RMP
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Update
REGIONAL MONITORING PROGRAM
FOR WATER QUALITY IN THE SAN FRANCISCO ESTUARY
A Cooperative Program Managed by the San Francisco Estuary Institute

INSIDE THIS UPDATE

The South Baylands Mercury Project:

Helping Managers Restore Tidal Marsh in the Face of Mercury Concerns

By Meredith Williams, meredith@sfei.org

Restoring large tracts of tidal marsh around San Francisco Bay will have wide-ranging benefits: flood control, endangered species habitat, Bay Trail recreation, and even sequestration of carbon and contaminants. As exciting as this is, the large restoration efforts in the Bay also create management challenges. Managers overseeing these efforts want to make sure to "do no harm" as they restore some salt ponds into thriving wetlands. One particular concern of managers – especially in the South Bay - is the possibility that restoration actions like breaching levees could increase mercury in the estuarine food web due to wetland processes. Managers need to be able to compare mercury conditions before and after marsh restoration. This comparison calls for monitoring by sampling mercury bioaccumulation in localized species (biosentinels) found specifically in salt ponds and tidal marsh. None of the previously employed biosentinels for the Bay ecosystem were marsh-specific. SFEI has added resident marsh species to the biosentinel tool kit to help meet the needs of South Baylands managers.

SFEI designed the South Baylands Mercury Project to give managers a monitoring tool for individual salt ponds and tidal marshes. The goal of the Project is to develop a mercury monitoring tool that will help managers make decisions about design and timing of their on-going restoration efforts. Within a marsh, there are habitats that differ in their abiotic and biotic characteristics. Consequently, methylmercury production may vary among these habitats. The team, therefore, designed a study to find appropriate biosentinel species for select marsh habitats: marsh plain, intertidal channel and panne (small ponds on the marsh plain). Several qualities are desirable in biosentinel species – they are widely distributed and abundant enough to ensure statistically significant sample size; they have small home ranges; they forage in one or just a few habitats; they are year-round marsh residents. Another consideration for the study was to target species that would be resident in salt ponds before restoration as well as in tidal marshes after restoration.

In this study, Pond A8 in the Alviso area of the South Bay is a planned restoration site. Currently, Pond A8 is a seasonal salt pond selected to be converted to tidal marsh. The ponds and the adjacent fringing marsh along Alviso Slough (just across the levee from Pond A8) are located at the base of the watershed that drains the historic New Almaden Mercury Mining District. The proximity to a known mercury source plus evidence that some wetlands are associated with high methylmercury production has managers concerned that the wetland restoration may increase mercury in the food web.

The South Baylands Mercury Project has targeted three primary marsh species. **Figure 1** illustrates the

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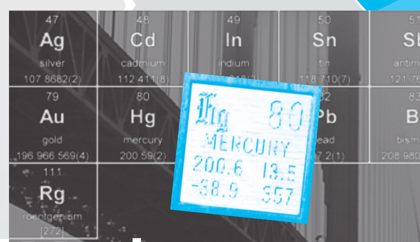

Modern Alchemy:

Tracking a Transformative Element in the Bay

By Glen Martin,
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San Francisco Bay and the Sacramento/San Joaquin River Delta constitute the largest estuary on the West Coast of North America. The Bay/Delta region is home to seven million people, serves several international ports, generates billions of dollars in agricultural products and contains the most sophisticated high technology complex in the nation.

The San Francisco Bay is also something else – a treasure trove of biological productivity. It supports a vast food web, ranging from phytoplankton to white sturgeon, Chinook salmon, harbor seals – even the occasional humpback whale. It is a nursery area for commercially important species such as Dungeness crab, and provides both recreation and food to anglers.

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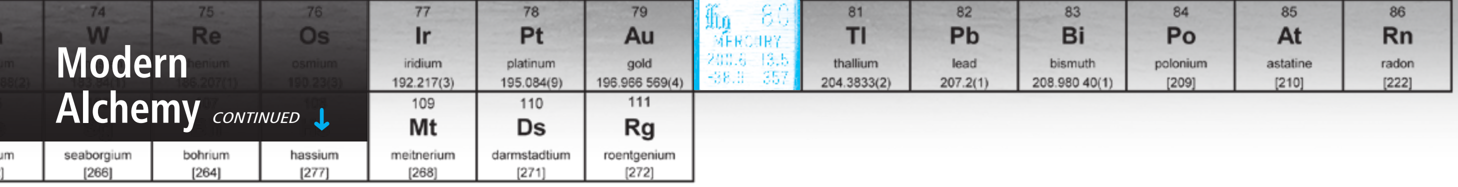

However, the Bay faces serious environmental problems. Among the foremost are pollutants. These include legacy deposits of PCBs, selenium and pesticides from agricultural runoff, polynuclear aromatic hydrocarbons (PAHs) from urban street runoff, and mercury.

