Key Uncertainty: Will tidal marsh restoration increase MeHg levels in indicative wildlife of managed ponds and tidal marsh?

Background and Rationale

Mercury (Hg) is dangerously toxic to wildlife and people. The organic form of mercury (methylmercury or MeHg) is a neurotoxin that readily accumulates in food chains. Minamata disease, or methylmercury poisoning, is characterized by peripheral sensory loss, tremors, and loss of memory, hearing, and vision (NRC 2000). Methymercury can be created from elemental mercury under low levels of oxygen (anoxia) in the presence of organic carbon and sulfate-reducing bacteria (NRC 2000, Wiener et al.2003). These conditions exist in the sediments of tidal marshes and other estuarine environments (Marvin-DiPasquale et al. 2000, Marvin-DiPasquale and Agee. 2003).

The potential exists to inadvertently increase the risk of mercury (Hg) accumulating in South Bay fish and wildlife through hydrological modification of salt ponds as part of the South Bay Salt Pond Restoration Project (Project). Concentrations of Hg in sediment and water tend to be greater in South Bay due to past local mercury mining (Beutel and Abu-Saba 2004). The Alviso Pond and Slough Complex are especially worrisome because they contain more Hg than most other areas of South Bay (Conway et al. 2004, SFEI 2005) and because they are slated for early hydrologic modification by the Project.

Bayland managers need to know how their actions affect the risk of mercury bioavailability and toxicity. The risk can be assessed most directly by monitoring Hg in 'biosentinel' wildlife species that represent habitat conditions that typically result from the planned management actions. Coupling such a monitoring effort to studies of MeHg production and biological uptake is essential to understand how management actions can be adjusted to reduce the risk of Hg toxicity.

Study Design Concepts

- Study Population: Selected "biosentinel" species of invertebrates, fish, and birds that indicate local bioaccumulation of mercury. The candidate species must have a small home range, be easily collected, and be residential within a habitat type or feature that is targeted for restoration or enhancement by the Project.

- Study Site: The geographic scope of the study changes over three phases. Study Phase 1 is restricted to the major habitat types of Pond A8 and Alviso Slough plus ambient sites of these same habitat types. Study Phase 2 expands to encompass a survey of these habitat types in the South Bay. Study Phase 3 focuses on South bay locales of special interest identified during Study Phase 2.

- Parameters Measured: Phase 1 involves sampling mercury in selected sentinel species and characterizing the mercury in their habitats. The parameters for wetland habitats include total mercury, methylmercury, reactive mercury, total carbon, sulfur, pH, conductivity, soil density, and grain size. The parameters for

aquatic habitats include unfiltered total mercury, methylmercury, TSS, dissolved carbon, temperature, pH, sulfur, and conductivity. Maps will be made of all habitat types surveyed.

- Study Design: The regional strategy for solving the mercury problem calls for an integrated program of monitoring plus focused research driven by questions and hypotheses that explicitly reflect the information needs of resource managers (Wiener et al. 2002). The proposed work would start by helping the Project Management Team define the mercury problem in practical terms, The work would then proceed to develop cost-effective indicators of the problem, survey its magnitude and extent (beginning with Pond A8 and its adjacent tidal habitats), test for correlations between the problem and manageable environmental factors, initiate research to understand the primary environmental factors most strongly influencing the observed correlations, and help translate these findings into recommended actions to either prevent or correct the problem.

The work would be conducted in three phases over three years. The approach is scalable, however, and could be used to monitor any management action at any spatial scale from one local habitat patch to the South Baylands as a whole.

The conditions of existing pond and tidal habitat types will be surveyed as analogues for what could be maintained or restored in the pond complexes based on different management scenarios. For example, the tidal habitats to be surveyed in Study Phase 1 represent the habitats predicted for PondA8 restoration. The existing pond habitats to be surveyed represent the expected future conditions of Pond A8 if it is not restored to tidal marsh. The comparisons are based on sentinel species that are common to tidal and nontidal habitats. For example, the same sentinel fish species will be sampled in Alviso Slough and Pond A8.

Study Phase 1 would:

- Develop sentinel species indicators of Hg exposure for Alviso Slough water column, pond water column, slough bottom, pond bottom, tidal marsh panne/pond margin, tidal marsh channels, tidal marsh vegetated plain;
- Assess the mercury problem for the habitat types listed above based on Hg concentrations in the associated sentinel species;
- Characterize the habitats in terms of their propensity to produce MeHg.

