What's Next?

Results from this assessment reveal a complex picture of Bay health. Some indicators show that aspects of Bay health are stable or improving slowly while others show declining trends. Clearly, work remains to "achieve and maintain an ecologically diverse and productive natural estuarine system" as envisioned in 1993 in the Comprehensive Conservation and Management Plan for the San Francisco Bay Estuary (CCMP). The members of the San Francisco Estuary Partnership remain committed to this goal as we continue to implement the actions called for in the CCMP. We also see opportunities to measure and evaluate that health more effectively, and to strengthen the integration of current monitoring and reporting efforts, both within the Bay proper and the Delta.

Continued work on improving Bay health

That significant additional actions will be needed to restore the Bay's health is not a surprise. It took many decades for the health of the Bay to reach its present compromised state, and

STRAW

RISE IMPACTS RAILS AND MICE MOST

While it has long been predicted that coastal areas and estuaries will be among the first to feel the effects of climate change and sea level rise, new USGS models show that sea level rise in the Bay could impact salt marshes sooner than thought—and that the endangered species that they are managed for—the California clapper rail, the black rail, and salt marsh harvest mouse—could suffer the most. The USGS study used RTK (Real Time Kinematic) GPS elevation data, plant community characteristics, and habitat information to develop sea level rise impact models for the San Pablo Bay National Wildlife Refuge. In contrast to most other models and maps, which are based on mean tides, USGS looked at what will happen during high tides. "If you're talking about animals, you need to talk about tidal cycles," says USGS's Karen Thorne. "Animals don't live in means—it's the extremes that matter." Thorne says the maps and models based on mean tides predict that the refuges around the Bay will be inundated in around 100 years. But the USGS model indicates a much shorter time frame: "Instead of being completely flooded by 1 meter of sea level rise, we're looking at a half meter where you'll have all of the refuge under water during high tides" says Thorne. "It's much more imminent than 2100."

Thorne says sea level rise will likely fragment habitat and make endangered species more vulnerable to predators, especially during the highest tides of the year. Right now those extreme events only happen a couple times a year, says Thorne, but as sea level rises, extreme events will happen more often. Thorne says USGS researchers have expanded their study to include 11 more marsh sites around San Francisco Bay, and found that some salt marsh patches are at much higher risk than others: a report was completed in July, 2011.* Thorne hopes her study will help resource managers save the rails and mice. "In San Francisco Bay resource managers really care; they're very concerned and surprised. They want to know what to do but they don't necessarily have the right information available to them." Thorne says that because the San Pablo Bay refuge is near so much open space, an obvious solution in that area is to acquire and/or preserve adjacent land on which the Bay can expand. The bottom line, she says, is that "if you're worried about endangered species, you need to take high tides into account."

A slightly different version of this article first appeared in ESTUARY NEWS, April 2011.

**Takekawa, J.Y., K. Thorne, K. Buffington. Program Summary Report: Sea-level rise modeling across the California salt marsh gradient for resource managers. Unpublished Report, USGS San Francisco Bay Estuary Field Station, Western Ecological Research Center. July 2011.*

VERNE NELSON

the most tractable problems were attended to first (e.g., polluted discharges from specific facilities). While a number of significant improvements have been made to Bay health during the past few decades, we are making slower progress on some of our most challenging problems, such as reducing pollution from urban and nonurban runoff. Funding for major public works projects has been increasingly difficult to secure, and so improvements to public infrastructure that might alleviate some of the most challenging problems have not always been feasible. Nonetheless, work is underway to green streets and cities, to use and reuse water more efficiently, and to continue to address pollution in our waterways.

As the community of agencies and organizations work around the region on major restoration efforts, we recognize that the pace of restoration can be slow and that it takes time for restored landscapes to reach their full potential as habitat. And while restoration funding and technical challenges will need to be addressed, the citizens of our region highly value the Bay, and we expect that the Bay Area will continue to be a national leader in habitat restoration.

Significant hurdles continue to stand in the way of reaching the CCMP goal of "increasing the amount of fresh water that flows into the Bay in most years." No clear path to achieving increased flows has yet emerged although efforts are now underway, both political and technical, to resolve aspects of this long-standing problem. The results of this analysis are consistent with previous evaluations and once again remind us that limited flows are having negative effects on the health of the Bay.

The San Francisco Estuary Partnership continues to implement the actions set out in the Comprehensive Conservation and Management Plan. The results of this report will assist efforts to focus on the most significant of those actions, help us make the best use of our resources, and provide a way to highlight the results of these efforts.

New and more refined health goals and indicators

While continued focus on long-term problems is vital, additional threats to the Bay's health continue to arise. The future condition of the Bay will be influenced by phenomena about which we are still learning—including climate change, the ecological impacts of species yet to be introduced to the Estuary, the impact of an aging pollution control infrastructure, and the influence of oceanic cycles such as the Pacific Decadal Oscillation or PDO.[26]

The Bay is also entering a new phase of sediment cycling and supply. After many decades of sediment building up on the Bay bottom from gold mining and other activities, the Bay is now showing signs of erosion. This could hamper wetlands restoration goals because accumulation of sediment is essential to building new wetlands and keeping existing wetlands from being drowned as sea level rises. Less sediment in the water allows for more light penetration, which could lead to algal blooms that impact Bay water quality and recreational opportunities.

