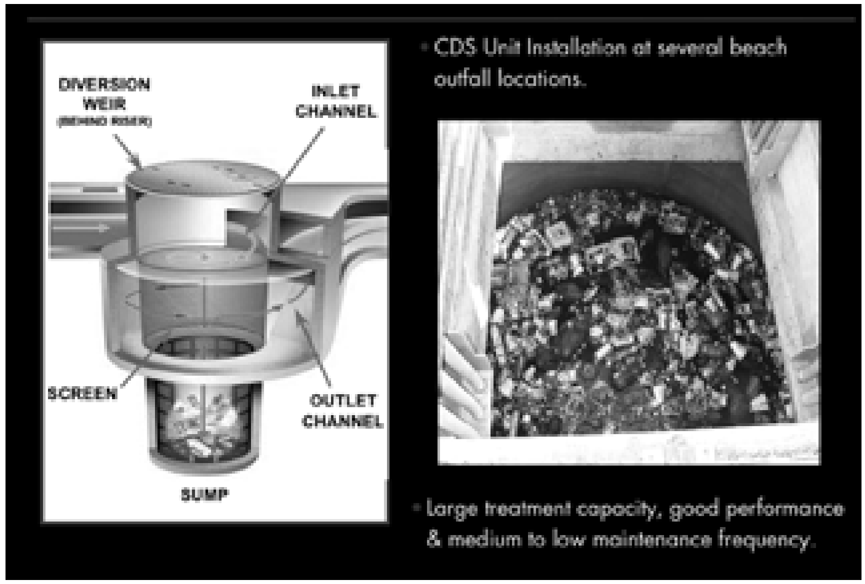
TAKE HOME POINTS

- Try to avoid litigation over TMDLs and regulations.
- Trash doesn't magically disappear out of structural controls; maintenance is needed.

STORM DRAIN END-OF-PIPE TRASH REMOVAL RETROFITS



Santa Monica

Sources of Pollutant Loads to San Francisco Bay: Knowledge and Challenges Ahead

LESTER MCKEE ET AL.
San Francisco Estuary Institute

Fish and biota in San Francisco Bay are contaminated with mercury (Hg) and polychlorinated biphenyls (PCBs), and public health advisories recommend limited consumption of fish caught from the Bay. In addition, polybrominated diphenyl ether (PBDE) concentrations in the Bay Area are amongst the highest reported in the world. Hg, PCBs, and PBDEs may be considered priority contaminants. Contaminants enter the Bay via river flow from the Central Valley, local tributaries and storm drains, municipal and industrial stormwater and wastewater, atmospheric deposition, and erosion of legacy contaminated Bay sediments. Of these pathways, the mass load in stormwater has the greatest uncertainty and is the most difficult to quantify. Stormwater mass loading studies began in 2002 on the Sacramento River. Since then, studies have been carried out on Guadalupe River, Coyote Creek, and in a storm drain in Hayward.

These studies demonstrate that stormwater mass loads have the potential to significantly decrease the rate of recovery of the Bay to desirable standards. The recently released total maximum daily load (TMDL) reports call for 50 and 90% stormwater load reductions for Hg and PCB respectively, but there is little information on where highest concentrations occur and how PCBs and Hg cycle through the urban environment. First-of-their-kind studies in the Bay Area indicate that much of the PCB mass occurs in older industrial areas. In contrast, Hg is more evenly distributed given its propensity for atmospheric transport and more ubiquitous historic and ongoing uses. Remaining challenges for Hg and PCBs include improving knowledge on sources, determining PCBs and Hg source-release processes, the character of released material, and the significance of dry-weather flows. PBDE challenges include improving knowledge of source areas and the mechanisms of release, and determining if mass loads from each main pathway stabilize or begin to decrease in response to bans.

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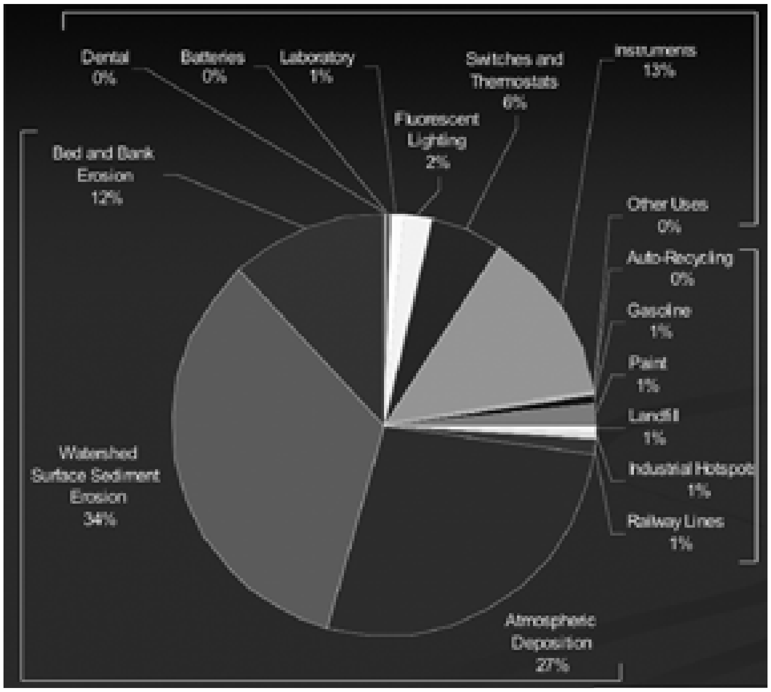
HOW THE MERCURY PIE IS CUT



SUGGESTED SOLUTIONS

- Develop side-by-side special studies that link hypothesized stressors with the Bay food-web.
- Employ source tracking tools (more of the same).
- Choose a series of "observation watersheds" for long-term monitoring.
- Employ watershed models:
  - To help determine priority watersheds to manage.
  - To focus data collection.
  - To improve loads estimates on a regional scale.
- Add analytes to the loading studies as new information emerges on impairment.
- Encourage more integrated water management (drinking water/flood management/ water quality).

Successes and Opportunities in Pollution Prevention

GAYLE TUPPER
East Bay Municipal Utility District

Pollution prevention is a proven effective and efficient means for utilities to achieve compliance and protect San Francisco Bay. East Bay Municipal Utility District has an innovative and successful pollution prevention (P2) program, focusing on pollutants of concern for EBMUD and the Bay. P2 at EBMUD has grown from controlling discharges at large industries to providing education and best management practices to smaller commercial businesses, and to residential outreach and collaboration with a range of partner organizations.

Successful approaches to P2 include the zero discharge program for industries that are able to eliminate their discharge for all regulated wastewater. Cost-saving incentives encourage businesses to implement zero discharge and thereby remove potentially significant amounts of pollutants from EBMUD's influent.

San Francisco Bay TMDLs are a driver for P2 efforts, with mercury as a primary example. EBMUD's multifaceted mercury program includes requirements for dentists to install amalgam separators, working with schools and colleges to remove all non-essential mercury from their campuses, and an ongoing residential thermometer exchange program. EBMUD has detected measurable reductions in mercury loading since the mercury program's implementation.

New P2 initiatives and new challenges include diverting unused pharmaceuticals from the sewer. EBMUD is establishing a user-friendly pilot pharmaceutical diversion program that meets stringent Drug Enforcement Agency requirements. EBMUD has also discovered the benefits of partnering with environmental nongovernmental organizations through joint efforts with Save The Bay, Baykeeper, and Environmental Working Group. These activities provide an effective synergy between EBMUD's technical resources and the grassroots outreach capabilities of the NGOs to communicate the importance of P2 to a wider audience. Opportunities in P2 abound in partnering with additional agencies, institutions, and organizations. Each partnership can enhance the effectiveness of pollution prevention efforts for the partners, for the target audience, and for the environment.

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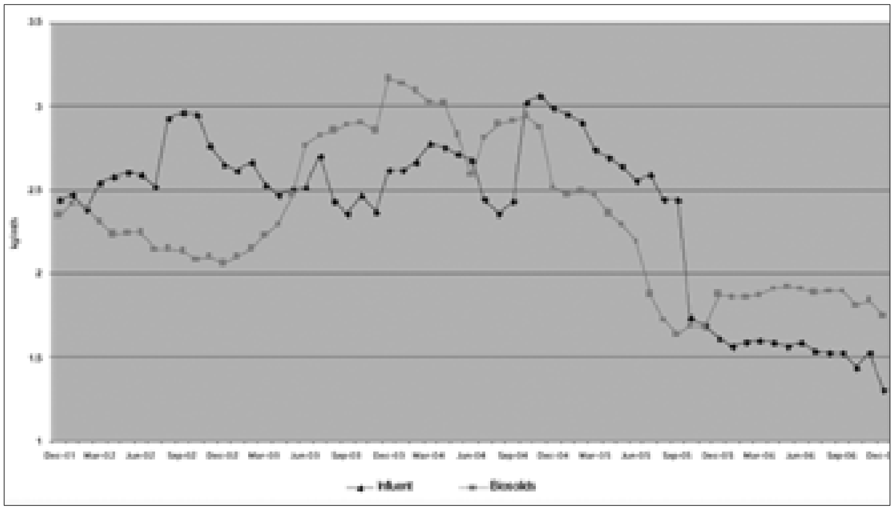
CHALLENGES AHEAD

- Pharmaceuticals—countering the "sewer it" or "flush it" message and dealing with take-back hurdles
- Emerging contaminants
- Personal care products
- Antibacterial products
- Flame retardants
- Nanoparticles
- Fats, oil, and grease ("FOG"); metals

UPCOMING PRIORITIES

- Continue to build upon mercury program
- Sanitary sewer overflow reduction through regional fats, oils, and grease control program
- Emerging pollutants—residential focus
- Continued development of partnerships

WASTEWATER TREATMENT PLANT MERCURY MASS LOADING 2001-06
12 Month Rolling Average



The result of our concerted mercury reduction efforts over the past five years.

