San Francisco Estuary Institute

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REGIONAL MONITORING PROGRAM FOR WATER QUALITY IN SAN FRANCISCO BAY (RMP)

REQUEST FOR PROPOSALS ON MERCURY FATE IN SAN FRANCISCO BAY

The Regional Monitoring Program for Water Quality in the San Francisco Estuary (RMP) is an innovative collaboration among scientists from the San Francisco Estuary Institute (SFEI), regulators from the San Francisco Bay Regional Water Quality Control Board (SFBRWQCB), and the regulated discharger community (e.g., representatives from wastewater treatment plants, stormwater management agencies, refineries, and dredgers). As a condition of their discharge permits, the discharger community funds the RMP to provide scientific information to serve as a basis for informed decisions on management of contaminant impacts on beneficial uses of the Bay.

The RMP is designed to address specific objectives and answer specific management questions (Appendix 1). As a result of historic mining operations, industrial discharges, urban runoff, atmospheric deposition, and other sources, the Bay has concentrations of mercury in biota which are impairing the beneficial uses of the Bay (e.g., consumption of sport fish, protection of endangered species (see the Mercury TMDL, http://www.swrcb.ca.gov/rwqcb2/TMDL/SFBayMercury/sr080906.pdf). In 2007, the RMP developed a series of key questions regarding mercury in the Bay (RMP Mercury Strategy – Appendix 2). The RMP is requesting proposals to address Question 2 in the Mercury Strategy:

2. **Which processes, sources, and pathways contribute disproportionately to food web accumulation?**

The question is described further in the Mercury Strategy (attached). The Program is interested in funding work that has a very high probability of advancing our understanding of the contribution of different pathways and/or processes to accumulation of methylmercury in the food web. "Pathways" include urban runoff, municipal effluent, industrial effluent, Delta outflow, nonurban runoff, atmospheric deposition, and remobilization of buried sediment. “Processes” refers to general features of different habitats that are associated with increased net methylation and food web uptake. A priority is to develop understanding on a broader scale to inform TMDLs, so information that can be generalized to different pathways or habitat types would be especially valuable. Studies that disprove the hypothesis that there are high leverage inputs would also be valuable.

As stated in the Mercury Strategy, Question 2 would most efficiently be answered after a reasonably solid understanding of where mercury is entering the food web is obtained (Question 1). The RMP is going to be developing this understanding (regarding Question 1) over the next few years through a broad spatial survey of mercury in small fish. In the meantime, to the extent possible, the Program is also interested in beginning to improve our understanding of whether high leverage inputs exist, and identifying what they are (Question 2).

Two examples of potential studies are listed below. These examples are just illustrative - proposal submitters are encouraged to consider other approaches and to propose what they consider to be the optimal approach to answering the question.

- Expose surrogate organisms (e.g., phytoplankton) to different waters from different pathways. Examine effect of different dilution series.
- Correlative field study. Coordinated measurements (reactive Hg? DGT? MeHg?) with the spatially and seasonally intensive measurements of methylmercury bioaccumulation (see Mercury Strategy for a description).

The proposals should explain how the proposed work addresses the overarching RMP goal of providing information needed to support water quality management decisions. Studies that have the potential to support decision-making more directly or in the nearer-term will be more valuable to the RMP.

Proposals for up to $200,000 for a two-year period (January 2008 – December 2009) will be considered.

Proposals are due on January 7. Proposals should be no longer than five pages in length, and follow the format shown in the attached example. The proposal should clearly state the hypothesis or hypotheses being tested, and also discuss the linkage between the proposed work and Question 1 (food web uptake). Submit the proposal to Jay Davis via email (jay@sfei.org).

The Review Process

These proposals will be reviewed at the next meeting of the RMP Contaminant Fate Workgroup on January 15 and the RMP Technical Review Committee meeting in March. These committees may request additional information after the first round of review. It is anticipated that a final decision will be made by the RMP Steering Committee in April.

If you have questions contact Jay Davis (jay@sfei.org, 510 746-7368) or Meg Sedlak (meg@sfei.org, 510 746-7345). Much more information on the RMP is available at www.sfei.org/rmp.

