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RMP Technical Review Committee Meeting

June 27th, 2006
San Francisco Estuary Institute
Second Floor Conference Room
7770 Pardee Lane, Oakland
10:00am-3:00pm

Lunch will be provided. We will take a short break and then keep working through lunch.

DRAFT AGENDA

1.	**Introductions and Approval of Agenda and Minutes** (Attachment)	10:00 Chair
2.	**Information: Steering Committee Report** (Attachment)	10:10 Meg Sedlak
3.	**Information: Update on Prioritization of S&T Elements** (Attachment) A progress report on the power analyses for S&T monitoring elements will be presented. Other aspects of the S&T redesign will also be discussed.	10:20 Ben Greenfield Jay Davis
4.	**Action: Selecting Pilot and Special Studies for 2007** (Attachments) A. Review of rankings B. Review of proposals submitted C. Recommendations for the SC on which proposals to fund **Action:** Develop a recommendation for the SC as to which studies should be included in the 2007 Plan.	11:00 Meg Sedlak Jay Davis
	BREAK	12:00
5.	**Lunchtime Presentations**: Updates on South Bay Salt Pond Mercury Monitoring, SWAMP Bioaccumulation Review, and Fish Mercury Project Activities	12:15 Letitia Grenier Jay Davis
6.	**Action: USGS Sediment Sampling Sites** The USGS has been monitoring suspended sediment concentrations at 6 sites within the Bay: Mallard, Benicia, Point San Pablo, Alcatraz, and Dumbarton and the Aquatic Transfer Station near Hamilton **Action:** Decide which stations to monitor in 2007	1:00 Dave Schoellhammer

7.	**Information: Benthic Workshop** A benthic workshop was held on May 23rd to discuss benthic assessment methodologies. One of the outcomes of this meeting was a recommendation for the RMP to coordinate with the IEP regarding sediment and benthic analyses. Bruce will summarize the workshop and outline benthic sampling strategies for the RMP.	1:30 Bruce Thompson
8.	**Information: Update on Workshops and Workgroups** • Pyrethroid Workshop was held on May 11 to discuss toxicity and chemical analyses. • CEP TC meeting on PBDE CMIA meeting was held on May 3rd. • Emerging Contaminants Workgroup meeting was held on June 1	2:00 Daniel Oros, Bruce Thompson, Meg Sedlak
9.	**Information: Pulse and Annual Meeting Update** An update on the status of the Pulse and Annual Meeting will be given.	2:30 Jay Davis
10.	**Information: Program Update and Laboratory Data Status** (Handouts) Updated deliverables scorecard and laboratory data tracking sheet	2:45 Meg Sedlak
11.	**Action: Set Agenda and Date for Next Meeting**	3:00 Chair
	Adjourn	

RMP Technical Review Committee Meeting
March 29th, 2006
San Francisco Estuary Institute
Meeting Minutes

In attendance: Jamison Crosby (Contra Costa Clean Water Program), David Dwinelle (US Army Corps of Engineers), Jim Cloern (USGS), Bridgette DeShields (BBL/WSPA), Andy Gunther (AMS), Alan Jassby (UC-Davis), Mike Kellogg (City and County of San Francisco), Larry Kolb (Regional Board), John Prall (Port of Oakland), Francois Rodigari (EBMUD), Chris Sommers (EOA-BASMAA), Karen Taberski (Regional Board), Dave Tucker (City of San Jose), Mike Connor (SFEI), Nicole David (SFEI), Jay Davis (SFEI), Ben Greenfield (SFEI) Sarah Lowe (SFEI), Lester McKee (SFEI), Jon Oram (SFEI), Daniel Oros (SFEI), Meg Sedlak (SFEI), Bruce Thompson (SFEI), and Don Yee (SFEI)

By telephone: Scott Ogle (Pacific Eco-Risk Laboratory) and Joy Cooke Andrews (Cal. State – Hayward)

1. Introductions and Approval of Agenda and Minutes

Dave Tucker opened the meeting by asking for comments on the December 2005 minutes. Ms. Taberski and Chris Sommers requested several minor editorial changes be made. Pending these changes, the minutes were approved.

With regard to the action items from the December meeting, Meg Sedlak indicated that several of the items would be discussed today including a discussion of RMP participants' status and trends priorities. A revised version of action items is attached to the meeting minutes.
Action item: Include action items from the March 2006 meeting into the action items previously developed.

2. Information: January Steering Committee Report

Meg Sedlak provided a brief summary of the Steering Committee (SC) meeting on January 23rd, 2006. Ms. Sedlak noted that many of the items discussed at the SC meeting were included on the day's TRC agenda (e.g., discussion of the Pulse outline, Evaluating Status and Trends Priorities, and SWAMP/CEP updates). The 2005 expenditures were less than budgeted. Approximately $60,000 of 2005 labor costs will be carried over into 2006 to complete unfinished tasks. An additional approximately $130,000 of unallocated subcontracts will also be carried over into 2006. The 2007 budget ($3,125,047) was approved by the SC with the previously agreed upon two percent increase in fees.

Ms. Sedlak indicated that the SC had approved the following Program name change from "Regional Monitoring Program for Trace Substances in the San

Francisco Estuary" to "the Regional Monitoring Program for Water Quality in the San Francisco Estuary." Ms. Sedlak asked the TRC to approve this name change. Karen Taberski motioned for approval; Bridgette DeShields seconded and the name change was passed unanimously.

3. Discussion: Information Needs of RMP Participants

Meg Sedlak explained that the RMP began a process last fall to review the information needs and priorities for the Status and Trends program. As part of this process, the RMP is soliciting input on a prioritization table that was presented in September 2005 to the TRC. Ms. Sedlak indicated that power analyses will be conducted on the sport fish, sediment, and water sampling elements to assist in the evaluation of Program elements. Sport fish power analysis was performed by a consultant, Andy Jahn, in November and presented to the Fish Committee in November 2005. Sediment and water power analyses will be completed in the Spring of 2006.

Ms. Sedlak indicated that the group could focus the discussion by going through the table prepared by SFEI staff for the September TRC meeting or by using the Regional Board's table that was presented in the December TRC meeting. The group thought it would be useful to discuss both.

Dave Tucker began the discussion by outlining BACWA needs. He indicated that their primary focus is on meeting the regulatory needs of their NPDES permits. Elements with direct impact on regulators or TMDLs are a high priority. As such, the group places a higher priority on water, sediment, and bioaccumulation Program elements. The group is also very interested in seasonal variation (e.g., winter sampling). Mr. Tucker would like RMP staff to evaluate the frequency of analyses (i.e., for some analytes it may not be necessary to sample every year if changes aren't expected). Mr. Tucker placed a high priority on identifying emerging contaminants with the idea of avoiding legacy contamination. Ms. Sedlak mentioned that an emerging contaminants workgroup has been developed and will meet in June (see item #10 Program updates or the March TRC package for further details). Mr. Tucker indicated that aquatic toxicity work is a lower priority for BACWA, and sediment toxicity is a lower priority since it is always toxic and the cause is unclear. Mr. Tucker advocated keeping a big picture perspective when adding or deleting Program elements.

David Dwinelle indicated that the dredging community is very interested in understanding the causes of sediment toxicity and specifically the causes of seasonal variation in sediment toxicity. Dredged material testing data indicate that some organisms don't do well in winter. Karen Taberski also expressed interest in determining the causes of winter toxicity. Mr. Dwinelle noted that the RMP tends to see higher sediment toxicity than does the dredging community using similar tests. Mr. Dwinelle also stated the importance of using RMP data to develop baselines for future comparison.

Bridgette DeShields noted that the Sediment Quality Objectives (SQOs) will generate additional data requirements. The SQO framework includes some toxicity test species not currently sampled by RMP, and some tissue sampling. She suggested that the RMP may need to collect additional data for the SQO (e.g., data that can be used to evaluate impacts to wildlife (e.g., small prey fish) and more sediment quality data).

Chris Sommers emphasized the importance of quantifying long-term trends and of power analyses in making decisions regarding the prioritization of Status and Trends elements. He also stated that an emphasis on contaminants in sediment is appropriate for the RMP given the impending SQOs and the fact that contaminants in sediments tend to drive the TMDL process and impact the food web more than water concentrations. Sediment input occurs in winter, suggesting the need for assessment in winter. Increasing use of pyrethroids also suggests a greater emphasis on sediment chemistry and toxicity. A shift toward sampling of bedded sediment is also occurring in tributary monitoring. BASMAA's priorities for RMP are not as driven by NPDES permit requirements as are BACWA's and WSPA's.

Karen Taberski noted that while the power analyses are important, in the case of the sediment redesign, it was a balance of the findings from the power analysis and the fiscal constraints of the program that determined the current sampling designs for water and sediment.

Andy Gunther asked how many samples are needed to meet the goals of the program, or exactly what questions is the program trying to answer? If it is an objective (e.g., water or sediment), how frequently does the program need to analyze to demonstrate that it is answering the questions? Chris Sommers indicated that the 303 (d) listing outlined data needs but that he thought it was relatively few samples to list a water body (e.g., two).

Mike Connor summarized day's discussion so far and he and Francois Rodigari suggested that the criteria for assigning priorities in the Table be clearly delineated.

For water chemistry:

- Evaluate number of sites;
- Understand the impact of seasonal variation and episodic events; and
- Evaluate the analyte list (need for new emerging contaminants) and the frequency at which existing contaminants are analyzed.