Mercury is a metal, manifesting in various forms. It enters the Bay in a variety of ways. Pathways include atmospheric deposition, loads from historical gold and mercury mines, municipal waste water treatment plants, and urbanized watershed drainages.

One mercury "species" in particular is a threat to organisms: methylmercury. This form is a potent neurotoxin; it is derived from inorganic mercury, and

In the past, methylmercury contamination usually was determined by measuring levels of the compound in sediment, the water column and the tissues of mature fish, says Greenfield. But there are problems inherent with relying solely on these approaches, he observes.

"Methylmercury levels in sediments and water can fluctuate widely depending on a number of short-term factors – rainfall, tides and temperature, for example," Greenfield noted. "Large fish tend to be older, and they're very mobile. You don't know where and when they picked up the methylmercury in their tissues."

"Biosentinels can be good for getting localized measures of methylmercury

which the compound is demethylated by sunlight, or how pore-water in sediment – which generally is relatively rich in methylmercury – mixes with water above the Bay bottom.

"One thing we've learned from the model is that changes in the Bay – flood runoff, tides, bacterial activity – can have a dramatic effect on the balance of methylmercury," says Yee, emphasizing that very little of the total inorganic mercury in a given system typically transforms into methylmercury. "The changes can show up very rapidly. Methylmercury processes in the Bay are extremely dynamic – they are by no means static, although we simplify some of them in order to be able to model the Bay."

The strong dependence and quick response of methylmercury concentrations to methylation and demethylation rates in the model show that management actions could have a positive effect over a short time frame.

can be readily available in aquatic food webs. It also "biomagnifies": if a small fish contaminated with methylmercury is consumed by a larger fish, the bigger fish retains a good portion of the methylmercury contained in its prey. This process is repeated up the food chain. Thus, top predators in aquatic systems – which can include marine birds and marine mammals – are most threatened by methylmercury impacts. Humans who consume contaminated fish also are at risk.

The scientific community is making considerable progress in identifying areas that produce methylmercury and understanding the underlying processes and pathways that increase methylmercury production. The Regional Monitoring Program (RMP) is developing a methylmercury mass budget: a model that identifies key factors affecting methylmercury concentrations in the Bay, and predicts fluctuations in the way the compound is distributed as methylmercury inputs and environmental factors change.

Biological Indicators of Methylmercury

Ben Greenfield, an environmental scientist at SFEI notes that "biosentinels" – wildlife captured at specific locations that are analyzed for methylmercury content – have been invaluable in generating new information on this compound. Biosentinels are also used by Darell Slotton, a research ecologist at UC Davis and a RMP collaborator.

exposure," he says. Resident wildlife species with small territories can provide local detail, while migratory or highly mobile species can help with understanding the bigger picture.

Tracking Methylmercury in the Bay

The body of methylmercury data that is accumulating has allowed SFEI researchers to develop a Methylmercury Mass Budget – a model that identifies key factors in methylmercury's distribution throughout the Bay.

"The mass budget helps us understand which sources and processes are most important," says Don Yee, an environmental scientist with SFEI. "Ultimately, we're hoping to develop a model that corresponds to the reality of the Bay/Delta system. If we succeed, the budget will help us decide where to focus our attention in monitoring, research, and ultimately management."

"Methylmercury mainly is produced through conversion, or "methylation," of inorganic mercury by sulfate-reducing bacteria," says Yee. "These bacteria favor anoxic, or low-oxygen, environments. Methylmercury can also be converted back to inorganic mercury in a process known as 'demethylation'."

The mass budget model can be used to analyze the influence of various parameters that affect the fate of methylmercury in the Bay: for example, the degree to

Because most methylmercury is found in sediments, factors that affect sediment processes have major impacts on concentrations predicted by the model for both sediments and water (Figure 1). Methylation and demethylation rates are critically important, with an estimated 5% of the methylmercury in the Bay newly created and destroyed each day. Loads carried in from the Delta and local watersheds contribute significantly to methylmercury concentrations in the water, with methylmercury released from sediments also constituting a major portion.