RMP OBJECTIVES AND MANAGEMENT QUESTIONS (ANNOTATED VERSION)

DRAFT 2007

GENERAL GOAL OF THE PROGRAM

Provide information needed to support water quality management decisions

OBJECTIVES AND MANAGEMENT QUESTIONS

Objective 1. Describe spatial patterns and long-term trends of pollutant concentrations in the Estuary

1.1 Do pollutant spatial patterns and long-term trends indicate particular regions of concern?

Spatial patterns indicate regions of concern, but persistence of patterns over time is also a factor

Includes goal of finding effective analytical methods and sampling designs and to identify the best chemical species to monitor

1.2 Are management actions effective in reducing pollutant concentrations in the Estuary?

Includes characterization of inventory.

Priority management actions to monitor include:

- Source control (including chemical bans)
- Wastewater and stormwater treatment
- Habitat restoration
- Pollution prevention

Objective 2. Project future impairment

2.1 What patterns of impairment are forecast for major segments of the Estuary under various management scenarios?

Includes goal of finding the most effective modeling approaches, including:

- Conceptual models
- Simple quantitative models (if appropriate)
- Complex quantitative models (if appropriate)

Implies need to predict:

- Future loads from important sources and pathways
- Losses through different mechanisms (outflow, degradation, etc.)
- Recovery of each Bay segment (which, in turn, implies the need for accurate models – conceptual and numeric – of pollutant fate)
- Future trends in estuarine processes. Important estuarine processes include:
    - sea level rise
    - changing river inflows
    - rising temperatures
    - changes in sedimentation patterns
    - food web shifts
    - exotic species invasions

Management scenarios include:

- Source control (including chemical bans)
- Wastewater and stormwater treatment
- Habitat restoration
- Development

2.2 Which contaminants are predicted to increase and potentially cause impairment in the Estuary?

Captures need to identify emerging pollutants based on chemical properties and actual or proposed uses

Objective 3. Describe sources, pathways, loading, and processes leading to pollutant-related impairment in the Estuary

3.1 Which sources, pathways, and processes contribute most to impairment?

Includes goal of finding the most effective indicators of loadings to support decision-making. Examples of loading indicators include:

- TSS (already used extensively)
- Other potential indicators (bioaccumulation assays, SPMDs)

Implies need to understand:

- Mass loads – essential for TMDLs
- Speciation (availability) of different inputs
- Temporal dynamics
  - seasonality
- Spatial patterns
  - Local impacts
- Linkage to impairment calls for modeling

For all of the major pathways:

- Wastewater effluents
- Urban runoff
- Nonurban runoff
- Atmospheric deposition
- Delta outflow
- Dredging and dredged material disposal
- Remobilization from Bay sediment
- In-Bay cycling
- In-Bay hotspots
- Wetlands

Processes include:

- Net methylation within the Estuary
- Erosion of buried sediment
- Diagenetic remobilization

3.2 What are the best opportunities for management intervention for the most important pollutant sources, pathways, and processes?

This is focused on intervention points for pathways and processes within the Estuary (e.g., net methylation hotspots, other pollutant hotspots)

The following questions are included under this broader question:

- Where are/were the largest pollutant sources?

- What processes cause release of pollutants from these sources?
- What are the best points for management intervention between source areas and the Bay?
- What management strategies are expected to be effective?

3.3 Are management actions effective in reducing loads from the most important sources, pathways, and processes?

Objective 4. Characterize the potential for adverse effects on humans and aquatic life due to pollution of the Estuary ecosystem

4.1 Which chemicals have the potential to adversely effect humans and aquatic life and should be monitored?

- Screening level evaluation of chemicals through review of existing information
- Captures need to identify pollutants of concern, including new and emerging pollutants
- Does not suggest that RMP will be performing laboratory dose-response studies of emerging pollutants

4.2 What potential for adverse effects on humans and aquatic life exists due to pollutants in the Estuary ecosystem?

This question drives thorough evaluation of the most serious concerns
This includes concerns due to:

- individual pollutants of concern
- the synergistic or antagonistic effects of pollutant mixtures
- the interaction of pollutants with other stressors

Includes concerns at regional and local scales
Sub-question: What are appropriate thresholds for concern?