For sediment chemistry:

- Evaluate number of sites
- Review analyte list
- Evaluate impact of new regulations (e.g., SQOs)

For bioaccumulation:

- Evaluate number of sites
- Evaluate seasonality

For sport fish:

- This review is largely going through the Fish workgroup

For sediment toxicity:

- Understand what is causing sediment toxicity
- Evaluate whether there are alternative ways to identify toxicity

For episodic toxicity:

- Needs to be redesigned
- Need to make sure that it is coordinated with other programs (e.g., CEP)
- Needs to have its own work group that is separate from the winter pilot

4. Information: Setting Priorities for the 2007 Program Plan

Meg Sedlak outlined the process for incorporation of new pilot and special studies into the 2007 RMP. She indicated that the TRC would need to rank the 12 pilot studies as high, medium or low and that she would send out a table with the studies to the TRC after the meeting. She requested that the rankings be submitted by May 1. Based on the current budget projections, approximately $300,000 is available in 2007 for pilot studies.

Ms. Sedlak briefly introduced each of the pilot studies and stated whether the idea had been reviewed by an RMP work group. Each of the authors of the proposals had an opportunity to very briefly outline the importance of their respective projects and to answer questions. Ms. Taberski and Mr. Sommers requested that pilot study # 2 Regional Watershed Monitoring Program be removed from the process as BASMAA and the Regional Board are currently working on a regional permit that may address some of these information needs.

5. Lunch Time Presentation: Recent Bay-wide Changes in Phytoplankton and related Water Quality

Alan Jassby of UC-Davis presented compelling evidence to show that in the last ten years, a significant fall phytoplankton bloom has developed. In addition, during the same time span, primary productivity in the Estuary has doubled. The reasons for this increase in productivity are not clear. Nutrient loading to the Bay has declined significantly over this period. Possible reasons for the increase include: a decrease in suspended sediment from the Delta resulting in a greater availability of light to the water column; upwelling in the Pacific Ocean (which may transport nutrients/algae into the Bay); and variations in the 18-year tidal cycle.

Jim Cloern commented on how significantly different the Estuary is today than what it was when the RMP began monitoring ten years ago.

6. **Update on SWAMP/CEP**

Rainer Hoenicke gave a brief update on the review of the SWAMP program. SPARC, the SWAMP review panel, met late last year to evaluate the program. A variety of recommendations were made including that the regional data gathering nodes such as the RMP be incorporated into the SWAMP program. Jay Davis and SFEI staff have recently completed a report evaluating all of the SWAMP bioaccumulation data. A companion report with recommendations for future Statewide bioaccumulation monitoring will be available soon. Requests for copies of these reports should be made to Jay (jay@sfei.org).

Andy Gunther stated that the CEP is undergoing redesign due to the lack of approval of TMDLs in Region 2. The Technical Committee has been disbanded. The Memorandum of Understanding that created the CEP will expire in September 2006. Andy was uncertain as to whether it would be renewed. However, funding for the joint CEP/RMP coring project has been secured and field work will commence in early May (3^{rd}-8^{th}).

7. **Information: Update on Mallard Island**

Nicole David gave a short presentation on the hydrology and rainfall patterns that resulted in the use of contingency funds to sample at Mallard Island in early January 2006. As a result of high flows in January, water was diverted to the Yolo Bypass to avoid flooding downtown Sacramento. Flows in downtown Sacramento were on the order of 50,000 cfs; corresponding flows in the Yolo Bypass were on the order of 260,000 cfs. The peak flows occurred between January 1st and 4^{th} were a combined flow of approximately 370,000 cfs.

Nicole indicated that the contingency money ($50,000) will be used to pay for the collection of samples and the laboratory analyses of the water samples for mercury, PBDEs, PAHs, PCBs, and selenium.

8. **Action: Inclusion of Cormorants into the Status and Trends Program**

Jay Davis indicated that the cormorant report was not finished and, therefore, it would be pre-mature to move on the recommendation for including the cormorants into Status and Trends at the meeting. He indicated that the report would be completed in the next week or so and that it would be circulated to the EEPS work group for approval and recommendation, to the TRC for approval and recommendation, and to the SC for approval and final incorporation into 2006 Status and Trends program.

Jen Hunt gave a short presentation on the cormorant egg monitoring pilot study. The study has sampled eggs in 2002 and 2004 as part of the exposure and effects pilot study (EEPS). In addition, previous data exists for one site from the CISNET program (1999 through 2001). Two ten eggs composite samples are collected at three sites in the Bay (Richmond Bridge, Don Edwards, and Wheeler Island). Samples were analyzed for PCBs, Hg, pesticides, PBDEs, and selenium. At select sites, concentrations PCBs (lipid normalized) and Hg exceed effectlevels thresholds. PCB concentrations are higher at the Richmond Bridge site (urban and industrial area); Hg concentrations are higher at Don Edwards (closer to Hg sources). No spatial differences were observed for DDT, selenium, or PBDEs. No long term trends are evident from the existing data.

Jay Davis stated that cormorant eggs are an important indicator species that should be included in the Status and Trends program for several reasons: a strong signal; good regional integrator; and indicator of upper trophic level exposure.

A power analyses suggested that there is not a great loss in power between one and two years. Jay recommended that the cormorants be include in the program biennially at a cost of $50,000.

Mike suggested that this recommendation be placed in context with the other biota that the RMP is sampling under both EEPS and Status and Trends. In response to a question from Bridgette DeShields, Jay stated that EEPS has monitored cormorants, terns, seals, and fish.

9. Information: Pulse Update

Jay Davis indicated that the 2006 Pulse was well on its way. The draft layout version of the Pulse will be available in the second week of May. Chris Sommers asked whether the mercury in hair item would be included. Jay Davis indicated that it would be written up; however, if the TRC did not like the article, it could be dropped from the Pulse at that point.

10. Information: Update on Dredging Food Web Modeling Study

John Oram gave an update on the modeling work that has been conducted to date looking at the impacts of dredging on the food web bioaccumulation. John synthesized suspended sediment plume studies, field data from EMAP, RMP and dredgers, and the Gobas bioaccumulation model to determine the impacts of dredging at the point of dredging (dredge site), near field (approximate 2 mile radius from dredge site), mid-field (large segment of Bay) and far field (the entire Bay). John focused on one contaminant (DDT). John observed significant bioaccumulation at the dredge site; a 3% difference in near-field concentrations; a 1 increase in far-field concentrations. John emphasized several constraints of the model (i.e., assumes steady state and continuous long-term exposure).

The results of the model generated substantial discussion. David Dwinelle indicated that Corps studies suggest that there is very little impact from dredging. Bridgette DeShields suggested that the assumptions of the model could be reviewed by Todd Bridges, who has developed bioaccumulation models of dredging. Andy Gunther indicated that the plume at the Alcatraz disposal site dissipates rapidly and to assume continuous exposure is not realistic. Mike Connor suggested that the input parameters to the model must be in error as the results for the dredge site were too high and did not make sense(*aside: further review of the model identified two discrepancies with the inputs; new model runs suggested a 100% increase at the dredge site*).

11. Information: Program Update and Laboratory Data Status

Meg Sedlak passed out a graphic showing that most of the 2004/2005 data have been received. She also highlighted two new work groups/workshops that were mentioned in the work group summaries attachment: the emerging contaminants workgroup and a benthic workshop. The emerging contaminants Science Advisory Panel members are: David Sedlak (UC-Berkeley); Jen Field (Oregon State) and Derek Muir (Environment Canada). The first work group meeting is scheduled for June 1st. Meg Sedlak also mentioned that pursuant to the request by the TRC, Bruce Thompson is organizing a benthic workshop for May 23rd. Karen Taberski and Bridgette DeShields indicate that this may conflict with NorCal SETAC meetings.

The meeting was adjourned at 3:15 pm.

ACTION ITEMS

ACTION	WHO	STATUS
Look into whether recent data on PCB congeners can be provided electronically	David Dwinelle	
Develop a Five-Year Plan for the RMP that addresses management objectives and questions	Jay Davis	To be conducted after preparation of all workgroup five-year plans.
Convene a meeting of the workgroups with TRC to discuss long-term plans	Meg Sedlak/Jay Davis	To be conducted after completion of a five-year plan for RMP
Conduct power analyses of S&T program elements, prepare new table with priorities and potential recommendations	Meg Sedlak/Jay Davis	To be conducted next quarter.
Convene a meeting of the winter sampling and episodic work groups	Meg Sedlak	
Convene a work group to evaluate benthic assessment methodologies and to achieve consensus on appropriate methodologies to use (~$10,000). Upon completion of this task, Bruce Thompson will prepare an EEPS work plan for benthos (~ $40,000) for approval by the TRC.	Bruce Thompson	

REGIONAL MONITORING PROGRAM FOR TRACE SUBSTANCES
STEERING COMMITTEE MEETING MINUTES
April 17th, 2006

Members Present:

Dave Allen,USS POSCO Industries
Kevin Buchan, WSPA
Beth Christian, RWQCB
Ellen Johnck, Bay Planning
Adam Olivieri, EOA
Brian Ross, USEPA
Chuck Weir, East Bay Dischargers Authority
Dyan Whyte, SFB RWQCB

Others Present:

Mike Connor, SFEI
Jay Davis, SFEI
Meg Sedlak, SFEI

1. Approval of Agenda and Minutes

Kevin Buchan opened the meeting and asked for comments on the January 2006 minutes. Meg Sedlak briefly outlined the status of several action items from the January meeting. With regard to the USGS sampling stations, Ellen Johnck had indicated that the members of the Bay Planning Coalition were very interested in continued funding of the Alcatraz site. Ms. Sedlak indicated that the Loch Lomond fees for 2004 had been written off per a recommendation from legal counsel at the RWQCB. Bruce Thompson has organized a benthic workshop for May 23rd at the RWQCB. Minor editorial clarifications were requested of the minutes and the minutes were approved. Mike Connor, Dyan Whyte, and Meg Sedlak had not met to discuss the outstanding CalTrans fees and means for getting this money to the RMP.