Stormwater Drainage System Maintenance Practices to Reduce PCB and Mercury Discharges to the Bay

JIM SCANLIN ET AL.
Alameda Countywide Clean Water Program

The San Francisco Bay is listed as impaired due to elevated concentrations of polychlorinated biphenyls (PCBs) and mercury in Bay fish and potential adverse effects to wildlife. Elevated concentrations of these pollutants have also been found in sediments within stormwater drainage systems throughout the Bay Area. Sediments within these drainage systems are carried by stormwater directly to the Bay. Municipalities and flood control districts throughout the Region prevent sediment from entering stormwater drainage systems or remove it from drainage systems through activities such as street sweeping, drop-inlet cleaning, and dredging flood control channels. By removing sediments, these practices also remove sediment-associated pollutants such as PCBs and mercury.

Several recent studies have attempted to characterize the mass of sediment, PCBs, and/or mercury removed through these practices. Results indicate that standard sediment removal practices conducted by municipalities and flood control districts remove a significant mass of these pollutants from stormwater drainage systems that may have otherwise reached the Bay. In Alameda County, street sweeping removes 100,000 cubic yards of material per year, including 3 kilograms of PCBs and 8 kilograms of mercury. Ninety percent of PCBs and mercury are removed by street sweeping in the northern part of the county. High-efficiency sweepers show a 70% increase in removal efficiency, but cost two to three times as much as current sweepers.

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TAKE HOME POINTS

- We have a good understanding of the sources and distribution of mercury and PCBs.
- There is no "silver bullet" control measure; we need to use a combination of measures, including reducing local air sources, and to work with the state on remediation.

Structural Control Solutions: Options, Information Gaps, and Challenges

MIKE STENSTROM
University of California, Los Angeles

After the construction of secondary treatment plants, urban runoff has become the major source of many pollutants, especially of heavy metals and trace organics associated with pesticide application and vehicular activities, and legacy pollutants such as mercury, chlorinated pesticides and polychlorinated biphenyls (PCBs). Further reductions of emissions of these pollutants must be obtained through urban runoff management. The recent implementations of total daily maximum loads (TMDLs) sets goals for these reduced emissions but provides little or no guidance about how to achieve the reductions. Decision makers are faced with the difficult task of choosing best management practices (BMPs) with very little guidance or assurances that they will work, or that the selection is anywhere near an optimal selection. Los Angeles' Proposition O, which allocated $500 million, is a good example of the difficulty. The full expenditure will reduce emissions, in the best example, for a single pollutant by only 13%, far short of the TMDL requirements. Many tools are available for ranking BMPs but few can be applied to understand how to meet a TMDL within existing constraints. We used modeling tools and existing monitoring data to evaluate alternatives for meeting the TMDLs for the upper Ballona Creek watershed. The results show the deficiency of monitoring data for verification, the need for additional BMP performance criteria, and the near absence of criteria to insure that BMP selections can comply with institutional and regulatory constraints. A particular problem is locating BMPs in a developed urban area, where virtually no land is available. In such cases, it is difficult to avoid selecting BMPs simply on the basis of "what can fit." The exercise also shows that BMPs may help meet several different TMDLs but are only being selected on the basis of a single TMDL.

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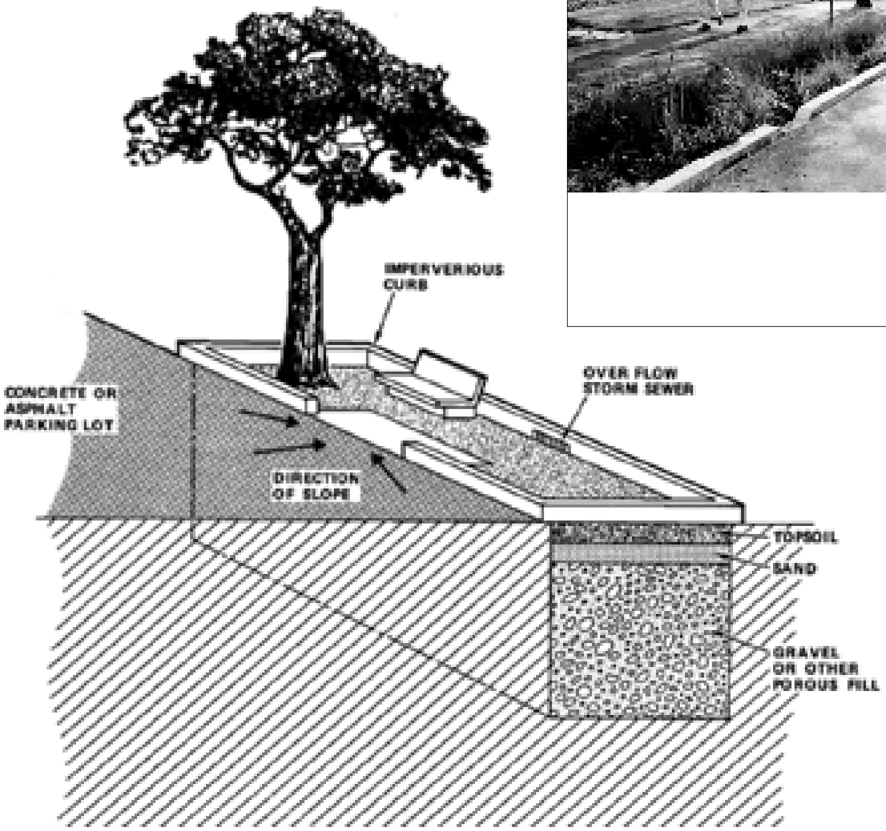
INFILTRATION TRENCH ON A LOCAL ROAD
(City of Portland Bureau of Environmental Services, 2004)

- Impervious drainage area $= 465\ m^2$
- Trench area $= 25\ m^2$
- A flow test with 25-year design storm (48 mm rainfall in 6 hours)
- 85% runoff volume reduction
- Saturated infiltration rate = 51 mm/hour



Example of an infiltration trench that can be used in an urban parking strip.

TAKE HOME POINTS

- We have a way to predict runoff and pollutant loads.
- We can identify the spatial origins of the loads.
- We can work with existing data although there is room for improvement.
- We can prioritize and locate BMPs.
- Our analysis suggests that we need small BMPS, applicable to road shoulders, small parking lots, medians, etc.

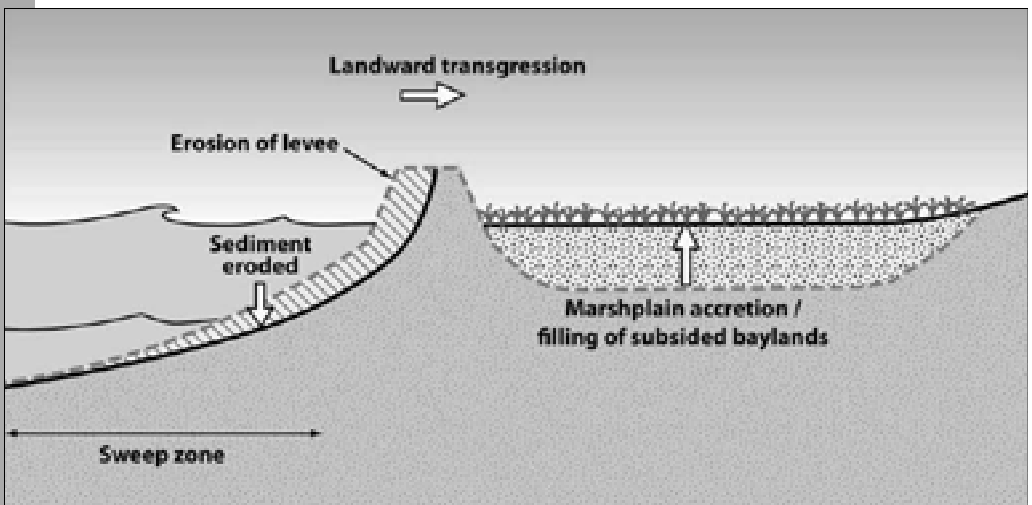
An oyster shell beach and backbarrier marsh, covered with gulls, Forster's terns, and willets, from Foster City. Photo and caption courtesy of Peter Baye.