Includes goal of finding the most effective indicators of effects to support decision-making. Possible examples include:

- biomarkers in fish that link to effects at the population level
- abiotic surrogates of risk and exposure (e.g., methylmercury in water – if a link to uptake in the Bay could be established)

4.3 Are management actions effective in reducing the potential for adverse effects on humans and aquatic life due to Bay pollution?

Captures need for sustained monitoring of risk indicators to determine whether risks are reduced

Objective 5. Provide monitoring information for comparison to regulatory guidelines and for establishing regulatory guidelines

Guidelines include TMDL targets, tissue screening values, water quality objectives, sediment quality objectives, and effluent concentrations

5.1 What percentage of the Bay is impaired?

Captures need for Bay-wide assessment

Implies need for probabilistic Bay wide sampling to determine spatial extent of impairment (exceedance of existing guidelines)

5.2 What is the percentage and degree of impairment in each Bay segment?

Implies need for understanding spatial extent and degree of guideline exceedance by segment so management attention can be focused accordingly

5.3 What are appropriate guidelines for protection of beneficial uses?

RMP has a role in providing the information needed in development of guidelines. Examples include:

- Effluent limits – CTR monitoring in support of permit development
- Water quality objectives – e.g., copper and nickel
- Sediment effects thresholds – e.g., studies to evaluate whether effects in the Estuary do occur at the 1 ppm PAH threshold being applied by NOAA

This does not mean that RMP will be independently evaluating or recommending water quality objectives and other guidelines.

Objective 6. **Effectively communicate information from a range of sources to present a comprehensive picture of the sources, distribution, fate, and effects of pollutants and beneficial use attainment or impairment in the Estuary ecosystem.**

This objective applies to all of the questions listed under objectives 1 – 5.

RMP MERCURY STRATEGY

Mercury is a pollutant of high concern in San Francisco Bay. This strategy has been developed to ensure that the RMP is providing the information most urgently needed by managers to find remedies to the Bay's mercury problem.

The focus of this strategy is on improving understanding of the production and uptake of *methylmercury*. Concentrations of total mercury in the Bay are expected to slowly decline over coming decades. The premise of this strategy is that it may be possible to identify the specific fractions of total mercury entering the Bay or already in the Bay that contribute disproportionately to accumulation in species of concern (as indicated by the TMDL targets – sport fish, small fish, avian eggs). If this premise is correct, then it may also be possible to reduce mercury accumulation in species of concern in a significantly shorter time-frame than is currently thought possible for total mercury reductions.

The RMP is already conducting a substantial amount of monitoring to understand status, trends, loads, and effects of mercury and methylmercury. The RMP will generally continue to gather this information. The following questions articulate the priorities for obtaining *additional* information on mercury in support of management.

The overarching goal of the RMP, and the intent of the RMP mercury strategy, is to provide the information needed to support water quality management decisions.

1. **Where is mercury entering the food web?**

Understanding where and when mercury enters the food web is critical in determining how to reduce food web contamination. Existing RMP monitoring (sport fish, bird eggs) is not answering this question with the degree of spatial or temporal specificity needed to support management. Only when mercury (as methylmercury) actually enters the food web can we be sure that it is part of the fraction of total mercury that contributes to impairment. The term "food web" as used here refers to the macro-scale food web, from algal producers to primary consumers and on up to predatory fish, birds, and humans (not the microbial food web). This question presently represents a major information gap.

- There are spatial and temporal dimensions to this question. The spatial scale of interest in relatively small (1 mile or less), so that uptake can be tied to particular pathways or processes occurring in specific habitats. The temporal scale of interest is annual or seasonal or shorter, so that the most critical years and times within years for uptake are characterized.

2. **Which processes, sources, and pathways contribute disproportionately to food web accumulation?**

This question can most efficiently be answered after question number 1 is answered. When the critical locations and times for mercury uptake are understood, it should be

possible to determine the origins of that mercury. These are referred to as the "high leverage" pathways and processes, and could include:

- Inputs from the various standard pathways (POTWs, industrial effluents, urban runoff, atmospheric deposition, Delta outflow, in-Bay contaminated sites, remobilization of buried sediment)
- Habitats with high rates of net methylation (due to the combined effects of methylation and demethylation) and food web characteristics that allow for substantial and efficient uptake into the food web.