Given these challenges and uncertainties, an ongoing assessment of how well we're doing the job is essential. We need thoughtful goals and benchmarks to help us map progress. We need indicators to help us track long-term physical changes so that we can continue to take the right steps to improve health and adapt to inevitable changes. We must clearly communicate to the public and to decision makers the condition of the Bay and present an accurate accounting of progress. This report delivers an essential snapshot of our understanding of the health of the ecosystem that can be used by scientists and resource managers in the future as they consider new information.

Future *State of the Bay* reports will be improved by refining existing indicators, developing new ones, and setting goals that can be used to evaluate those indicators (Table 7). For example, natural habitats—like wetlands, especially tidal marshes—that remove carbon dioxide from the atmosphere should be valued highly as the need to mitigate impacts from climate changes becomes clear to all. Understanding and tracking this ecological process will require new research to measure the movement of greenhouse gases into and out of different Bay habitats.

Table 7: Possible refinements for future *State of the Bay* reports.

INDICATOR REFINEMENT	RATIONALE
Carbon sequestration	Understand and measure Bay habitats as sources/sinks of greenhouse gases
Resilience to climate change	Understand if the Bay is becoming more or less capable of withstanding the expected stressors due to climate change
Sediment supply	Understand if there is enough sediment entering and circulating in the Bay to maintain and restore baylands
Nutrient cycling	Understand if processes that cycle nutrients through the Bay are being overwhelmed by human inputs
Aquatic resource restoration	Understand the extent and trends for restoration of eelgrass, oysters, and streams; add subtidal habitats goals and indicators
Watershed health	Improve and expand the use of current and new methods; go beyond the demonstration stage to assess regional watershed health; add upland habitat goals
Improved stewardship indicators	Improve existing stewardship indicators and develop additional measurements that highlight evolving public actions
Goals for existing indicators	Establish numeric goals for indicators such as the Fish Index or the Freshwater Flow Index to substitute for reference conditions that have not been subject to public debate

FISCAL AND REGULATORY CONSTRAINTS TO THE PACE OF HABITAT RESTORATION

Is the restoration of the Bay's habitats proceeding as fast as it should? If not, what constraints are slowing the process?

Funding, says San Francisco Bay Joint Venture coordinator Beth Huning, sets the pace of restoration. State bonds were a reliable source before the recent freeze. Federal stimulus funds channeled through NOAA helped deliver the South Bay Salt Pond and Napa Plant Site projects more quickly than initially projected.

Huning says a recent analysis for the San Francisco Foundation indicates that bond money will run out in about three years, with no new bonds in place. Congressional member requests for funding have ended with the elimination of the earmark system, leaving the budgeting process to federal agencies. As revenues decline, it will take more energy and strategy to match from multiple sources what was previously secured through direct appropriation or bond funding. That will make it difficult to maintain the recent pace of restoration.

Coastal ecologist Peter Baye, a long-time observer, sees current models of planning, budgeting, and implementing large restoration projects as products of the economic climate of the late 1990s and early 2000s, adapting slowly to recent economic decline. The resulting lag time could pose a challenge for large projects with long planning and implementation horizons, like Montezuma Wetlands.

Baye is also concerned that the feasibility of restoration may decline as sea level rise accelerates. He foresees a shift to projects with minimal flood-control costs relative to the size and importance of wetlands recovered, or selection of targets based on adjacent land use that is insensitive to flooding. Another adaptation might be providing habitat in more cost-efficient ways, such as reconnecting hydrology in existing muted marshes where limited tidal exchange occurs through culverts or small channels. However, Baye says some Fish and Game-led projects may already be as lean as possible under current regulatory and monitoring requirements.

Along with funding, the regulatory process can extend the timetable for restoration. Permitting can be time-consuming as project managers address endangered species and multiple jurisdictions. As Huning sees it, after the current group of restoration projects is delivered, it will be harder to deliver a second round of projects, due to declining funding.

MICHAEL BUKAY

Integration with other monitoring and reporting efforts within the Bay and Delta

The San Francisco Estuary Partnership plans to periodically produce *State of the Bay* reports and will refine and improve the methods and content of the report over time. Achieving these improvements will require the support and input of all the organizations that participate in the Partnership, and it will also require that the monitoring programs that generate the key datasets remain in place. Among these are the San Francisco Bay Program of the Department of Fish and Game and the Regional Monitoring Program for Water Quality managed by the San Francisco Estuary Institute (SFEI). Continuing these programs involves maintaining both the scientific expertise and the institutional support necessary to conduct the monitoring, analyze and report on the data, and maintain data archives so they may be used by future investigators.

Other evaluation reports, like SFEI's annual *Pulse of the Bay* and *Pulse of the Delta,* and The Bay Institute's *Ecological Scorecard* contribute significantly to Bay health assessment. We hope to strengthen the collaboration among these assessment programs as we work together toward an expanded "voice" for the health of the Bay.