Action: Mike Connor, Dyan Whyte and Meg Sedlak to meet to discuss CalTrans fees.

2. Committee Member Updates

Dyan Whyte gave an update on Water Board TMDL activities. The Napa River TMDL for Pathogens will be considered for adoption on June 3rd /4th. The Hg TMDL is undergoing public comment. Documents related to the Hg TMDL are posted on the RWQCB web site.

3. Information: Technical Review Committee (TRC) Meeting Summary

Meg Sedlak summarized the minutes from the TRC meeting on March 29, 2006. Ms. Sedlak indicated that the major items were: a discussion of information needs for the Status and Trends (S&T) program from the RMP participants; a discussion of the 2007 Pilot and Special Studies (PS/SS); and a presentation of the results of the cormorant egg surveys in 2002 and 2004 and consideration of possible inclusion of this element in the 2006 program. Dyan Whyte asked whether the 2006 sport fish program would be eliminating species that were important for regulatory review xx and emphasized the need for the five species that are most popular for consumption, as indicated in the mercury TMDL. Jay Davis indicated that he would review this to confirm that none had been dropped.

Ms. Sedlak briefly described the 11 pilot and special study ideas that had been received to date. Approximately $300,000 is available for PS/SSs in 2007.

A RMP technical report on the cormorant egg monitoring pilot has been circulated to the TRC. To date, this monitoring has occurred biennially (2002 and 2004) with sampling at three locations in the Estuary. The EEPS advisory panel has recommended that sampling occur triennially. Contaminants of interest include: PCBs, Hg, pesticides, PBDEs, and Se. Cormorants are important because they are piscivores that indicate exposure at the top of the food chain. The cost is estimated to be approximately $50,000. The TRC and EEPS advisory panel are reviewing the recommendation to incorporate cormorants into S&T.

Action item: Jay Davis to confirm that the sport fish sampled meet the regulatory needs of the Water Board.

4. Information: Budget Status

Ms. Sedlak reviewed the RMP budget summary memorandum. The 2005 revenues exceeded the expenditures. Ms. Sedlak indicated that revenues were higher as a result of increased revenue from dredgers ($108,000) and increased revenue from interest on RMP funds (the 2005 budget initially projected revenue of $35,000 from interest; actual interest received was $103,136). Expenditures were less than projected as a result of decreased labor costs ($61,000 less than expected) and unspent funds that were set aside for episodic toxicity (~$100,000). Several labor tasks were initiated late in 2005 (e.g., small fish project and the 2003 sport fish final report) and were not completed in 2005.

A request was made to carry over the 2005 labor funds over as specific line items in the 2006 budget and to carry over the unspent subcontracts and direct cost as unallocated revenue. Ms. Sedlak presented a revised 2006 budget with the increase revenue from unspent 2005 funds (i.e., $61,394 unspent labor, $135,638 in unallocated subcontract funds, and $3,914 in unspent direct costs). Projected revenue for 2006 is $3,519,507.

Ms. Sedlak then presented to the Committee the new line item expenditures from the budget that was presented in January 2006. Ms. Sedlak showed $61,000 to complete 2005 carryover tasks, $50,000 for the power analyses for Status and Trends, and $50,000 for replenishing the contingency funds that were spent to sample the high flows in January. Jay Davis stated that the request for funds for the power analyses was made by the TRC as part of the review of the Status and Trends program. Ms. Whyte questioned why there was a line item for manuscript writing; Jay Davis and Meg Sedlak clarified that this was associated with specific tasks. Meg Sedlak will update the Detailed Workplan for 2006 to specifically indicate which tasks will include manuscript preparation.

Chuck Weir indicated that episodic toxicity might be tied to application of pesticides and runoff. Mr. Weir was interested in correlating the applications of pesticide to water quality. Meg Sedlak stated that Pesticide Action Network North America (PANNA) was developing a database of water quality and pesticide application. Chuck Weir asked that RMP staff follow-up on this.

A motion for approval of the revised 2006 budget was made by Chuck Weir; seconded by Adam Olivieri and the revised 2006 budget was approved by the Committee.

Ms. Sedlak reviewed outstanding fees for 2006, 2005, and 2004. Outstanding invoices for 2006 total $296,457 and included EBDA ($113K), South Bayside ($27K), Phillips 66 ($47K) and CalTrans ($70K). Outstanding participant fees for 2005 totaled approximately $60K, largely due to CalTrans ($35K) and City of Vallejo Marina ($21K). SFEI is working with the Vallejo Marina to obtain the fees. With regard to 2004, Ms. Sedlak indicated that based on legal counsel with the RWQCB, Loch Lomond Marina fees were written off in the first quarter of 2006 ($19,622). As a result of the bankruptcy settlement, stock was received for the 2004 Mirant fees owed ($4,519). RMP will sell these shares and the revenues will be used to offset the fees.

Adam Olivieri suggested that the Program consider an alternative way of accounting in which each year is treated separately. This item will be revisited at the next Committee meeting.

Action items: Meg Sedlak to investigate PANNA's pesticide application/water quality monitoring data base and provide the Steering Committee with an update. Meg Sedlak will update the Detailed Workplan for 2006 to specifically indicate which tasks will include manuscript preparation.

5. Action: Discussion of Short-term Investment of RMP fees

Mike Connor stated that RMP fees are currently held in a Local Agency Investment Fund (LAIF). In effort to identify means for squeezing more dollars out of the Program, he suggested that a portion of the RMP fees be placed in Certificates of Deposit managed by Wells Fargo Brokerage Services (WFBS), which depending on the interest rates offered by LAIF and WFBS might result in an increase in revenue to the program of $15,000 to

$30,000. Dr. Connor explained that the financial risk with WFBS was slightly higher than the LAIF; however, the financial committee generally considers CDs to be one of the safest securities.

The Committee was in agreement that this was a sensible way to increase Program revenues. Ellen Johnck motioned for approval; Chuck Weir seconded and the motion passed.

6. Information: Pulse Outline and Annual Meeting

Jay Davis presented a revised outline of the Pulse. There was some discussion of the article on Hg in Hair. Jay indicated that this topic provides important context for interpreting the exposures that occur through consumption of Bay sport fish. He indicated that the item would be written in a balanced manner but if the Committee did not find it appropriate that it could be easily dropped.

7. Discussion: Agenda for Annual Meeting

Jay Davis presented a tentative outline of speakers for the annual meeting in September. The theme for the meeting is Adapting Monitoring to Changing Management Needs. Dr. Davis indicated that the meeting would address emerging contaminants and he proposed the following speakers/topics: Don Weston (pyrethroids), Jim Cloern (changes in water quality in the Bay), Daniel Oros (PBDEs), Jay Davis (PCBs), Fred Hetzel (PCB TMDL). A suggestion was made that under the panel discussion of RMP Status and Trends Monitoring that the following individuals be included on the panel: Bridgette DeShields, Dave Tucker, Ellen Johnck, Karen Taberski, and Chris Sommers.

Chuck Weir indicated that he was particularly interested in emerging contaminants and how to avoid future legacy contaminants. A suggestion was made that Kelly Moran speak at the meeting on the topic of pollution prevention.

Dyan Whyte thought that the session regarding redesigning the S&T program might be a little dry for the end of the day.

8. Information: Discussion of Projected Future Loss of Dredging Fees

Brian Ross and Beth Christian gave a presentation on the reduction of dredging disposal in-Bay and its financial implications to the RMP. The long-term management goal for the Bay is to reduce the amount of dredged material disposal in the Bay to approximately 1.2 million cubic yards per year. In 2005, the annual amount of material dredged from the Bay was approximately 3.4 million cubic yards.

Brian and Beth noted that although it appeared that the intent of the new dredger fees implemented in February 2005 was to give small volume dredgers a break through the use of a sliding fee scale, in fact because the dredging occurs infrequently, the volume is typically greater than the highest sliding fee structure (i.e., greater than 55,000 cubic yards) and the dredger is assessed at the highest fee, 0.4 cent per cubic yard. There was some discussion of this issue. It was suggested that the small dredgers be invoiced annually; however, this had been proposed and none of the dredgers were interested in pursuing this. Mike Connor noted that the small dischargers were often the ones who resulted in substantial RMP administrative costs as they were frequently delinquent on fees.

Brian and Beth noted that much of the material dredged in the Bay would likely go to upland disposal as part of wetland restoration projects (e.g., Hamilton air field site) or ocean disposal. Brian stated that the Hamilton site would receive 25 million cubic yards over 15 years and as a result in-Bay disposal at sites SF-10 and SF-9 would largely cease. It is possible that the upland disposal projects could be billed as in-Bay disposal; however, available funds from the Army Corps might be limited.