The strong dependence and quick response of methylmercury concentrations to methylation and demethylation rates in the model show that management actions could have a positive effect over a short time frame.

"If we could decrease methylation or increase demethylation on a wide scale, we would rapidly be able to reduce methylmercury in the Bay within much less than a year," says Yee. "Of course those efforts would need to be sustained, or methylmercury levels could rise again just as quickly."

Even if actions affecting methylation and demethylation on a Bay-wide scale are beyond our reach, management of more limited areas with particularly serious problems could be feasible, Yee says. SFEI, in collaboration with local stakeholders and the Regional Board, has developed a mercury strategy to identify places, times, and ways to best manage the problem.

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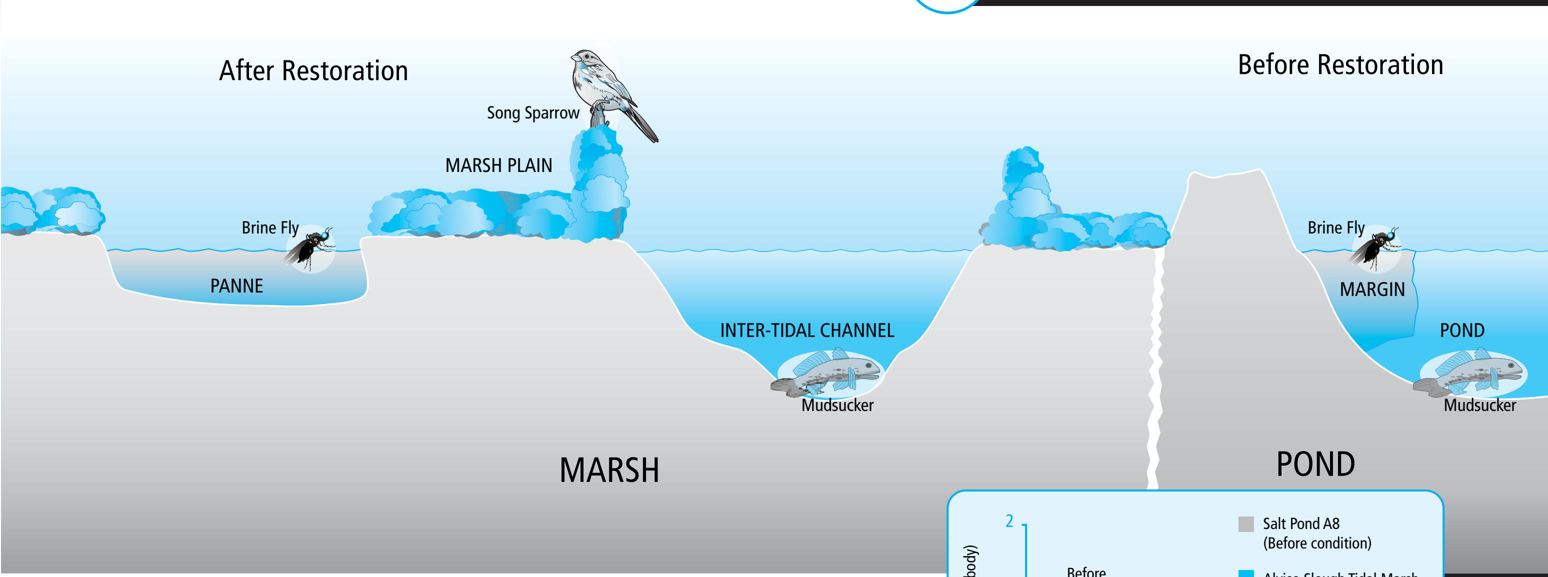
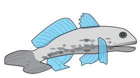
Figure 1 Resident wetland sentinels can be used to compare restoration options.



relationship of these three species to their specific habitats in salt ponds and tidal marsh.

Brine flies reside at the margins of salt ponds and in tidal marsh pannes, making them suitable for before and after comparisons. Sampling at salt pond shorelines measures mercury in the before-restoration condition, while flies caught in existing adjacent tidal marsh pannes are indicators of likely mercury bioaccumulation after restoration.



The **longjaw mudsucker** is a territorial fish and highly localized. The fish sampled in South Bay stay confined to small intertidal channels and are uncommon in large, subtidal sloughs.