Restoration

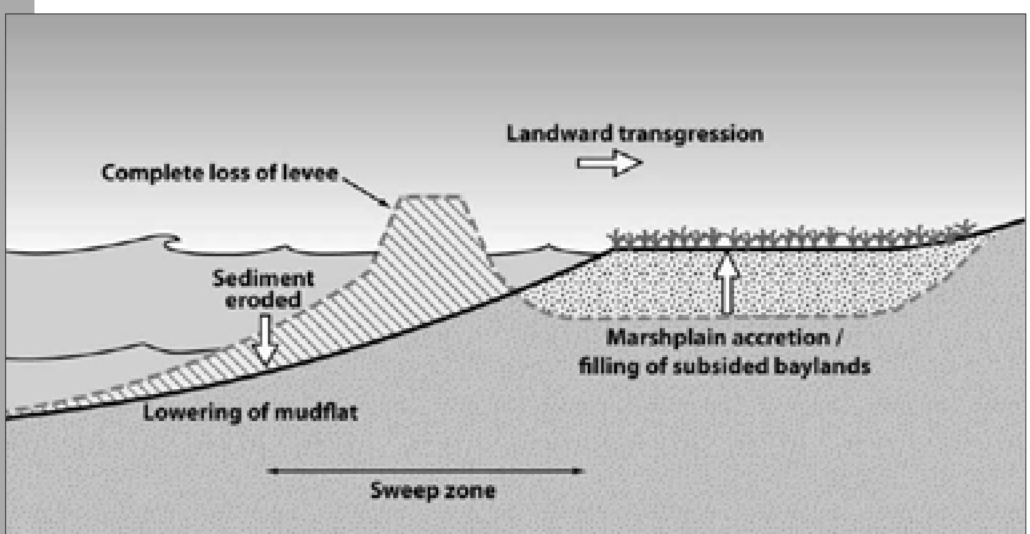
Managing Wetland Habitats as Sea Level Rises

JEREMY LOWE, PWA, Ltd. and PHYLLIS FABER, Faber & Associates

RESTORATION WITH LEVEE IN PLACE



LEVEE FAILURE AFTER RESTORATION



In the last century sea level rise has accelerated and the landward movement of the marshes has been restricted by bayfront levees. The marshes have been "squeezed" between the rising water and the levees, resulting in erosion of the mudflats and loss of marsh. In turn, the loss of marsh in front of the levees has allowed larger waves to reach and erode the levees.

Most restoration projects in San Francisco Bay are subsided sites separated from the Bay or slough by levees. The levees fronting marshes and mudflats play important, but poorly understood, roles in the evolution of restored sites and in flood management. The bayfront levee blocks tidal flows across the marsh but also blocks the movement of sediment, organic plant material, and detritus that would otherwise move between the outboard mudflat and the marsh on spring tides or during storm surges. The bayfront levee and outboard marsh may provide protection to the evolving site from the erosive effects of waves, allowing sedimentation to occur within the site and protect-

At the same time that sea level rise is creating a demand for more sediment, the construction of bayfront levees has restricted the transgression of the system, potentially reducing the availability of sediment to the marshes.

Top: This diagram shows a levee dividing the baylands from the Bay. Inboard of the levee is a subsided site which, through some combination of filling and natural processes, will sediment up to colonization elevation. The levee protects the site during its early evolution allowing sediment to build up and vegetation to establish. However, outboard of the levee the natural forces of the Bay are still at work. The sweep zone continues to erode, the sweep zone profile lowers, and the edge of any outboard marsh is eroded. The levee prevents the landward transgression of the profile. The mudflats and marsh are "squeezed" between the rising Bay water and the levees, resulting in erosion of the mudflats and loss of marsh. In turn, the loss of marsh and mudflat in front of the levees allows larger waves to reach the levees and causes the toes of the levees to be undermined.

Bottom: If the erosion of the levee continues, and the levee eventually fails, the sweep zone-marsh system is reconnected. The sweep zone profile is now much lower and the marsh edge too far seaward, and exposed to greater wave action. The consequence of this is rapid erosion of the marsh edge to reestablish the equilibrium profile.

ing the inboard levee until marsh vegetation can colonize. Therefore, there is a tradeoff between leaving the levee in place to provide sufficient protection from waves and reconnecting the geomorphic unit and ecological processes so that the restored marsh, outboard marsh, and mudflat are sustainable.

San Francisco Bay marshes have handled historic sea level rises well. But sea level rise will accelerate. Will the marshes keep up? As the waters rise, mudflat and marsh systems tend to move landward—if enough sediment is available. In the long-term, we may need to recharge mudflats with dredge soil.

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Dredged Sediments, Cleaned Contaminated Sediments, and Creative Wetland Restoration Solutions

NAOMIE FEGER, San Francisco Bay Regional Water Quality Control Board
ROGER LEVENTHAL, FarWest Restoration Engineering

The San Francisco Bay Regional Water Quality Control Board has made significant progress during the last decade on two fronts: addressing "toxic hot spots" remediation along the margins of San Francisco Bay and promoting the beneficial reuse of dredged sediment. Remediation of contaminated sediment hot spots presents significant challenges from multiple perspectives. Many of the Bay "toxic hot spot" cleanups are associated with existing wetlands or planned wetland restoration projects and thus must meet stringent cleanup standards to protect endangered species. Cleanup actions can be constrained by potential impacts to existing endangered species, complicating the execution of any remedial action. Restoration project designs that include the beneficial reuse of dredged sediments are not always popular, yet they can present advantages where cleanup is necessary and may lead to the inadvertent creation of endangered species habitat.

Recent projects using dredged sediments for tidal marsh and seasonal wetland restoration include the Montezuma and Hamilton restoration projects, and the Bair Island restoration projects, which used a combination of dredged sediments and upland soils for creating tidal marsh habitats.

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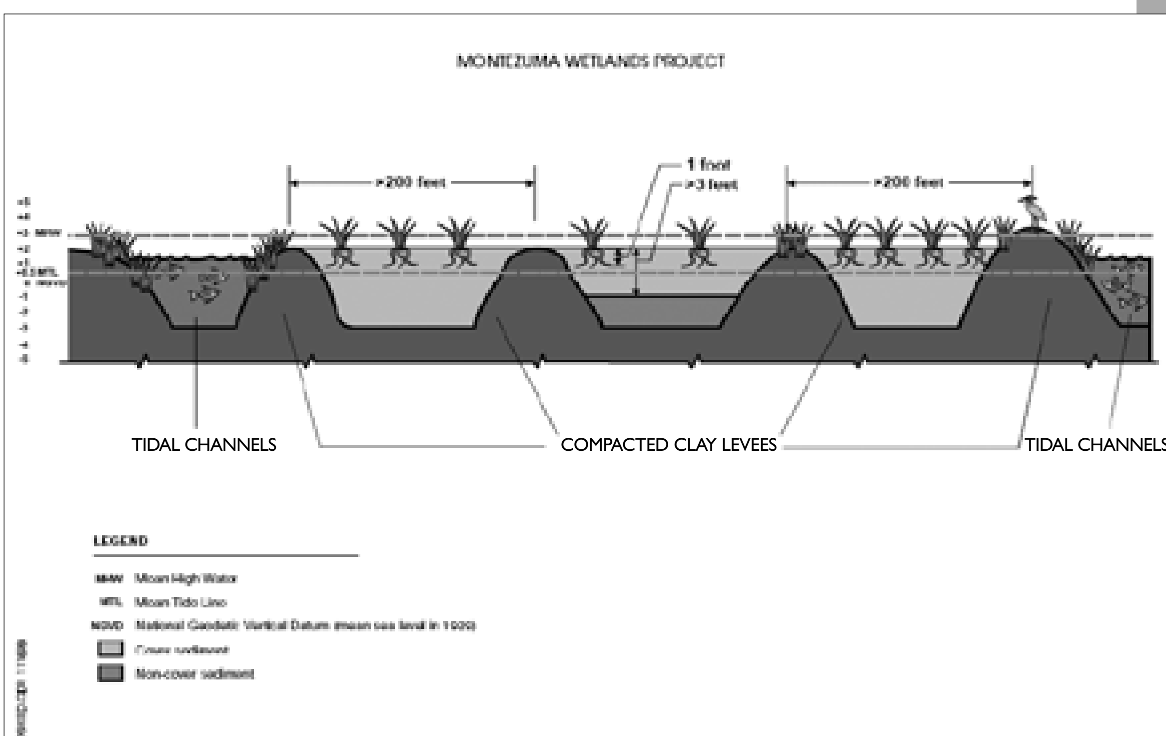
SCHEMATIC CROSS-SECTION OF NON-COVER SEDIMENT ISOLATION



Effects of Inundation and Salinity on Tidal Marsh Vegetation

TOM PARKER ET AL.
San Francisco State University

Climate change models for the San Francisco Bay-Delta Estuary predict increased salinity and inundation due to reduced freshwater inflows from the Bay-Delta watershed and increased rates of sea level rise, both likely to cause a considerably negative impact on wetland biodiversity and productivity. Our recent research at six sites across the North Bay and Delta indicate that inundation is a much better predictor of tidal marsh plant distributions than elevation alone. Plant species richness increased from 10 to 20 species in Bay salt marshes to over 100 species in freshwater tidal systems. Similarly, end-of-year biomass increased from 600-800 to 2,500 g C/m^2/yr from salt marshes to Delta freshwater tidal marshes. As a way of investigating more specific impacts from climate change, we evaluated changes in pickleweed (*Sarcocornia pacifica*) productivity along a salinity gradient in the Bay. Within three marshes, plots were established near channels with good drainage and in poorly drained sites away from channels. We found that increases in soil pore salinity had no measurable effect on plants near channels but had a strongly negative impact on productivity in poorly drained plots. Taken together, these results suggest that, for the most salt tolerant plant species in San Francisco Bay, increases in inundation greatly increase sensitivity to salinity, implying that primary productivity will diminish at faster rates than expected. These changes could cascade into terrestrial and pelagic animal communities linked to wetlands.