There was some discussion of having the wetland restoration projects contribute to the RMP as the environmental issues associated with these projects are strongly linked to the Bay (e.g., methylation of mercury that occurs in wetlands).

Mike Connor suggested that Shelah Sweatt, Beth Christian, Dyan Whyte, Ellen Johnck, Meg Sedlak, and he meet to discuss this issue.

Action: Meg Sedlak to organize a meeting with Shelah Sweatt, David Dwinelle, Beth Christian, Dyan Whyte, Ellen Johnck, and Mike Connor to discuss how to address the revenue shortfall associated with reduced in-bay disposal.

9. Action: Maintenance of a Reserve for the RMP

Meg Sedlak proposed that the RMP maintain a small portion of its funding in a reserve pool to cushion unexpected financial shortfalls that may occur as a result of shortfalls in revenue (e.g., shortfalls in dredger fees, decreases in interest rates), changes in program elements, or difficulties in transferring state funds to the RMP. Ms. Sedlak proposed $200,000 in reserve for discussion purposes. She noted that surpluses remain from 2003, 2004, and 2005 totaling approximately $146,000. Surpluses in future years would be added to the fund until it reached $200,000.

Steering Committee members approved the maintenance of a $200,000 reserve.

10. Information: Program Update

Meg Sedlak handed out the Scorecard and noted that a major deliverable this quarter had been completion of SPLWG reports. The date for the next SC meeting was tentatively scheduled for July 17th, 2006. Committee members also proposed the following dates for future SC meetings October 16th and January 15th.

The meeting was adjourned at 3:00 pm.

To: RMP Technical Review Committee
From: Ben Greenfield, SFEI
Contact Info: Ben@SFEI.org, 510-746-7385
Subject: Focus of 2006 RMP Power analysis

The Technical Review Committee has asked RMP staff to undertake power analysis to evaluate the cost effectiveness and statistical power of the RMP status and trends monitoring design. We have begun these analyses and plan on completing them by the Fall Technical Review Committee meeting. The purpose of this memo is to communicate our current thinking on the power analysis, and make sure the direction is consistent with the interests and concerns of RMP stakeholders. At the June 27 meeting, feedback will be solicited on whether the approach is consistent with TRC understanding of priority uses for the Status and Trends data set. Feedback may also be provided outside the meeting by contacting me directly.

The results of power analysis are entirely dependent on the questions asked and the specific assumptions incorporated into the analysis. The power analysis is currently scoped to evaluate the power using the RMP data set for two scenarios (Table 1). The first scenario is comparison of the RMP data to thresholds of management significance. This is essentially analogous to the previous power analysis (Lowe *et al.* 2004), with the difference that updated thresholds and data are used. This analysis only focuses on thresholds of management significance for the Bay. These include California Toxics Rule water quality criteria, TMDL thresholds, and segment specific objectives used in regulatory decision-making (Table 2). The second scenario is an evaluation of the ability of the RMP sampling design to detect long-term trends. The specific question that will be addressed can be summarized as follows, "*given an expected rate of decline over a specified time frame, what is the ability of a sampling design to detect a significant negative trend.*" To address this question, we have developed a Monte Carlo simulation program that simulates declining concentrations with variability estimated based on current RMP data. The program then determines the proportion of results that would be statistically significant declines, using linear regression analysis. Results using this program will be presented at the June 27 meeting.

The focus of the power analysis, as currently scoped, will be on compounds that are of current high management priority for the Bay, and compounds expected to represent management concerns for the future. Compounds of current high management priority include PCBs, Hg, copper, and nickel (Table 1). Although there are many new compounds detected in bay waters and sediments, data collection on these compounds is very limited to date (Oros *et al.* 2003). Of the compounds of future concern, only PBDEs currently have sufficient local monitoring data to be effectively evaluated using power analysis. Therefore, the evaluation of potential concerns for the future will focus on PBDEs.

To ensure that the analyses represent up-to-date management priorities and concerns of RMP participants, I have prepared a bulleted listing that summarizes the key questions and plans for these analyses. This listing incorporates the feedback of RMP scientists, Regional Board staff, and scientist representing the city of San Jose[1].

Water

- The water power analysis will focus primarily on comparing results from individual segments to key thresholds (Table 1).
    - These thresholds may be basin specific (Cu and Ni) or California Toxics Rule (other compounds) (Table 2).
    - For many compounds, concentrations are consistently well below these thresholds. The threshold comparison power analyses will therefore emphasize compounds observed to exceed current thresholds (Table 3).
- A key focus of the analysis will be whether samples should be reallocated among segments. The last power analysis, driven by copper, put a large number of sites in South Bay/Lower South Bay. Should this be changed to a more spatially balanced design?
    - Determine # samples required to distinguish individual segments from thresholds
    - Use variance estimates that account for spatially stratified probabilistic survey design (following Lowe *et al.* 2004).
- For mercury, the analysis will also evaluate power for temporal trend detection with the water sampling design. Mercury is chosen for this because it currently has a TMDL objective based on water column concentrations (Table 2). For most compounds, trend evaluation won't be a priority because water is not expected to be a particularly useful indicator of trends.

Sediment

- Question #1: Can we reduce the number of sites in any of the segments and maintain reasonable power?
- Question #2: What power do we have for temporal trend detection with our sediment sampling design?
    - Sediments are also not the best indicator of trend, given mixing of deep sediments (Fuller *et al.* 1999). So the sediment trend evaluation should be interpreted with caution.
- Water Board staff[2] did not present any relevant sediment concentration thresholds of concern in current Bay wide regulatory evaluations. ERLs and ERMs (Long *et al.* 1995) are more of a diagnostic benchmark, rather than a target objective. Furthermore, none of the TMDLs have sediment targets (Hg has a target in Total Suspended Sediments, which is actually calculated from water data). So it appears that the sediment data aren't routinely used for any kind of threshold-based status evaluation. Thus, sediments won't be compared to thresholds in the first set of evaluations.

[1] The city of San Jose contacted us to discuss the RMP power analysis in relation to their compliance monitoring for copper and nickel.
[2] Richard Looker, Karen Taberski, and Fred Hetzel, *pers. comm.*

- Further sediment evaluations may be conducted in consulting with Don Stevens (who aided in the statistical approach developing the initial monitoring designs).
- The statewide Sediment Quality Objectives program is developing a multiple line of evidence approach that will be relevant for future sediment evaluations. This approach may include specific guidance on sediment sampling design or numeric chemistry criteria, which may be used in future sediment power analyses.

Bivalves

- Water Board staff indicated that bivalves are predominantly used to evaluate trends. Therefore, trend evaluation will be the focus of the bivalve analysis (Table 1).
- Key question: How much power would be lost by switching from annual sampling to biennial or triennial sampling?

Sport Fish

- Sport fish are actually used quite actively by the Regional Board for status and trend evaluation. In particular, they are targets for the Hg and PCB TMDLs.
    - Note that the Hg TMDL thresholds are length-adjusted.
- Question #1: How much power would be lost by going from triennial sampling to less frequent sampling? E.g., every 4, 5, or 6 years.
- Question #2: How much power would be lost or gained by switching from triennial sampling to collection of a very large number of samples, waiting a long time period (e.g., 10 years), and then collecting a new batch of samples.

Small fish

- Small fish Hg collections are currently in the pilot study phase. Small fish may be incorporated into Status and Trends monitoring to evaluate potential wildlife exposure and temporal trends.
- Threshold comparisons will focus on the TMDL target for Hg in small fish (0.03 μg/g; Table 2).
- As only one year of data has been collected, ability to detect long-term trend will not be the focus of present analyses.

Cormorant Eggs

- Cormorant eggs are a relatively new component of RMP monitoring, and their use in status and trend evaluation is likely to be similar to sport fish.
    - Because there are limited data on cormorant egg contaminant residues, power analyses on them will be somewhat limited in scope.
- Question #1: What is the effect of different sampling designs on power to detect temporal trends?
- Question #2: What is the effect of different sampling designs on power to detect spatial patterns?

Table 1. Priority analyses and compounds. Trend Analysis: Evaluate power to detect trend given the rate and time frame. Threshold Analysis: Evaluate power to detect whether concentrations in a given year are above or below the threshold of concern.

	Trend analysis		**Threshold analysis**	**Priority analyses:**					
Compound	**Time frame**	**Change rate of interest**	**Relevant thresholds for current comparison**	**Water (total)**	**Water (dissolved)**	**Sediment**	**Bivalves**	**Bird eggs**	**Sport fish**
PBDEs	10, 20, 100 yr	20%, 50%, To reach thresholds				Trends	Trends	Trend	Trends
PCBs	10, 20, 100 yr	20%, 50%, To reach thresholds	PCB TMDL (fish tissue), CTR (total PCBs in water)	Threshold		Trends	Trends	Trend	Threshold/ Trends
Mercury	10, 20, 100 yr	20%, 50%, To reach thresholds	Hg TMDL (sediment, small fish, sport fish), CTR (water)	Threshold (1)/ Trends		Trends	Trends	Trend	Threshold/ Trends
Copper	No trend work	No trend work	Revised thresholds (dissolved - 6 and 6.9)	Threshold (2)	Threshold				
Nickel	No trend work	No trend work	Revised thresholds (dissolved - 11.9)	Threshold (2)	Threshold				
Lead	No trend work	No trend work	Maybe CTR (occasional exceedances)	Threshold (2)	Threshold				

1. Note that the Hg TMDL requires evaluation of an Hg in TSS calculation, which should be used for the water evaluation
2. These compounds appeared to exceed some CTR thresholds for total in water, based on the RMP annual monitoring results, but I'm not sure how important these thresholds are.