Study Phase 2 would:

- Expand the sentinel species survey to encompass more of the South Baylands. This phase provides a picture of the spatial variability in mercury problem within and between bayland habitats in South Bay.

Study Phase 3 would:

- Initiate focused research to better understand the linkages between Hg contamination in sentinel species and bio-goechemical indicators for specific habitat types in selected areas, based upon the results of Study Phase 2;

- Help translate the scientific understanding of the Hg problem into habitat designs and management options that minimize the problem.

Time Frame for Study: fall 2005 through winter 2008.

Estimated Study Costs: $750,000

Management Questions

Phase 1 of this study will initially determine the relative risks of mercury toxicity represented by different habitat types resulting from different management options for Pond A8. For example, if the ratio between the ambient slough benthic risk and the Alviso Slough benthic risk (based on the benthic sentinel species) is less than the ratio between the ambient slough benthic risk and the Pond A8 benthic risk, then the managers could assume that sampling breaching the pond would not result in a net increase in benthic risk. The same analyses will proceed for the other habitat types. If the restoration of Pond A8 is indicated to increase the net risk of mercury toxicity, then the managers might consider other options than simply breaching the pond, including:

- not breaching the pond;
- capping the sediments in the pond or removing them before restoring the pond to tidal action (this pertains to the condition that existing benthic conditions in the pond represent relatively high risk due to legacy mercury loads in the pond);
- breaching the pond but excluding any tidal habitats, such as marsh panes, small channels, or densely vegetated marsh plains, if their ambient conditions tend to represent relatively high risk; and
- dredging Alviso Slough (this pertains to the condition that a relatively high risk of mercury toxicity in Alviso Slough is due to its legacy mercury load, and that the scour of these sediments and their possible transport into Pond A8 after it is breached represents a net increase in risk for restored tidal habitats in Pond A8).

Phase 2 of this study will profile the relative risk of mercury toxicity among the habitat types resulting from different planned management actions throughout the South Bay. This profile will provide the managers with a number of options, including:

- Assessing the importance of the risk of mercury toxicity relative to other stressors, such as gull predation, flood hazards, biological invasions, and accelerated sea level rise;
- Prioritizing the restoration or maintenance of habitat types and habitat features based on their relative contributions to the local and regional risk of mercury toxicity; and
- Targeting research to explain the conditions of highest risk, and/or to establish threshold of mercury concentration among the sentinel species that correspond to significant biological harm. This option would be translated into Study Phase 3 of the study, which is designed to address the primary information needs of the managers based on the Study Phase 2 profile of South Bay conditions.

Citations

Beutel, M., and K. Abu-Saba. South Bay Salt Ponds Restoration Project: Mercury Technical Memorandum. Brown and Caldwell / Larry Walker and Associates. Report prepared for the South Bay Salt Ponds Restoration Project Management Team. 47 pp.

Conaway, C.H., Watson, E.B., Flanders, J.R., and Flegal, A.R., 2004, Mercury deposition in a tidal marsh of south San Francisco Bay downstream of the historic New Almaden mining district, California: Marine Chemistry, v. 90, p. 175–184.

Marvin-DiPasquale, M., and J.L. Agee. 2003. Microbial mercury cycling in sediments of the San Francisco Bay-Delta. Estuaries 26:1517-1528.

Marvin-DiPasquale, M., J. Agee, C. McGowan, R.S. Oremland, M. Thomas, D. Krabbenhoft, and C. Gilmour. 2000. Methyl-mercury degradation pathways: a comparison among three mercury-impacted ecosystems. Environmental Science and Technology 34:4908-4916.

NRC (National Research Council). 2000. Toxicological Effects of Methylmercury. National Academies Press, Washington DC.

SFEI. 2005. The Pulse of the Estuary 2005. San Francisco Estuary Institute, Oakland, California.

Wiener, J.G., D.P. Krabbenhoft, G.H. Heinz, and A.M. Scheuhammer. 2003. Ecotoxicology of mercury. *In* Handbook of Ecotoxicology, 2nd edition. D.J. Hoffman, B.A. Rattner, G.A. Burton, and J. Cairns, eds. Boca Raton, CRC Press, pp. 409-463.