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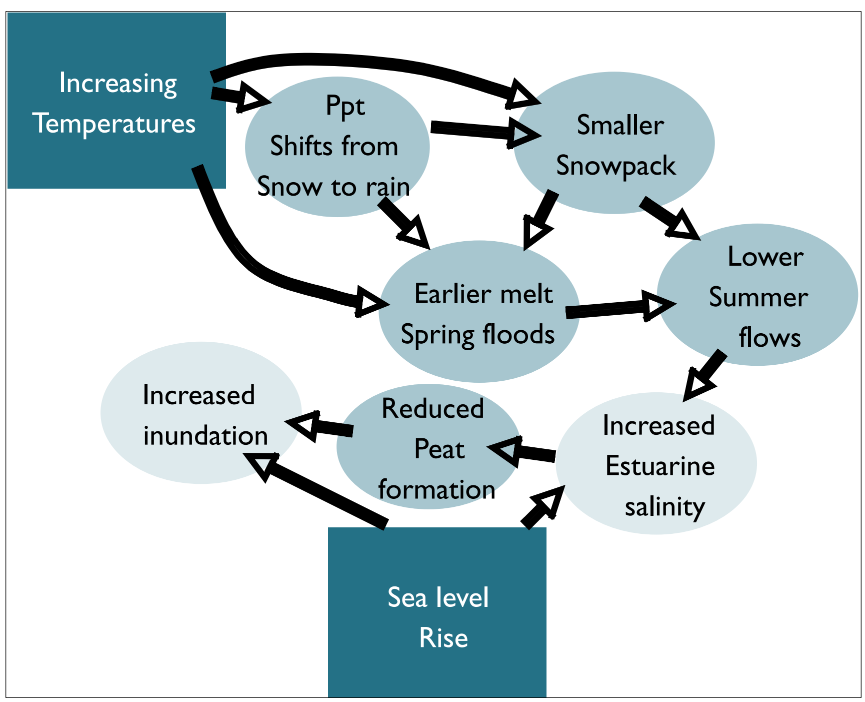
TAKE HOME POINTS

- Reducing the rate of change in wetlands depends on maintaining or enhancing freshwater flows into the Delta in the summer/fall periods (levee protection, less diversion).
- Restoring new marshes sooner might increase their likelihood of long-term success and persistence.

Sarcocornia pacifica

GLOBAL WARMING IMPACT ON SF BAY-DELTA

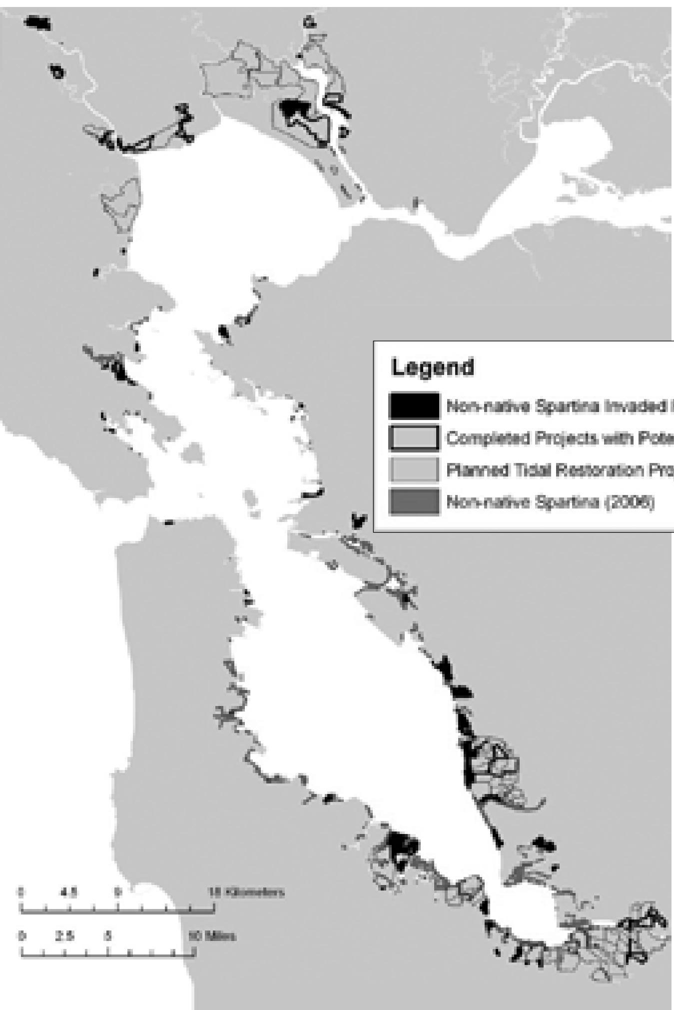


Invasive *Spartina* Control: Clearing The Way For Tidal Marsh Restoration

PEGGY OLOFSON
San Francisco Estuary Invasive Spartina Project

A historical review of tidal marsh restoration in southern and central San Francisco Bay shows that where tidal flows are restored, invasive hybrid *Spartina* soon follows. The data suggest that tidal marsh restoration has even accelerated the spread of invasive *Spartina*. The soft, open sediment and quiescent hydrology of newly opened diked ponds are ideal nurseries for hybrid *Spartina*, which can become established and start spreading seed long before any other type of vegetation appears. Efforts to "design around" invasive *Spartina*, by moving the tidal breach away from hybrid *Spartina* patches or by steepening the channel banks to reduce "optimal" seedling habitat, have proven futile—nearly all sites were quickly invaded, and most became dominated by hybrid *Spartina*.

Recognizing the unacceptable effect of hybrid *Spartina* on tidal marsh habitat, and the looming threat to planned major restoration in the South Bay, the State Coastal Conservancy initiated a regional plan of control and eradication in 2000. The San Francisco Estuary Invasive *Spartina* Project systematically mapped and developed control strategies for every non-native *Spartina* population in the Bay (now more than 140 sites), acquired environmental authorizations, developed extensive partnerships, and began implementing aggressive control in 2005. In 2006 and 2007, the control program treated more than 1,600 net acres of *Spartina* (more than 98% of the Bay-wide population), and showed remarkable efficacy (60-90% killed). Unfortunately, in the last two years, the plant has also spread into two newly opened restoration sites in the East Bay, and into a small portion of the Petaluma River. Nevertheless, barring additional expansion into new areas, the Invasive *Spartina* Project expects to achieve eradication of all visible populations of non-native *Spartina* by 2011.



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TAKE HOME POINTS

- New tidal restoration projects in the vicinity of seed-producing hybrid *Spartina* have an extremely high likelihood of becoming invaded by the hybrids and then becoming mass exporters of seed and propagules to other locations, including other restoration projects.
- Restoration proponents can reduce the risk of project invasion by following "best practices" developed by the ISP, in collaboration with USFWS, DFG and others.

  These practices include

  1. not opening new projects too near hybrid *Spartina*
  2. not planting non-native *Spartina* species
  3. verifying the genetics of native *Spartina* and not planting native *Spartina* if it could be pollinated by hybrid pollen
  4. rigorously monitoring new projects and removing any non-native *Spartina*
  5. making sure equipment and dredged materials are free from *Spartina* seed and fragments. **Complete practices can be found at *www.Spartina.org*.**
- The ISP staff is available to advise and assist project planners in assessing invasion risk and developing site-specific procedures. Call 510-548-2461 or email project specifics to info@*Spartina*.org.
- With the work of *Spartina* Project partners and the cooperation and assistance of the restoration community, we can clear the way for a future of successful, large-scale restoration, unimpeded by invasive *Spartina*!

Determinism, Chaos, and Randomness: Restoring Delta Ecosystems

STUART SIEGEL ET AL.
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Possibilities? Needs? Wants? Restoring Delta ecosystem functions is complex and uncertain yet possible. Restoring habitats and key processes and reducing stressors comprise the triad necessary to "fix" the Delta. Because the Delta of the past cannot be restored and it is not possible for the Delta to become all things to all people and all organisms, we must consider the probabilities and bounding conditions to frame our visions.

Drivers of ecosystem restoration complexity and uncertainty fall into three categories. Delta services—water supply, agriculture, recreation, flood management, transportation, utilities, and typically last, ecosystem—create competing demands and major constraints that require give-and-take and money to restore ecosystem functions. The intersection of natural processes and human-based stressors within and outside the Delta—water quality, subsidence, channel geometry, levee failures, invasive species, sea level rise, climate change, urbanization, seismicity, upstream water diversions, etc.—present major boundaries on restoration opportunities. Current planning efforts—Delta Vision, Bay Delta Conservation Plan, Ecosystem Restoration Program Conservation Strategy and the Delta Restoration Plan, Delta Risk Management Strategy, Pelagic Organism Decline Action Plan, and Recovery Plans—provide vital planning vehicles and raise the key question about establishing priorities.

Tidal restoration remains a clear priority though it will take decades to achieve its goals. The Delta's subsidence and low sediment supply means that most of the Delta is not feasible for restoration; we can restore tidal wetlands in certain perimeter areas only, even considering rapid peat accumulation of emergent vegetation. Sea level rise dictates the need for landscapes that can shift inland over time. The near total loss of historic Delta wetlands equates to no design templates. Other ecosystem types are also necessary to restore Delta ecosystem function: floodplains, riparian, and "green" levees. Water supply, entrainment, and food resources all must be addressed for effective ecosystem restoration.