Table 2. The thresholds of management significance for RMP stakeholders and the Regional Board. These will be used both in threshold analyses, and in determining the power to declare a declining trend sufficient to reach thresholds.

Compound	**Matrix**	**Threshold**	**Source and basis**	**Segments**[3]
Cu	Dissolved H20	6.9 µg/L	Tom Hall, Richard Looker, Peter Schafer, *pers. comm.* Revised Cu guidelines.	LSB
Cu	Dissolved H20	6.0 µg/L	Revised Cu guidelines.	SB, CB, SPB, SU
Hg	Total in TSS	0.2 ng/g (ppb) dry sediment	2006 TMDL Draft Basin Plan Amendment. Appendix A. Pg. 7	All
Hg	Sport Fish	0.2 µg/g (ppm) wet	2006 TMDL Draft Basin Plan Amendment. Appendix A. Pg. 4	All
Hg	Small Fish	0.03 µg/g (ppm) wet	2006 TMDL Draft Basin Plan Amendment. Appendix A. Pg. 4	All
Ni	Dissolved H20	11.9 µg/L	Tom Hall, Richard Looker, Peter Schafer, *pers. comm.* Revised nickel guidelines.	LSB
Ni	Dissolved H20	8.2 µg/L	Revised nickel guidelines.	CB, SPB, SU, SB
PCB	Total in Water	170 pg/L	CTR to protect human health	All
PCB	Sport Fish	10 ng/g (ppb) wet	PCB TMDL. Fred Hetzel *pers. comm.*	All

[3] Abbreviations for Bay segments in this document follow RMP conventions: SU – Suisun Bay, SPB – San Pablo Bay, CB – Central Bay, SB – South Bay, LSB – Lower South Bay.

Table 3. Compounds observed to exceed management thresholds in recent RMP monitoring. These will be the focus of the threshold component of the power analysis. Results are based on evaluation of Annual Monitoring Results (SFEI 2005).

Matrix	Constituent	Threshold (µg/L)	Threshold type	2002/2003 Number exceedances	N	Location of Exceedances
Water	Total Copper	3.7	"non-regulatory saltwater effects threshold"	15	60	SU, SPB
Water	Total Lead	3.2	"non-regulatory freshwater effects threshold"	3	60	SPB, LSB
Water	Total Hg	0.051	"lower South Bay site specific objective"	1	11	LSB
Water	Total Hg	0.025	"regulatory objective"	2	49	SPB
Water	Total Ni	7.1	"non-regulatory effects threshold"	4	49	SU, SPB
Water	Total Sum PCBs	0.17	"human health criterion"	54	60	All Segments

References cited:

Fuller, C. C., A. van Geen, M. Baskaran, and R. Anima. 1999. Sediment chronology in San Francisco Bay, California, defined by 210 Pb, 234 Th, 137 Cs, and 239,240 Pu. Marine Chemistry **64**:7-27

Long, E. R., D. D. MacDonald, S. L. Smith, and F. D. Calder. 1995. Incidence of adverse biological effects within ranges of chemical concentrations in marine and estuarine sediments. Environmental Management **19**:81-97

Lowe, S., B. Thompson, R. Hoenicke, J. Leatherbarrow, K. Taberski, R. Smith, and D. Stevens, Jr. 2004. Re-design Process of the San Francisco Estuary Regional Monitoring Program for Trace Substances (RMP) Status & Trends Monitoring Component for Water and Sediment. SFEI Contribution 109, SFEI, Oakland, CA. http://www.sfei.org/rmp/rmp_docs_author.html

Oros, D. R., W. M. Jarman, T. Lowe, N. David, S. Lowe, and J. A. Davis. 2003. Surveillance for previously unmonitored organic contaminants in the San Francisco Estuary. Marine Pollution Bulletin **46**:1102-1110

SFEI. 2005. 2003 Annual Monitoring Results. The San Francisco Estuary Regional Monitoring Program for Trace Substances (RMP). San Francisco Estuary Institute (SFEI), Oakland, CA. http://www.sfei.org/rmp/2003/2003_Annual_Results.htm

							TRC Reviewer						
PS/SS Proposal	**Budget**	**Allen**	**Prall**	**DeShields**	**Hall**	**Kellogg**	**Rodigari**	**USEPA***	**Sommers**	**Taberski**	**Tucker**	**Total**	**Comments**
							(deferred ranking)						
1. Small Tributary Loading	$154,000	2	3	3		3		3	3	3	3	23	
2. Guadalupe River Watershed Model	$30,000- $60,000	1	2	3		1		3	2	1	1	14	
3. SW Sewershed Outfall Sampling	$20,000 - $100,000	2	3	2		1		2	1	2	1	14	
4. Cont. Fate and Bioacc. Model	$55,000 - $90,000	1	2	3		3		1	1	3	1	15	
5. Effects of EDC on Bay Biota	$100,000 - $250,000	1	3	2		2		2	1	3	1	15	**BRD:** Cost seems high when we are not sure of the level of concern for these compounds - could there be a lower level of effort study initially? **KT**: High but try funding through EEPS and scaling down price
6. Water Toxicity to Ambient Biota	$60,000	1	3	1		1		2	1	2	1	12	
7. Pyrethroids in SF Bay	$50,000	3	2	2		3		2	1	3	3	19	**KT**: High priority but fund thru Episodic Tox.
8. Hg Isotopes as Source Indicators	$60,000	1	1	1		1		3	2	1	1	11	**BRD**: Not sure how this will benefit TMDL process
9. Emerging Contaminants; PFOS in SF Bay and Pharmaceuticals	$60,200	3	2	2		3		3	1	3	2	19	Recommendation from Emerging Contaminant Workgroup to fund
10. Remote Sensing of Sed. Transport	$10,000	1	2	3		3		2	1	3	1	16	
11. Hg in Human Hair	$6,000	1	1	1		1		3	1	1	1	10	**BRD**: Not sure of how this would impact management decisions - seems like other factors (not related to SF Bay exposure) are reflected in this type of study
12. Metals and Organics in Small Fish	$60,000?												

Please rank the projects by priority: High, Medium or Low
3- Highest --> 1 - Lowest

*Ranking in the EPA column is a result of averaging rankings from Nancy Yoshikawa, Diane Fleck, Karen Schwinn and Luisa Valiela, with the understanding that a low ranking does not mean that we think that it shouldn't be done but we would be okay with it being deferred to another year given other priorities.

STUDY X.X.X Small Tributaries Loadings Study in Zone 4-Line A

Estimated Cost: **$154,300**

Oversight Group: Sources Pathways & Loadings Work Group

PROPOSED DELIVERABLES AND TIME LINE

Deliverable	Due Date
Task 1. Invoicing, budget tracking, meetings, emails, phone calls, field personnel coordination	12/31/07
Task 2. Field equipment installed	9/30/06
Task 3. Raw discharge and turbidity data available for WG discussions	4/30/07
Task 4. Finalized contaminant data provided by the Labs to the RMP data management group	7/1/07
Task 5. Finalized, discharge, turbidity, and SSC data provided to RMP data management group	7/1/07
Task 6. RMP internal QA completed, data formatted	9/1/07
Task 7. Draft report, SPLWG review, final report	12/31/07
Task 8. Expense forms submitted monthly	12/31/07

BACKGROUND

This project aims to implement a 2nd *Small Tributaries Loading Study* in an observation watershed. Davis et al. (2000) recommended that six observation watersheds picked on the basis of land use. This long standing recommendation by the SPLWG was endorsed by the WG during 2005 and written into the SPLWG 5-year Work Plan (McKee, 2005). To-date, most information on the functioning of small tributaries in the Bay Area is based on water and sediment data collected by the USGS. During WY 2003-2006, the SPLWG oversaw the 1st *Small Tributaries Loading Study* on the Guadalupe River (McKee et al., 2004, 2005, 2006) chosen based on recommendations by Leatherbarrow et al. (2002). During 2005, the SPLWG oversaw a small pilot reconnaissance study of small tributaries in an effort to make a decision on where to begin a 2nd *Small Tributaries Loading Study*. Given that historic and current industrialized areas are found mainly on the lower-rainfall Bay margin, the SPLWG decided to recommend a small industrial watershed. Through a process of voting and WG discussion, Zone 4 Line A was chosen. Study of this small 4 km^2 area in industrial Hayward will provide valuable information on loads derived from small, low rainfall, but highly impervious, commercial and industrialized “storm drain watersheds” on the Bay margin. This is particularly important for updating regional TMDL estimates of Hg and PCBs loads derived from urban runoff. In addition, loadings studies will provide baseline data so that trends through time can be assessed, and provide data for models that describe biological effects in the Bay.