The **saltmarsh song sparrow** is a year-round resident of the tidal marsh and forages, breeds and lives exclusively in the marsh. Since salt ponds have no marsh plains, sparrows cannot be included in before and after comparisons. Sparrows can, however, be indicators for mercury bioaccumulation in different marsh types, such as ancient and restored marshes.

The study also monitored additional marsh plain birds and pelagic fish that did not meet as many criteria as the three target species.

Results from fish and fly sampling provide an important answer for managers seeking to minimize mercury exposure. Figure 2 shows that the mercury levels in both mudsuckers and brine flies were higher in Pond A8 (the "before" condition) than in tidal marshes (the expected "after" condition). This suggests that restoring Pond A8 to tidal marsh might reduce mercury accumulation in the food web. Mercury cycling is complex, so further monitoring of restoration projects is highly advisable to determine actual impacts on bioaccumulation.

Mercury monitoring with saltmarsh song sparrows showed significant variation along the 4-mile length of Alviso Slough. The site-specific differences in sparrow mercury levels illustrate that even wetlands in close proximity can have varying effects on food web methylmercury.

Small fish did not exhibit the same pattern as the birds along Alviso Slough. This difference in pattern between birds and small fish indicated that mercury bioaccumulation in one habitat (marsh plain) isn't always connected to accumulation in adjacent habitats (tidal sloughs). Each biosentinel can only provide information about its own habitat.

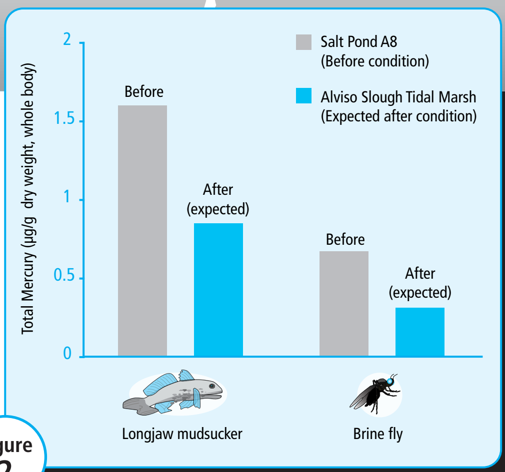


Figure 2 Wetland sentinels indicated that mercury bioaccumulation was lower in tidal marsh than in unrestored Salt Pond A8.

Biosentinel species are proving useful tools for managers as they plan tidal marsh restoration. In order to use biosentinels effectively for adaptive management, it's important for managers to clearly identify the questions they need answered. Continued refinement of these monitoring tools is essential to helping managers track the effect of their actions on mercury accumulation in Bay-Delta food webs.

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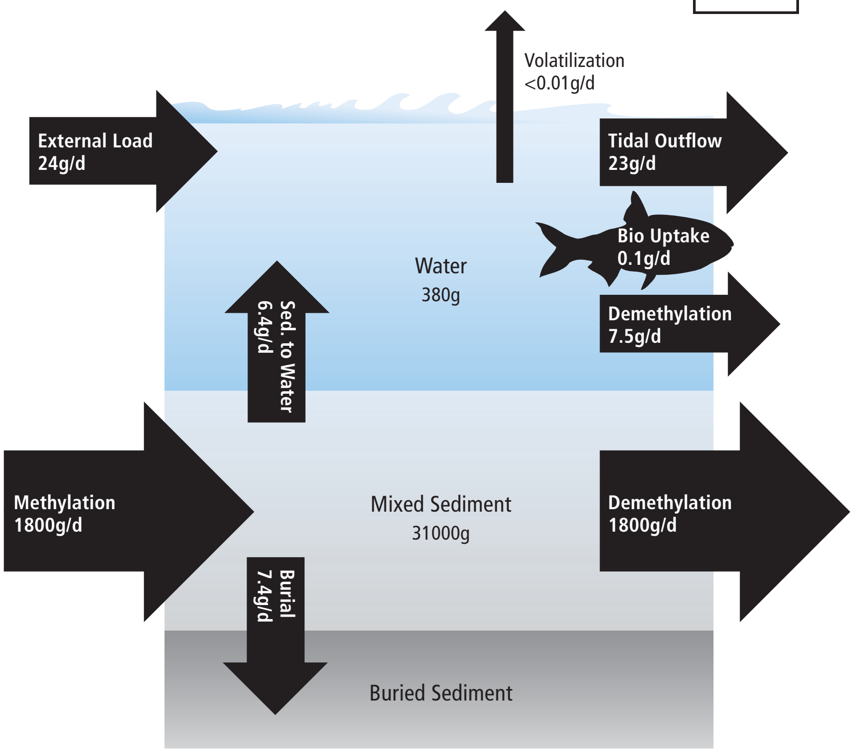
Figure 1