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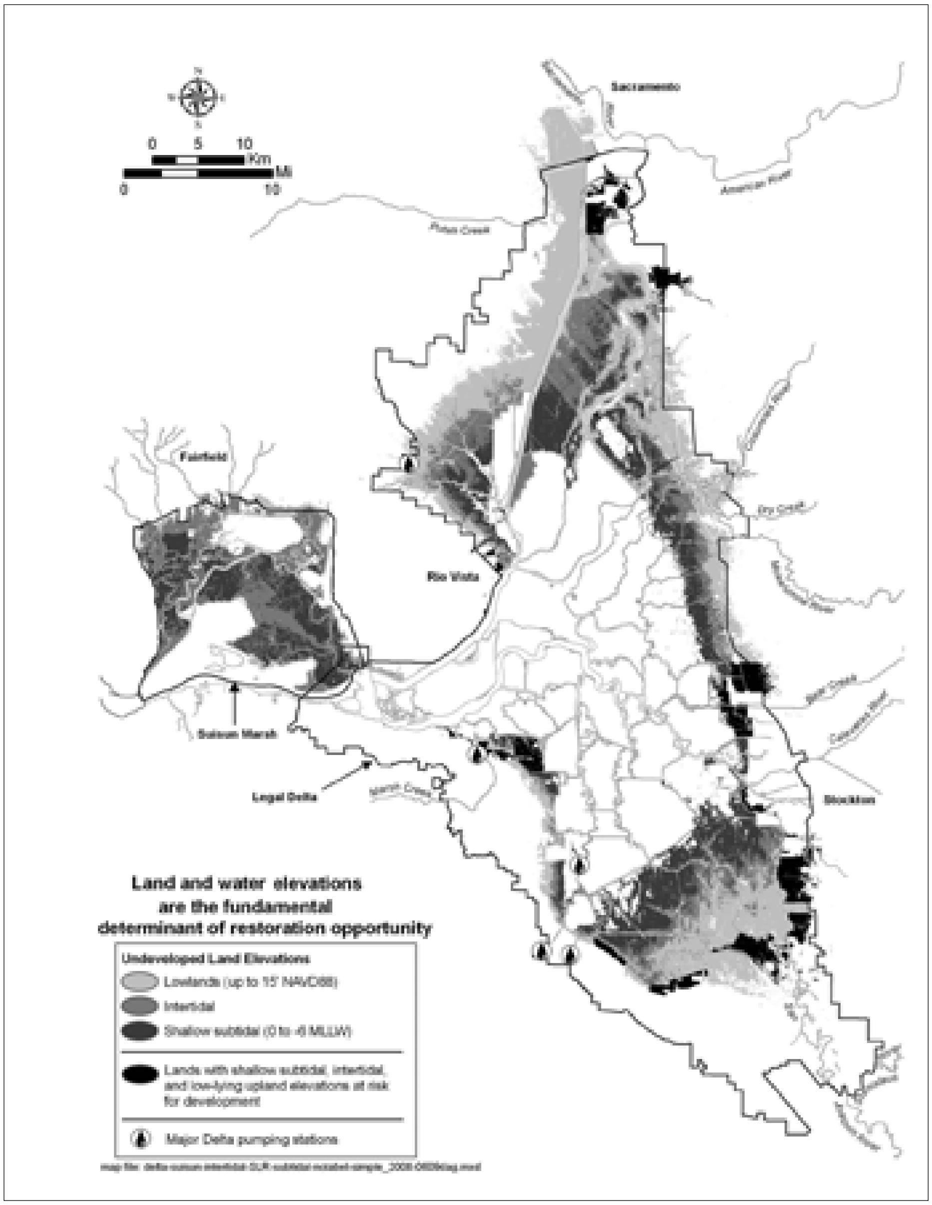
- **Determinism** = some aspects of the system will go in a well-understood direction UNLESS perturbed.
- **Chaos** = some aspects of the system could go in unpredictable directions IF perturbed.
- **Randomness** = drivers of change can be unpredictable in space, time, intensity.

ESTUARINE AND FLOODPLAIN RESTORATION OPPORTUNITY AREAS



Planning Ecosystems Based on Historical Landscapes

ROBIN GROSSINGER
San Francisco Estuary Institute

Historical data are essential for both understanding how ecosystems have changed through human land use and for identifying the full range of potential future scenarios. Using diverse historical records, a wide range of information about historical landscapes can be confidently reconstructed. These data often reveal that our current assumptions about the "appropriate" or "target" habitats for restoration are based more on relatively recent, disturbed conditions than actual pre-modification conditions. In contrast, spatially accurate maps of historical landscapes can help elucidate the relationship between native habitats and physical processes such as local topography, soils, and climate. Historical data can thus help us design new ecosystems based on an understanding of the natural controls on habitat form and function.

Through historical ecology research in the San Francisco Bay area, scientists are recognizing that a diverse range of natural stream, riparian, and wetland functions have been tended to be overlooked because of their early modification. Many watersheds had large, mid-elevation wetlands that trapped fine sediment, maintained base flow, and provided calories for juvenile salmonids. Some streams that are currently being managed for perennial flow using imported water were largely intermittent under natural conditions, with associated native species assemblages. Some riparian habitats, such as the now-rare sycamore alluvial woodland, have experienced disproportionate decline and may be more appropriate restoration targets in some places given likely future climate scenarios. Similarly, floodplain sloughs are a significant missing element on some streams but not others. Information from historical landscapes can help explain the limitations of current conditions and provide new management options for contemporary watershed management.

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A rare sycamore alluvial woodland

Restoration in South San Francisco Bay

CLYDE MORRIS
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The South San Francisco Bay has a long history of restoration that includes some fairly old but significant projects such as the creation of Coyote Creek Lagoon in south Fremont, Coyote Creek salt marsh restored by the Santa Clara Valley Water District, the Don Edwards San Francisco Bay National Wildlife Refuge's (Refuge) restoration of La Riviere Marsh in Fremont, and Cargill's restoration of the Whale's Tail in Hayward. The Coyote Creek Lagoon project is one of the longest continuously monitored restoration projects in the Bay Area.

More recent restoration projects include the Mid-Peninsula Open Space District's tidal restoration of the Cooley Landing pond and the Refuge's 2005 restoration of the former Cargill Island Ponds in cooperation with the Santa Clara Valley Water District. Catellus's creation of vernal pools for three endangered species in the Warm Springs area of the Refuge has greatly expanded this resource, which is rare in the South Bay.

More recent projects have demonstrated changing approaches to restoration in the Bay Area. We are no longer just focused on projects as compensatory mitigation but have turned toward restoration to achieve all the intrinsic values wetlands offer society. We have also moved beyond just trial-and-error efforts, as knee-jerk management has been replaced with true adaptive management. The South Bay Salt Pond Restoration Project led by the California Coastal Conservancy, California Department of Fish and Game, and the Refuge is planning the restoration of 15,100 acres of salt ponds over the next 50 years, with 2,940 acres of tidal marsh and 710 acres of managed ponds to be established in the near future. The project's science team has developed specific studies to be conducted as a part of the Phase 1 projects to address key uncertainties such as bird use in reconfigured ponds, wildlife response to public access, and legacy mercury in Bay muds. Results of these studies will help us to better plan future projects.

Bair Island restoration of 1,400 acres by the Department of Fish and Game and the Refuge has finally begun, thanks to a long list of partners. Although this project has confirmed the long held theory of the strength of partnership, it has some new twists too. Beneficial reuse of dredge material to restore Inner Bair Island is on schedule. Charging construction companies for the discharge of clean fill for restoration of tidal marsh may be just the ticket for funding future restoration of subsided ponds.

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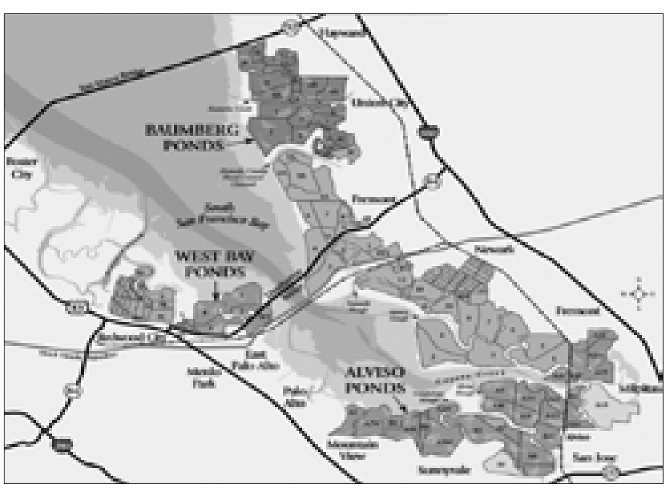
SOUTH BAY SALT POND RESTORATION PROJECT



TAKE HOME POINTS

- Restoration has evolved from simply fulfilling compensatory mitigation requirements to meeting society's goals for improving water quality, flood protection, wildlife conservation, and wildlife viewing.
- We have a long (20 plus years) history of a variety of wetland restoration projects, from tidal marsh to vernal pools to salt pans for snowy plovers.
- Many of these projects have been monitored, some for decades, and the results made available for us to learn from. Our monitoring techniques have evolved from a focus on meeting permit requirements to studies designed to learn how to do it better.
- We are moving from mitigation projects consisting of small patches to large scale restoration opportunities.
- We are now using true adaptive management instead of just talking about it. We identify key uncertainties that may impede us from meeting our restoration goals and are designing studies into the restoration projects to address these uncertainties.
- Funding for adaptive management is more challenging to obtain then other types of restoration funding. We need to commit to not allowing future large scale restoration such as is proposed with the South Bay Salt Pond Restoration Project without assuring funding for studies to address key uncertainties, which will allow for true adaptive management.