APPLICABLE RMP OBJECTIVES AND MANAGEMENT QUESTIONS

Q1. Describe the distribution and trends of pollutant concentrations in the Estuary (c)

Q2. Project future contaminant status and trends using best understanding of ecosystem processes and human activities (d,e,f,h,j)

Q3. Describe sources, pathways, and loading of pollutants entering the Estuary (e,f,g,h)

APPROACH

The team will consist of SFEI scientists and Rand Eads (RiverMetrics LLC) who worked with us on the Guadalupe River Study. Field data will be collected during the wet season

(October-April) when about 95% of the loads are transported in Bay Area drainages. We will use the "Guadalupe River *Small Tributaries Loading Study"* protocol modified to suit the characteristics of Zone 4 Line A (Figure). This will include real-time turbidity and stage (or velocity) measurement provided on the internet, ISCO automatic sampling equipment (given expected response time of 15 minutes and for overnight hours – see below), SFEI field sampling for velocity, SSC, trace contaminants, and POC and DOC. Zone 4 Line A is located in the City of Hayward. Samples will be taken downstream from Cabot Blvd. The channel is a straight engineered channel, flowing through a single barrel concrete box culvert under Cabot Blvd. The concrete culvert bed and wingwalls extend 3 m from the culvert, but elsewhere the bed is natural. Downstream the bank slopes are approximately 3:1 with concrete slabs armoring the base of the banks. A sidewalk exists on both the upstream and downstream sides, but the downstream side is preferable because there is channel maintenance scheduled that may disrupt our equipment. Sampling equipment (Marsh-McBirney velocity meter and a DH 81 fitted with Teflon lab prepared TM clean components) will be deployed from the foot bridge that we will install about 30 m downstream from Cabot Blvd. The turbidity probe would be mounted on the downstream side of the foot bridge. We have discussed obtaining an encroachment permit with Arleen Feng (Alameda County Public Works Agency, Clean Water Division) and will meet the County engineer to discuss the project in June. The surrounding area is an industrial office park, with semi-truck traffic and low crime potential during the day, but may not be ideal during nighttime hours. Field staff will work in a team of at least two during the day. The automatic sampler (ISCO or similar) will do most of the work during darkness.

A)


B)


C)


D)


A) Downstream side of the concrete single barrel culvert. B) Downstream side sidewalk and fence. C) Looking downstream. D) Looking upstream.

TIME SENSITIVITY
Proposed start date: October 1st 2006

TASK DESCRIPTIONS
Task 1 Project management
Carry out all fiscal management, team coordination, and problem solving. Given the field-based nature of this project, we have anticipated and budgeted for problem solving to ensure the highest data retrieval rate during the initial phases of the study when most problems are likely to occur. Given the diversity and experience of the team (River-Metrics and SFEI), the specificity of the tasks, and the interrelationships between tasks, staff hours have been budgeted to maintain close communication during the field season.

Task 2 Sampling equipment purchase, prefabrication, installation
To be subcontracted to Ran Eads at RiverMetrics LLC. Order equipment and prefabricate the sampling booms, footbridge infrastructure, field-shelter ready for installation. Meet on-site and install and test equipment.

Task 3 Field Data collection
Collect water samples for analysis of SSC, HgT, HgD, MeHgT, MeHgD, trace metals (Cd, Cr, Cu, Ni, Pb, Zn), DOC, POC, trace organics (PCBs, PBDEs). For Hg and TMs, equipment and sampling procedures will follow accepted trace metal clean protocols. All samples will be collected using a DH-81 depth integrating sampler (that utilizes laboratory trace metal cleaned Teflon components) deployed by hand off the footbridge, labeled and shipped to the lab obeying appropriate holding times (Hg and TMs = 48 hours; organic carbon = 21 days; trace organics = 28 days). Velocity will also be measured in the cross section to calibrate the stage measurements (or if funding allows, to calibrate the point velocity measurements collected using Doppler instrumentation).

Task 4 Laboratory Analysis
4a **Trace Organic compounds -** To be carried out by Todd Fisher at AXYS Analytical
4b **Hg, TMs, SSC, Grainsize -** To be carried out by Autumn Bonnema at Moss Landing Marine Laboratory
4c **DOC, POC -** To be carried out by Ken Davis at Applied Marine Sciences in Texas

Task 5 Turbidity, discharge and SSC, QA and record generation/finalization
To be subcontracted to Ran Eads at RiverMetrics LLC. Provide quality control and quality assurance for the turbidity record. Provide sediment load estimates using SSC data collected by SFEI. Provide SFEI with both corrected and raw data, and quality codes in a spreadsheet format.

Task 6 Data Management
Data will be received from our contracted labs by our RMP data management team within 60 days of the receipt of samples from the field team. Cristina Grosso will log the

receipt of the data and then queue it for the approved RMP data management process. The data will be formatted and routed through the RMP QAQC program.

Task 7 Reporting

A full technical report will be written in at the end of the first year of the study and reviewed by the SPLWG so that the study can be modified in subsequent years based on WG input. The report will follow a standard format (abstract, introduction, methods, results, discussion, and recommendations, references and an appendix of raw data.

Task 8 Travel, shipping, miscellaneous

Costs include mileage, velocity equipment rental or purchase, sample shipping, and any minor miscellaneous expenses.

BUDGET

Activity	Description	Approximate Cost
Task 1	Project management	$10,000
Task 2	Sampling equipment purchase, prefabrication, installation	$25,000
Task 3	Field Data collection	$25,000
Task 4a	Laboratory Analysis (Trace Organic compounds)	$27,200
Task 4b	Laboratory Analysis (Hg, TMs, SSC, Grainsize)	$19,700
Task 4c	Laboratory Analysis (DOC, POC)	$1,000
Task 5	Turbidity, discharge and SSC, QA and record generation/finalization	$5,000
Task 6	Data Management	$11,900
Task 7	Reporting	$27,000
Task 8	Travel, shipping, miscellaneous	$2,500
Total		**$154,300**

REFERENCES

Leatherbarrow, J.E. Hoenicke, R. and McKee, L.J., 2002. Results of the Estuary Interface Pilot Study, 1996-1999, Final Report. A Technical Report of the Sources Pathways and Loading Work Group (SPLWG) of the San Francisco Estuary Regional Monitoring Program for Trace Substances (RMP). San Francisco Estuary Institute, Oakland, CA. March 2002. 90pp.

McKee, L., Leatherbarrow, J., Eads, R., and Freeman, L., 2004. Concentrations and loads of PCBs, OC pesticides, and mercury associated with suspended sediments in the lower Guadalupe River, San Jose, California. A Technical Report of the Regional Watershed Program: SFEI Contribution #86. San Francisco Estuary Institute, Oakland, CA. 79pp.

McKee, L., 2005. Sources, Pathways, and Loadings: Five-Year Work Plan (2005-2009). A Technical Report of the Sources Pathways and Loading Workgroup (SPLWG) of the San Francisco Bay Regional Monitoring Program for Trace Substances (RMP): SFEI Contribution #406. San Francisco Estuary Institute, 30 Oakland, CA. 21pp.

McKee, L., Leatherbarrow, J., and Oram, J., 2005. Concentrations and loads of mercury, PCBs, and OC pesticides in the lower Guadalupe River, San Jose, California: Water Years 2003 and 2004. A Technical Report of the Regional Watershed Program: SFEI Contribution 409. San Francisco Estuary Institute, Oakland, CA. 72pp.

McKee, L., Oram, J., Leatherbarrow, J., Bonnema, A., Heim, W., and Stephenson, M., 2006. Concentrations and loads of mercury, PCBs, and PBDEs in the lower Guadalupe River, San Jose, California: Water Years 2003, 2004, and 2005. A Technical Report of the Regional Watershed Program: SFEI Contribution 424. San Francisco Estuary Institute, Oakland, CA. 47pp+Appendix A, B.

STUDY X.X.X Storm Drain Outfall Sediment Characterization

Estimated Cost: **Option A $56,800 (3 locations)**
Option B $81,150 (5 locations)

Oversight Group: Sources Pathways & Loadings Work Group

PROPOSED DELIVERABLES AND TIME LINE

Activity	Description	Due date
Task 1	Project Management	30-Jun-08
Task 2	Watershed Classification and Aerial Photographic analysis	30-May-07
Task 3	Field Reconnaissance and Final Pick of 5 Watersheds	30-Jul-07
Task 4	Detailed Field Study	15-May-08
Task 5a	Trace Organic compounds	15-Jul-08
Task 5b	HgT, SSC, Grainsize, and bulk density	15-Jul-08
Task 5c	DOC, POC	15-Jul-08
Task 6	Data Management	15-Sep-08
Task 7	Reporting	31-Dec-08

BACKGROUND

This project aims to determine if sediment removal at stormwater outfalls (or depositional zones inside flood channels) on the Bay Margin could remove mass of PCBs and Hg and help to address water quality problems in the Bay. If this method is determined to be suitable, it would provide a watershed scale BMP that would capture many smaller contaminated “hotspots” in a single place – there are few other watershed scale solutions that don’t require space or routing to a treatment facility. Where storm drains discharge to the Bay margin, sediments can build up and form deltaic sediment deposits that contain contaminant mass. In the case of a tidal flood channel, sediment often deposits further upstream at or near the null point of the mixing zone between fresh and salt water. We recently measured one such deposit at the Sausal Creek outfall which had a volume in excess of 6,000 m^3. However, without sampling, it is difficult to know the associated mass of PCBs and Hg. There are many such deposits on the Bay margin and inside the flood control channels. However, there are many unknowns. A potential flaw in this management solution is that the majority of the mass of PCBs and Hg is carried in the very fine grain size fractions that may be tidally reworked and dispersed. Although it is recognized that channel maintenance is an ongoing effort, we will work with BASMAA agencies to determine the cost to implement such a control measure at a frequency that optimizes contaminant removal and provide a cost per unit mass ($/kg PCBs; $/kg Hg) so that the method can be compared with other management options.