The RMP is going to be developing an understanding of where and when mercury enters the food web (Question 1) over the next few years. In the meantime, to the extent possible, the Program is also interested in beginning to improve our understanding of whether high leverage inputs exist, and identifying what they are, and setting the stage for expedient management of those inputs.

3. **What are the best opportunities for management intervention for the most important pollutant sources, pathways, and processes?**

   After the high leverage pathways and processes are identified, opportunities for management intervention can be evaluated.

4. **What effects can be expected from management actions?**
   Answering this question implies a conceptual, and ideally quantitative, model of the behavior of mercury in the ecosystem. Such models should be developed continually as knowledge accumulates. Answering this question is especially important after questions 1 – 3 have been answered.

5. **Will total mercury reductions result in reduced food web accumulation?**
   This question is not part of the sequential chain of questions 1 – 4. It is a question that could be addressed at any time. Experimental or field approaches may be useful in answering this question.

Five-Year Plan for RMP Mercury Studies

In addition to existing RMP elements evaluating mercury and methylmercury (Table 1), components will be added or expanded to address mercury questions 1 and 2. Since the answers to these questions are so poorly known at present, making progress on these questions is a sufficient goal for the next several years.

Question 1 will be addressed through spatially and seasonally intensive measurements of methylmercury bioaccumulation. A stratified random design will be used to test hypotheses formulated based on current understanding regarding the pathways and habitats expected to potentially have a strong influence on methylmercury accumulation into the food web. This work will be designed and performed under the guidance of both the Contaminant Fate Workgroup (with their expertise in mercury cycling) and the Exposure and Effects Workgroup (expertise in bioaccumulation

monitoring). This work is a top priority for the RMP. The funding level for this work will be $150,000 per year for 2008, 2009, and 2010.

The best approach to answering Question 2 is less obvious. Possible approaches include exposing surrogate organisms to different source waters or performing a correlative field study in coordination with the methylmercury bioaccumulation study. Question 2 will be addressed through issuing a Request for Proposals. The funding for this work will be $100,000 per year in 2008, 2009, and 2011.

Table 1. Mercury and methylmercury studies and monitoring proposed for the RMP from 2008 to 2012. Numbers indicate proposed budget allocations in 1000s. Matching funds from other programs indicated in parentheses.

Element	Questions	2008	2009	2010	2011	2012
Food Web Uptake (Small Fish)	Mercury 1, RMP 1.1, 1.2	150	150	150	150?[a]	150?
High Leverage Pathways and Processes	Mercury 2, RMP 3.1	100	100		100	
Surface Sediments (THg, MeHg)	RMP 1.1, 1.2	135[b]	135[b]	135[b]	135[b]	135[b]
Water (THg, MeHg)	RMP 1.1, 1.2	320[b]	320[b]	320[b]	320[b]	320[b]
Sport Fish	RMP 1.1, 1.2, 4.2, 4.3, 5.2		215[b]	41[b]		218[b]
Avian Eggs	RMP 1.1, 1.2, 4.2, 5.2[e]	120[b]			120[b]	
Effects on Birds	RMP 4.2, 5.3	70[c] (34)[d]	50[b] (20)[d]	50[b] (20)[d]	50[b] (20)[d]	50[b] (20)[d]
Sediment Cores (THg)	RMP 1.1, 1.2, 2.1			100[b]		100[b]
Small Tributary Loading (THg)	RMP 3.1, 3.2	100[b]	100[b]	100[b]	100[b]	100[b]
River Loading (THg)	RMP 3.1, 3.2, 3.3			140[b]		
Guadalupe Loading (THg)	RMP 3.1, 3.2, 3.3			65[b]		
Guadalupe Model (THg)	RMP	75				
Watershed Load Model (THg)	RMP 3.1, 3.2	40				
Remote Sensing	RMP 2.1	14				

[a] The need for continuing this work will be evaluated after three years.
[b] Hg and MeHg are part of a longer list of pollutants covered by this budget.
[c] A study by USGS: Mercury-Selenium Effects on Reproductive Success of Terns and Stilts in San Francisco Bay.
[d] Matching funds from USGS.
[e] Useful in evaluating the “monitoring target” for avian eggs in the mercury TMDL.