Tidal Restoration and Enhancement on San Pablo Bay National Wildlife Refuge

CHRISTY SMITH
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The San Pablo Bay National Wildlife Refuge encompasses 13,190 acres of open bay, slough, tidal marsh, and seasonal wetlands in the northern portion of the San Francisco Bay Estuary. Restoration and enhancement activities of these areas range from treatment of invasive non-native plants, limited mosquito control, improvement of tidal exchange, and complete tidal restoration planning. Our work involves partners including other landowners or agencies. Lower Tubbs Island and Lower Tubbs Setback taught the Refuge many lessons that are being used to plan the Cullinan Ranch tidal restoration.

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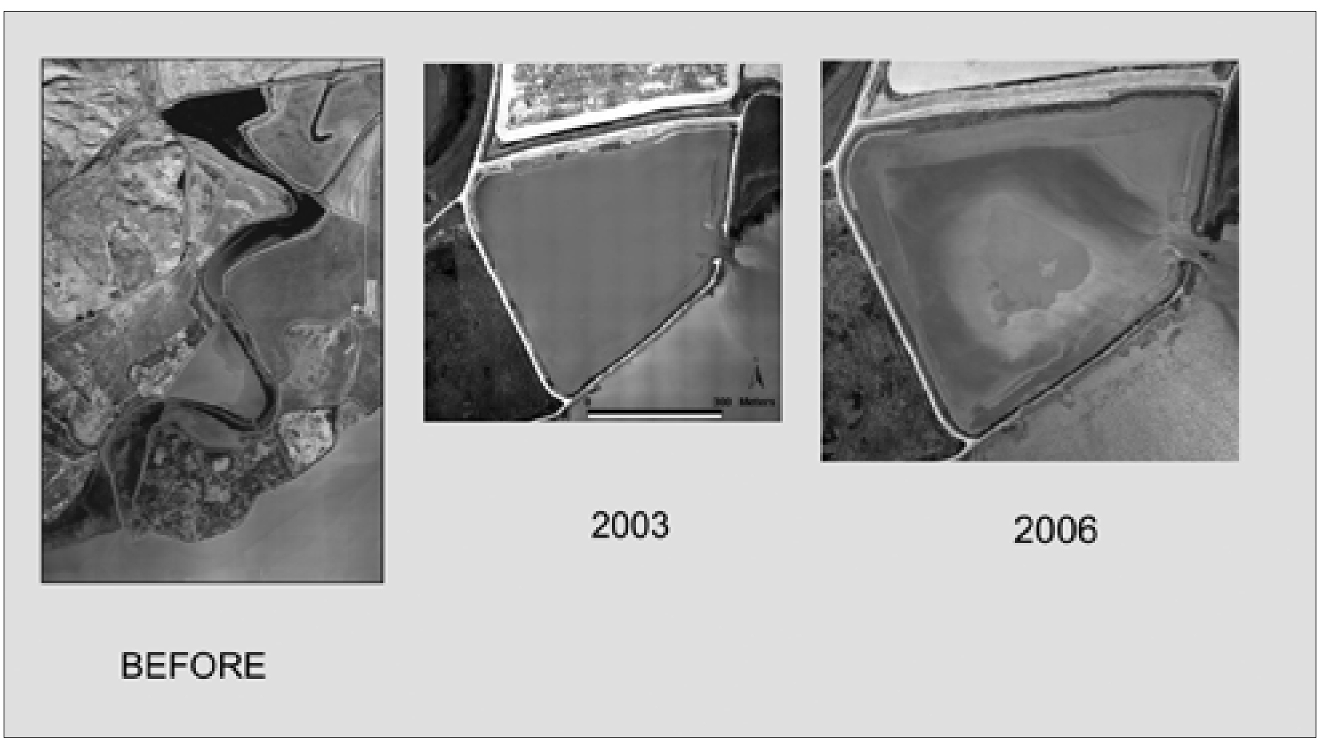
LESSONS LEARNED

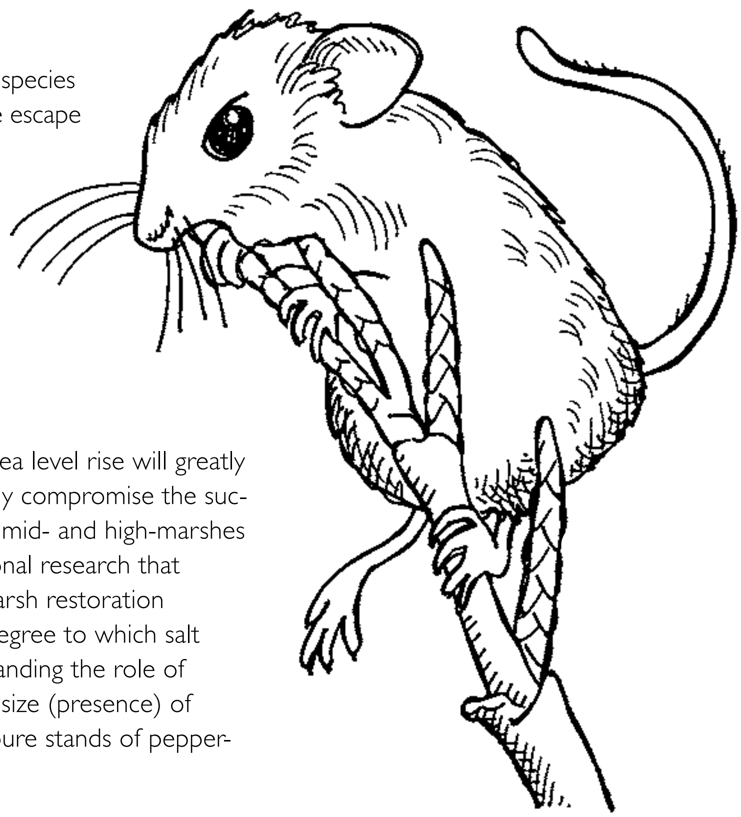
- Use adaptive management.
- Keep partners involved.
- Seek additional information: Throughout the planning process, scoping process, and all processes, remain open and ready to receive new information and/or ideas and be prepared to modify, adapt, or change things within the project as needed. The entire process should be about learning, adapting, and bringing the best available and most current knowledge, science, and experience to the table. In cases where the project cannot be changed, adapted, or modified, communications and messages should be continually fine-tuned to better articulate the project and its issues.

TUBBS ISLAND SETBACK: TIDAL RESTORATION



Small Mammals and the Success of Salt Marsh Restoration Projects

HOWARD SHELLHAMMER
H.T. Harvey and Associates



Small mammals (salt marsh harvest mice and various species of shrews) depend on higher marsh zones and adequate escape cover, both of which are reduced or lacking in much of San Francisco Bay, especially in the South Bay. Salt marsh harvest mice need large, deep, mature, salt marshes with internal escape cover and high marsh zones that provide escape cover at the upper edge. Salt marsh wandering shrews need the high and higher half of the middle (pickleweed) marsh, as well as debris and wrack.

Restoration projects that produce more pickleweed zones and escape cover will serve these species best. Sea level rise will greatly impact both of these marsh components and potentially compromise the success of marsh restoration projects. The sustainability of mid- and high-marshes during the rise of sea level needs to be studied. Additional research that needs to be done includes evaluating the success of marsh restoration projects, particularly in the South Bay, to find out the degree to which salt marsh harvest mice use brackish marshes; and understanding the role of the higher marsh zone in brackish marshes, population size (presence) of shrews, both pre- and post-restoration, and effects of pure stands of peppergrass on salt marsh harvest mice.

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A draft recovery plan with good mouse architecture would include:

- Marsh complexes of at least 1,000 acres in size.
- Broad connections between viable habitat areas within marsh complexes allowing for movement of mice.
- Mid-marsh or pickleweed zone 200 meters deep or more, maturing over time to support internal escape cover along smaller internal channels.
- Outboard dikes with 10 to 1 slope on outboard sides to provide escape cover at the upper edges of the marshes.

Avian Demographic Parameters and Tidal Marsh Restoration Success

NADAV NUR and
MARK HERZOG
PRBO Conservation Science
ANITRA PAWLEY
Stillwater Sciences

Restoration of tidal marsh habitat is a high priority for government agencies, non-governmental organizations, and multi-partner collaborative efforts, such as the San Francisco Bay Joint Venture. Many restoration projects are underway or planned throughout the San Francisco Estuary, and some have already been completed. There is a critical need for metrics of restoration success that can be applied to these projects, both at the single-site level, and at a broader, programmatic level. Developing informative and effective metrics will be of great value in designing restoration projects at both local and Bay-wide scales, and in evaluating projects while they are underway so as to contribute to adaptive management of these projects. In addition, these metrics can inform decisions regarding the role of restoration in the context of larger programs that may incorporate mixed land uses (e.g., the decision between restoration and enhancement).