APPLICABLE RMP OBJECTIVES AND MANAGEMENT QUESTIONS

Q1. Describe the distribution and trends of pollutant concentrations in the Estuary (c)

Q2. Project future contaminant status and trends using best understanding of ecosystem processes and human activities (d,e,f,h)

Q3. Describe sources, pathways, and loading of pollutants entering the Estuary (c,g)

APPROACH

A screening level survey of a number of these deltas and depositional zones including the measurement of volume, TOC, and grainsize will be used to develop a list of priority sites. A detailed field study of 5 priority sites over a wet season will provide chemistry and morphology information. One of the priority locations for detailed study could be completed at the outfall of a new small tributaries loading study (Zone 4 Line A) to gain an understanding of the portion of load that is stored in it channel (Figure 1).

Figure 1. Aerial photo of the Zone 4 Line A channel and outfall at Hayward Landing. In this case sediment has built up in the channel a lateral bar deposit from the Bay to a distance of 1 km upstream (about 2/3 of the width of this photo image).

Using aerial photographs identify 20 such deposits on the Bay margin and inside flood control channels focusing on industrial watersheds but including a variety of watershed types (Note for the purposes of this study, we have identified 3 primary watershed types (Figure 2)).

Collect 3 cores from each to be analyzed for grainsize, bulk density, and organic carbon. Select 3-5 deltaic deposits that have small grain sizes and high organic carbon present and monitor size over a single wet season to determine dynamics in relation to storm events and tidal processes. Complete laboratory analysis for the TMDL contaminants in the bulk sediment (Hg and PCBs, and other high priority contaminants with TRC consultation). Calculate contaminant mass in each deposit and interpret the data collected with reference to land use, sediment processes and hydrology of the upstream watershed. Consult with stakeholders throughout the pilot study and estimate the cost of removal and disposal of such deposits ($/unit mass of contaminant).

TIME SENSITIVITY

Proposed start date: March 15th 2007

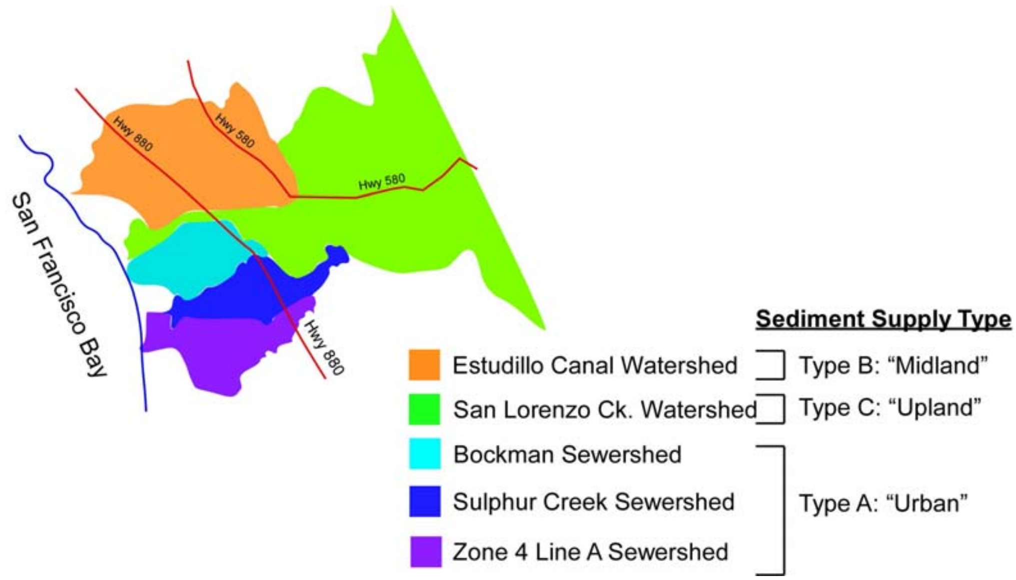


Figure 2. Watershed classification for contaminant loading studies – Example (Hayward). Watershed Type A: Urban industrial sediment supply only – no upland areas providing "clean sediment"; Watershed Type B: Sediment supply from industrial areas and additional sediment supply from residential areas in the foothills; Watershed Type C: Sediment supply dominated by "clean" upland sediment supply sourced from open space and low density residential areas of the upper watershed.

TASK DESCRIPTIONS

Task 1 Project management

Carry out all fiscal management, team coordination, and problem solving. Given the field-based nature of this project, we have budgeted for development of the field protocols and logistical issues.

Task 2 Watershed Classification and Aerial Photographic analysis

Classify watersheds into Type A, Type B, and Type C and consult with BASMAA stakeholders to pick 30 candidate watersheds / sewersheds around the Bay margin from Richmond to South San Francisco (Note Marin and Vallejo/Benicia are excluded at this time due to a lack of storm drain maps). Use aerial photo images to make a first cut on 20 watersheds where a reconnaissance will be completed.

Task 3 Reconnaissance and final pick of 5 watersheds

Complete 5 days of fieldwork to identify logistical issues, photograph sites and identify limits of tide, fence structures, levee banks, channel vegetation types etc. At each site collect 3 cores ready for analysis for grainsize, bulk density, and organic carbon. Present results to BASMAA, discuss jurisdictional issues and choose 5 channels or outfalls for detailed field study.

Task 4 Detailed Field Study

On four occasions over the wet season (after storms) measure the morphology of the deposits to determine processes of deposition. One month after the wet season (May or June) complete a final survey of morphology and take 3 cores from the deposit ready for analysis for grainsize, bulk density, organic carbon, HgT, PCBs, and PBDEs.

Task 5 Laboratory Analysis

4a **Trace Organic compounds -** To be carried out by Todd Fisher at AXYS Analytical

4b **Hg, SSC, Grainsize, and bulk density -** To be carried out by Autumn Bonnema at Moss Landing Marine Laboratory

4c **DOC, POC -** To be carried out by Ken Davis at Applied Marine Sciences in Texas

Task 6 Data Management

Data will be received from our contracted labs by our RMP data management team within 60 days of the receipt of samples from the field team. Cristina Grosso will log the receipt of the data and then queue it for the approved RMP data management process. The data will be formatted and routed through the RMP QAQC program.

Task 7 Reporting

A full technical report will be written and reviewed by the SPLWG. The report will follow a standard format (abstract, introduction, methods, results, discussion, and recommendations, references and an appendix of raw data.

Task 8 Travel, shipping, miscellaneous

Costs include mileage, velocity equipment rental or purchase, sample shipping, and any minor miscellaneous expenses.

BUDGET

Option B (Favored option)

Activity	Description	Approximate Cost
Task 1	Project Management	$8,000
Task 2	Watershed Classification and Aerial Photographic analysis	$4,240
Task 3	Field Reconnaissance and Final Pick of 5 Watersheds	$7,200
Task 4	Detailed Field Study	$10,880
Task 5a	Trace Organic compounds	$10,500
Task 5b	HgT, SSC, Grainsize, and bulk density	$6,050
Task 5c	DOC, POC	$1,200
Task 6	Data Management	$11,900
Task 7	Reporting	$18,680
Task 8	Travel, shipping, miscellaneous	$2,500
Total		$81,150

Using a coupled contaminant fate and bioaccumulation model to evaluate food web uptake for PCBs and PBDEs

Ben K. Greenfield, John Oram, and Andy Jahn

Project Cost Range: $20,000 – $96,000

Oversight Group: Contaminant Fate Work Group, Technical Review Committee, Regional Board

PROPOSED DELIVERABLES AND TIME LINE

Deliverable	**Due Date**[1]
Task 1. Synthesize information on food web pathways	September, 2007
Task 2. Run coupled fate and bioaccumulation models – PCBs	September, 2007
Task 3. Parameterize and run models – PBDEs	October, 2007
Task 4. Technical report of findings	December, 2007

APPLICABLE RMP OBJECTIVES AND MANAGEMENT QUESTIONS

1. Describe the distribution and trends of pollutant concentrations in the Estuary

c. How are contaminant patterns and trends in the Estuary over time affected by remediation and source control or pollution prevention in the watersheds?

e. What effects on beneficial uses or attainment of Water Quality Standards will occur due to large-scale habitat restoration in the Estuary in decades to come?

2. Project future contaminant status and trends using best understanding of ecosystem processes and human activities

a. Can reasonably accurate recovery forecasts be developed for major segments and the Estuary as a whole under various management scenarios?

b. Can potential impairment and degradation be better anticipated in the face of projected changes in land and water use and management, as well as product use and disposal?

e. How will the importance of each pathway change through time under various management and development scenarios?

f. What are the likely consequences of various management actions or risk reduction measures?

3. Describe sources, pathways, and loading of pollutants entering the Estuary

h. What is the relative importance of pollutant loadings from different sources and pathways, including internal inputs, in terms of beneficial use impairment?