As researchers gain a refined understanding of methylmercury in the Bay/Delta, the ability of regulators to develop responses to the problem will be enhanced. There may be two general avenues for addressing the contaminant says Richard Looker, a water resource control engineer for the San Francisco Bay Regional Water Quality Control Board, the agency that manages water quality in the Bay.

"The biosentinel work and other studies are allowing us to hone in on methylation zones," says Looker. "In turn, that could help us control the sources that feed those zones. We should be able to marshal our resources in a more concentrated, effective way."

"If we can trace specific markers, we may be able to identify some sources of inorganic mercury that present more of a methylation problem than others," Looker says. "Again, that could help us prioritize better. At this point, we need more research. We know intuitively that not all mercury 'pools' are equally bioavailable – but we need quantitative evidence that unequivocally backs that up."

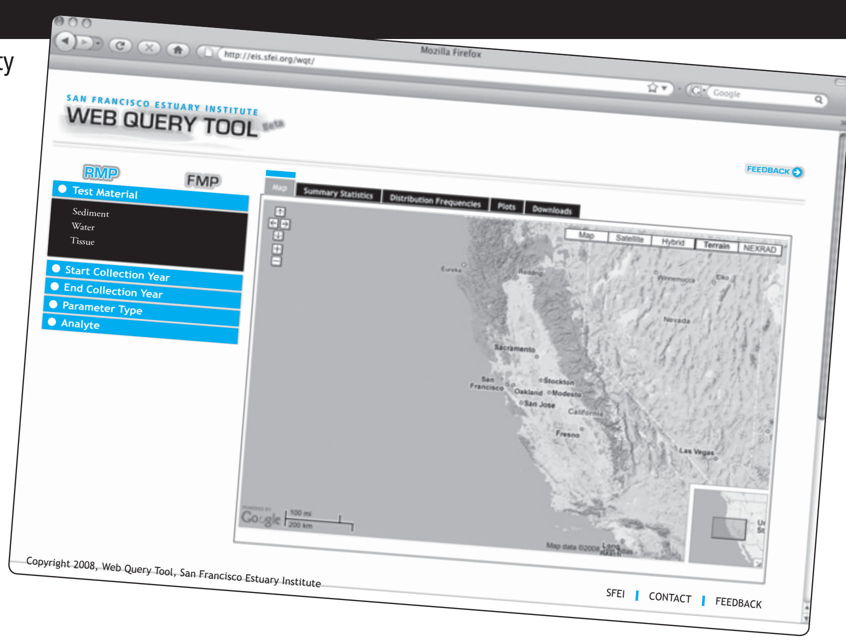
Figure 1.
Methylmercury Mass Budget Conceptual Model.

Processes (in grams/day (g/d)) that contribute to the methylmercury inventory (in grams (g)) for San Francisco Bay water and sediment. Sum of methylmercury additions and losses comprise the mass methylmercury budget.

New! WEB QUERY TOOL

By John Oram, joram@sfei.org

The Regional Monitoring Program for Water Quality in the San Francisco Estuary is proud to announce the release of its new **WEB QUERY TOOL**. This **beta release** builds on previous RMP query tools by adding interactive mapping and charting capabilities. The aim is to provide an online experience where users can access and explore RMP data in an intuitive manner. Users of the **WEB QUERY TOOL** will also notice the availability of non-RMP data. Specifically, fish tissue data from the Fish Mercury Project are included in this version of the query tool. This integration of information from multiple monitoring programs is a proof-of-concept illustrating how a single interface can be used to provide access to a broad range of environmental data. Many more datasets will be added as the 'bugs' are worked out over the next year.



Test-drive the new WEB QUERY TOOL today at ➞ http://eis.sfei.org/wqt/.

Feedback is welcome.

For more information about the RMP, or to receive the RMP newsletter, contact SFEI at 510-746-7334 or visit the RMP Web site at www.sfei.org/rmp.

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