We have developed a framework for the collection and evaluation of monitoring data of birds that incorporates different spatial and temporal scales, using current projects throughout the San Francisco Bay/Delta region. Our approach is both hierarchical and integrated, in which some metrics are collected with broad spatial coverage (e.g., species presence or absence), while other metrics pertain to estimates of demographic parameters, requiring more intensive fieldwork at fewer sites. We focus on population trends and the proximate and ultimate factors that influence and collectively determine trends in abundance and in presence of species. Reproductive success serves as an important component of population change, one that reflects local (site-specific) conditions, as well as broadscale influences (e.g., due to climate variability). In addition, one can determine critical baseline values of reproductive success that are required to maintain target populations. Data on tidal marsh song sparrows at newly restored and mature sites provide an example of our demographic-based monitoring approach, which is applicable at the regional scale as well. Among our findings, song sparrow nest survival rates at restoration sites were as high or higher than those observed at mature sites. At some marshes (including restoration sites), nest survival met the minimum requirement necessary to maintain population stability. Using information collected at an earlier stage to refine the sampling design and/or effort and fine-tune benchmark values of parameters, we can build an adaptive approach into the monitoring process. Less-intensive population metrics may be more appropriate for monitoring clapper rails and other tidal marsh-dependent species.

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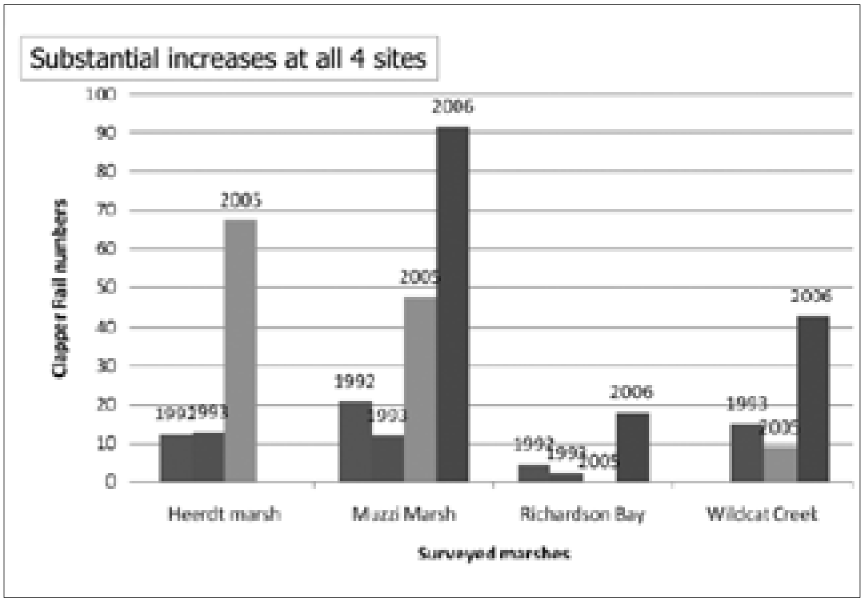
TAKE HOME POINTS

- It's important to determine whether restoration sites are population sources or sinks. One of two restoration sites studied appears to function as a population source.
- Sites differ in bird population response: not all mature sites are alike; neither are all restoration sites.
- Different metrics work best for different species: presence/absence for clapper rail; abundance for common yellowthroat; nest success for song sparrow.
- Monitoring an important parameter such as nest success can be more cost-effective than complete demographic studies.

CLAPPER RAIL COMPARISONS: 1992/1993 vs. 2005/2006



San Francisco Bay Area Upland Habitat Goals

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Land Conservation Services

STUART WEISS
Creekside Center For Earth Observation

RYAN BRANCIFORTE
Greeninfo Network

The San Francisco Bay Area Upland Habitat Goals Project, modeled after the successful San Francisco Baylands Ecosystem Goals Project, is determining how many acres of what types of habitats—and in what configuration—are necessary to preserve biodiversity in the nine-county Bay Area. Initiated by the Bay Area Open Space Council to address the lack of a scientific vision for biodiversity preservation, the Upland Goals Project will recommend a network of conservation lands that will include existing protected lands (lands permanently protected by fee or conservation easement ownership by public agencies or conservation nonprofits for natural resource protection) as well as additional lands proposed for conservation. The project applies the coarse filter/fine filter approach to conservation planning. The coarse filter analysis sets protection goals for all vegetation types while the fine filter analysis selects specific conservation targets to refine the coarse filter recommendations. The project is using conservation-planning software supplemented with expert opinion to arrive at conservation land network options. The final report will not only make recommendations for habitat protection goals but will also address stewardship, implementation strategy, research needs, and evaluation criteria. The planning process will create a framework to allow for the goals to be updated as new data become available and progress is made in accomplishing the goals or finer-scale planning is desired. The GIS database compiled for the Upland Goals Project is available via the Internet at http://openspacecouncil.org/projects/upland/download.

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Coastal scrub

Where Do We Go with the Baylands Ecosystem Habitat Goals?

CARL WILCOX
California Department of Fish and Game

The completion of the Baylands Ecosystem Habitat Goals Project in 1999 was a milestone for the Bay. It was an articulation of a blueprint for restoration of the Bay shoreline, reconnecting uplands with the Bay. The Goals strove to provide a biologically based vision for ecosystem restoration to address the competing needs of tidal marsh dependent species and those species that had come to use the habitats provided by diked baylands. Since that time, habitat acquisition and restoration efforts have accelerated, with the Napa Salt Ponds, Eden Landing Ecological Reserve Restoration, Bair Island, South Bay Salt Pond Restoration, and other projects all helping to complete the mosaic anticipated in the Goals Project. As the Goals Project nears its 10th anniversary, we should review it in light of new knowledge acquired since it was initially written, perhaps in a workshop venue. It should also be linked with other regional efforts such as subtidal, upland, and riparian goals, as well as CALFED's Ecosystem Restoration Program.

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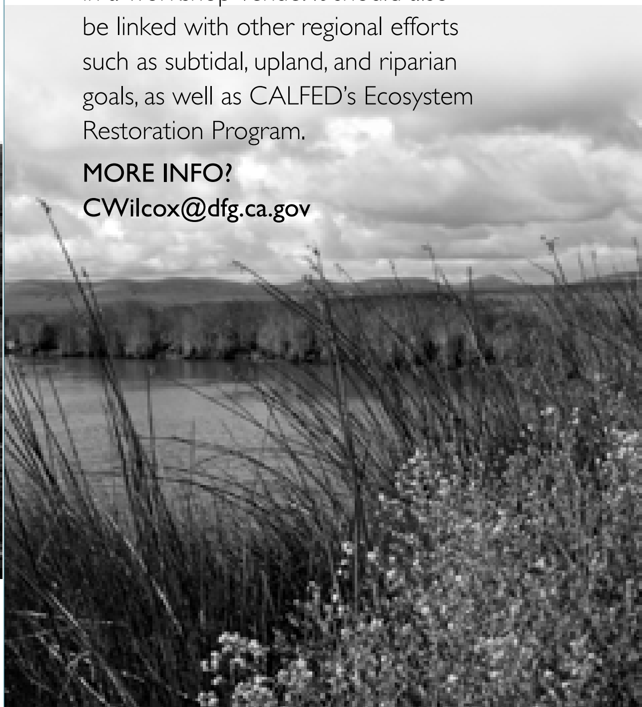

Hidden Bay Habitats: The Subtidal Habitat Goals Project

KORIE SCHAEFFER
NOAA Fisheries
CAITLIN SWEENEY
Bay Conservation and Development Commission

The subtidal habitats of San Francisco Bay face numerous pressures. Human uses such as fishing, marinas, shipping and ports, dredging, sand mining, transportation projects, recreational use, and industrial uses have direct impacts on Bay subtidal habitats. Subtidal habitats are also threatened by non-native species and other systemic alterations such as bathymetric changes, water control in the Delta, and both point and nonpoint source pollution. As a result of these and other impacts, habitats have been degraded or lost and native species are in decline. These pressures are creating an increased need to develop a plan to protect and enhance subtidal resources within San Francisco Bay.

The San Francisco Bay Subtidal Habitat Goals Project will establish a comprehensive and long-term vision for research, restoration, and management of the subtidal habitats of the San Francisco Bay. The primary product of the Subtidal Habitat Goals Project will be a document that provides recommendations and goals for protection, restoration, and research to improve subtidal habitat management in San Francisco Bay. Resource managers will be able to use the resulting document to make informed decisions; restoration advocates will be able to prioritize restoration activities and pursue funding for subtidal restoration projects; and researchers will be able to prioritize research and monitoring needs and pursue funding for subtidal projects.

The San Francisco Bay Subtidal Habitat Goals Project is a collaborative interagency effort between BCDC, the California Coastal Conservancy, National Oceanic and Atmospheric Administration (NOAA), and the San Francisco Estuary Project.

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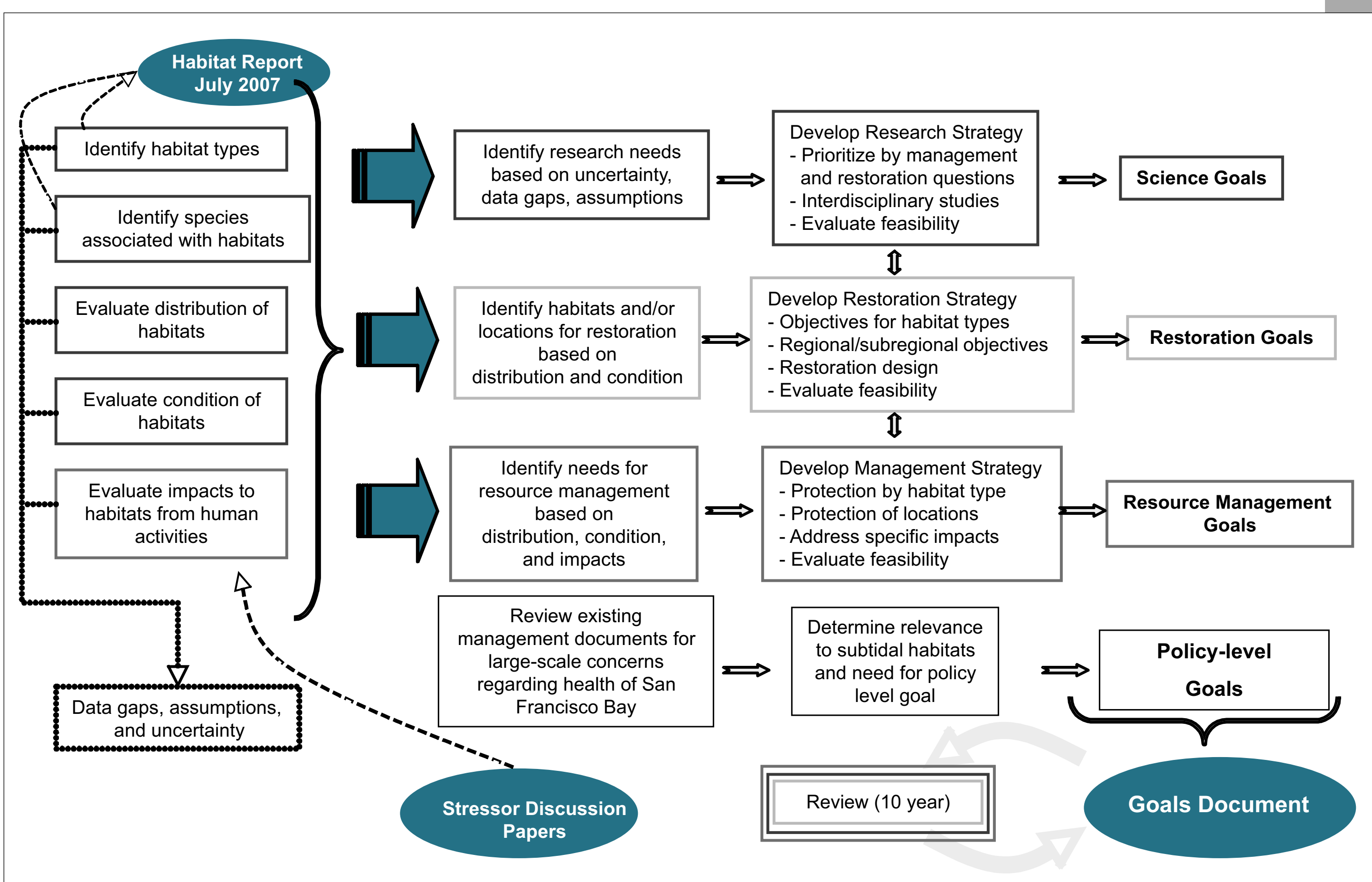
PROCESS FOR DEVELOPING SUBTIDAL HABITAT GOALS

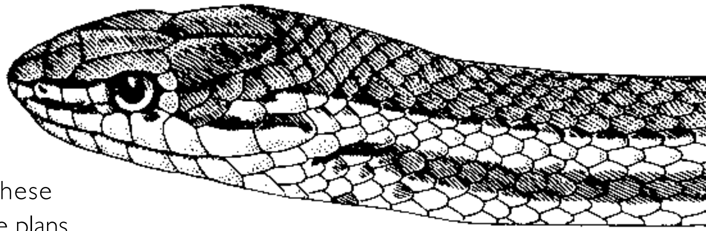


Turning Conflict into Cooperation: Bay Area Habitat Conservation Planning

ERIC TATTERSALL ET AL.
U.S. Fish and Wildlife Service

Multi-species Habitat Conservation Plans (HCP) and their state counterpart Natural Community Conservation Plans (NCCP) are tools for creating community based conservation plans that contribute to the recovery of state and federally listed plant and animal species while providing for orderly and streamlined development within the planning area. They are designed to provide for landscape scale conservation instead of mitigation on a project-by-project basis. The first HCP in the nation was completed in the Bay Area for San Bruno Mountain in the mid 1980s. Currently there are three HCP/NCCPs in preparation or completed in the Bay Area.

On July 25, 2007, permits under the state and federal endangered species acts were issued to the cities of Pittsburg, Clayton, Brentwood, and Oakley, and Contra Costa County for the East Contra Costa County HCP/NCCP with broad landowner, environmental group, and developer support. The plan covers 225,000 acres and authorizes up to 15,000 acres of development while protecting and managing 30,000 acres of habitat and open space for the San Joaquin kit fox, California red-legged frog, California tiger salamander, Alameda whipsnake, and 25 other species. Similar plans are currently underway in Solano and Santa Clara Counties. These multi-species landscape scale plans are sponsored by local governments and are community based planning processes involving a broad array of development, environmental group, landowner, and other interested stakeholders in the affected area.



California Department of Fish and Game

Successful development requires commitment by local governmental leaders and strong public involvement along with state and federal resource agencies. More recently significant progress has been made toward melding wetland permitting into the plans to provide enhanced wetland conservation and added permit streamlining.

While development of HCP/NCCPs can often be a time consuming process, issuance of permits is not the end: it is only the beginning, as these plans have 30-50 year life spans. They take ongoing active involvement of all of the interested parties to ensure successful implementation through adaptive management.

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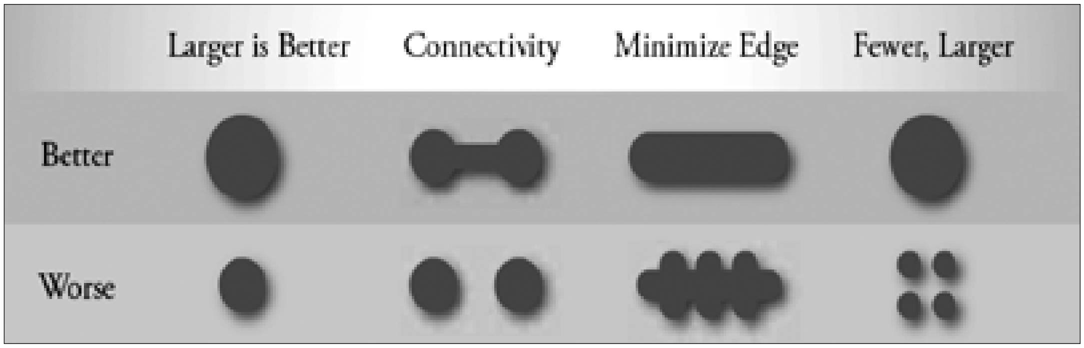
CONSERVATION BIOLOGY 101



The science of conservation biology has important principles that were used to design the proposed HCP/NCCP preserve system. Examples of these principles are represented in the box.

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*Titles within Presentations and Posters are based on abstracts and posters submitted prior to the conference. Some details may have changed since then: see abstracts for updates.

ACRONYM KEY

ABAG: Association of Bay Area Governments

BCDC: (San Francisco) Bay Conservation and Development Commission

CALFED: CALFED Bay-Delta Program

CCC: California Coastal Conservancy

CEMAR: Center for Ecosystem Management and Restoration

CEQA: California Environmental Quality Act

CSU: California State University

CVP: Central Valley Project

CVRWQCB: Central Valley Regional Water Quality Control Board

DFG or Cal Fish & Game: California Department of Fish and Game

DHS: California Department of Health Services

DWR: California Department of Water Resources

EBMUD: East Bay Municipal Utility District

GGNRA: Golden Gate National Recreation Area

HSU: Humboldt State University

IEP: Interagency Ecological Program

IRWM: Integrated Regional Wetland Monitoring Program

ISP: Invasive Spartina Project

MLML: Moss Landing Marine Lab

MTC: Metropolitan Transportation Commission

MWD: Metropolitan Water District of Southern California

NEPA: National Environmental Policy Act

NMFS: National Marine Fisheries Service

NOAA: National Oceanic and Atmospheric Administration

NOS: National Ocean Service

OEHHA: California Office of Environmental Health Hazard Assessment

PBDE: Polybrominated Diphenyl Ether

PEEIR: Pacific Estuarine Ecosystem Indicator Research

PRBO: PRBO Conservation Science, formerly Point Reyes Bird Observatory

PWA: Philip Williams & Associates

RCD: Resource Conservation District

SJSU: San Jose State University

SBSP: South Bay Salt Pond Restoration Project

SFBBO: San Francisco Bay Bird Observatory

SFBCDC: San Francisco Bay Conservation and Development Commission

SFBJV: San Francisco Bay Joint Venture

SFBRWQCB: San Francisco Bay Regional Water Quality Control Board

SFEI: San Francisco Estuary Institute

SFEP: San Francisco Estuary Project

SFSU: San Francisco State University

STRAW: Students and Teachers Restoring a Watershed

SUNY: State University of New York

SWP: State Water Project

SWRQB: State Water Resources Control Board

TBI: The Bay Institute

TMDL: Total Maximum Daily Load

UC: University of California

USF: University of San Francisco

USACOE: United States Army Corps of Engineers

USBR: United States Bureau of Reclamation

USDA: United States Department of Agriculture

USEPA: United States Environmental Protection Agency

USFWS and/or U.S. Fish and Wildlife: United States Fish and Wildlife Service

USGS: United States Geological Survey

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A NOTE TO STATE OF THE ESTUARY CONFERENCE PARTICIPANTS

This report includes a mixture of original unpublished and published research presented at the October 2007 State of the Estuary (SOE) conference.

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