4. Measure pollution exposure and effects on selected parts of the Estuary ecosystem (including humans)

b. Which (co-)factors (e.g., food web structure) influence exposure and effects of specific pollutants on biota?

c. What ecological risks are caused by pollutants of concern?

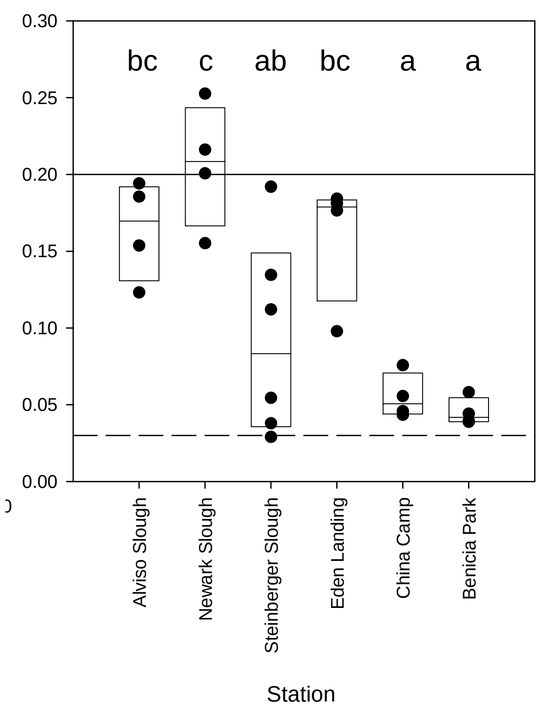
6. Effectively communicate information from a range of sources to present a more complete picture of the sources, distribution, fate, and effects of pollutants and beneficial use attainment or impairment in the Estuary ecosystem

[1] Note that the majority of analyses for this study would be conducted in the Fall/Winter season, to provide sufficient time in the Spring/Summer to collect dietary data in the field

BACKGROUND

One of the key issues identified in recent field studies is the potential for substantial spatial variation in wildlife exposure to PCBs, mercury, and other compounds in San Francisco Bay. In the RMP small fish pilot study, significant differences in fish Hg exposure have been observed among locations (e.g., Figure 1). Also, wildlife target species, including least tern and harbor seals, preferentially inhabit and forage in specific areas of the Bay (Goals Project 2000, Grigg 2003). These spatial differences suggest that management targeted towards specific portions of the Bay may have a broader overall impact on target wildlife species.

Figure 1. Mercury concentrations in Mississippi silverside collected in 2005. Letters indicate results of Tukey HSD test; stations with different letters have significantly different Hg concentrations.



Models have been proposed and incorporated for use in the RMP to synthesize RMP monitoring data, evaluate environmental processes, and estimate the effects of management decisions. Previous RMP modeling special studies have provided useful information on contaminant fate, transport, and bioaccumulation (Davis 2004, Gobas and Arnot 2005, Greenfield and Davis 2005). However currently available contaminant fate and bioaccumulation models have not been used to their full potential to evaluate potential impact of management actions on Bay wildlife targets. In particular, the relative importance of sediments vs. the water column for contaminant uptake by biota (Burkhard et al. 2003), the importance of variation in food-web structure (Gobas and Wilcockson 2002), and spatial variation throughout the Bay require further evaluation.

Modeling efforts to date have focused primarily on PCBs, legacy pesticides, and PAHs (Davis 2004, Greenfield and Davis 2005, Leatherbarrow *et al.* 2006). In recent years, new synthetic compounds have been released into the Bay, including pesticides, personal care product ingredients, flame retardants, plasticizers, and pharmaceuticals (Oros *et al.* 2003, Oros *et al.* 2005). In particular, polybrominated diphenyl ether flame retardants (i.e., PBDEs) have been identified as potential future “legacy pollutants,” due to their environmental persistence and bioaccumulation (Darnerud *et al.* 2001). Due to this concern, PBDEs have been added to RMP Status and Trends Monitoring; as yet, there has been no effort to evaluate the fate and bioaccumulation of PBDEs using mechanistic models.

It is hoped that future modeling of watershed contaminant loading processes may provide an opportunity for a coupled watershed-bay-food-web model. Thus, although refining the food-web model in important unto-itself, it also represents a key step towards this larger vision of models as a management tool for the Bay.

APPROACH

We propose a special study to evaluate the relative importance of different sources and spatial locations in determining contaminant fate and bioaccumulation to the San Francisco Bay food web. This project is scoped to include PCBs and PBDEs; based on funding constraints, the RMP Technical Review Committee could choose one or both of these compounds (Table 2).

Two general activities are proposed. First, a literature review and field dietary study would aid in evaluating food web transfer pathways for contaminants. Second, the multi-box contaminant fate model (Oram et al. 2006) would be linked with the food web bioaccumulation model (Gobas and Arnot 2005) to evaluate spatial variation in contaminant sources and pathways. The model simulations would focus on evaluating how potential management actions and food web structures are likely to affect contaminant bioaccumulation in different parts of the Bay. A primary contribution of this special study would be to further understanding of fate and bioaccumulation of PBDEs, which are of future management concern.

The spatial locations of the study would be selected with three objectives: 1. to correspond with priority areas for Bay wildlife; 2. to correspond with locations sampled as part of the RMP EEPS Small Fish Contaminant Monitoring Pilot Study; and 3. to represent a broad range of conditions in San Francisco Bay. Figure 2 presents proposed target locations; final locations would be selected in coordination with the TRC and Regional Board.

Figure 2. Proposed study target locations.

The final technical report would present the results of data synthesis on contaminant trophic transfer, mechanistic model simulations, and information gaps identified as priorities for future study.

TASK DESCRIPTIONS

This project will consist of four tasks, described below and budgeted in Table 2.

Task 1. *Synthesize information on food web pathways*

A conceptual model has been constructed that depicts key processes believed to affect PCB uptake by target sentinel species (Davis et al. 2006). Based on this conceptual model, the first component of this project would be to synthesize the latest available information on food web transfer pathways, with particular emphasis on contaminant exposure to piscivorous wildlife. This would include looking at literature and local information (Task 1a) and conducting dietary analysis of local fishes (Task 1b).

In Task 1a, literature and local information would be combined to determine expected spatial differences in food web structure among the four sampling locations. The review would include studies by SFSU Tiburon, Point Reyes Bird Observatory, Bodega Marine Labs, USFWS, USGS, and local consulting firms. This synthesis would also include a previous food web study funded by the Regional Board (Roberts *et al.* 2002), as well as discussions with Regional Board staff to confirm management priorities and target species previously identified. It is expected that Task 1 would result in a proposal for additional field studies to improve future estimates of food web and dietary variation in San Francisco Bay.

Dietary analyses would focus on small fish that are preyed upon by wildlife (e.g., Mississippi silverside, topsmelt, arrow goby, cheekspot goby, Bay goby). The focus on small fish for the field study is based on three factors. First of all, small fish comprise a major dietary component for sensitive wildlife species (e.g. least tern). Second, local data on small fish diets are very limited, while more data are available on human sport fish diets (e.g., Roberts *et al.* 2002). Third, several ongoing studies, including the RMP small fish Hg study (Figure 1), the IEP Midwater Trawl Survey (Orsi 1999), and the USFWS juvenile salmon seining program frequently sample small fish in the Bay, providing good cost-leverage. Finally, small fish have smaller home ranges and are therefore more likely to indicate patterns of spatial variation within the Bay (e.g., Figure 1).

Diet analysis of local fish would be based on seine samples, trawls, and other readily available collection opportunities, to achieve good spatial coverage over the Bay. Sampling effort would focus in particular on the study locations (Figure 1). Appropriate sized fish of selected species from a variety of habitats and sub-embayments would be measured, weighed, and dissected. The entire length of the gut would be inspected, and the contents identified to the lowest practicable taxon. Prey subsamples would be counted and weighed, to generate estimates of proportionate mass intake, used as an input parameter for the food web model. Fish lipid content, another important model input parameter (Gobas and Arnot 2005), would also be determined for a subset of samples.

Task 2. *Run coupled fate and bioaccumulation models for PCBs*

In Tasks 2 and 3, the contaminant fate and food web models would be run in parallel. Task 2 would focus on PCBs and Task 3 would focus on PBDEs. For both tasks, model simulations would evaluate the importance of spatial variation in contaminant sources and fate. Spatial variation in contaminant fate would include estimating water-borne sources, water column concentrations, sediment concentrations, and contaminant partitioning, in the four target locations (Figure 2). Spatial information on dietary uptake, obtained in Task 1, would also be incorporated. The bioaccumulation model would be used to evaluate the potential importance of spatial variation in food web structure and contaminant partitioning for contaminant bioaccumulation among the locations.

The modeling effort for PCBs may be broken down into three specific subtasks: quantify specific sources and loadings (Subtask 2a), quantify uptake by fish and wildlife (Subtask 2b), and test management scenarios (Subtask 2c). In Subtask 2a, the multi-box fate model would be populated with best available current data on PCB sources and distributions throughout the Bay. The model would then be run, while tracking the proportion of PCBs in each model segment that are derived from each of the separate contaminant sources built into the model (Table 1). These sources would be further broken down based on segment position; for example, the China Camp site will be affected by wastewater discharge from San Raphael, Novato, and the Petaluma River. The model would be run to provide quantification of the contribution of each source to sediments and the water column.

Table 1. Contaminant sources in San Francisco Bay (modified from Davis *et al.* 2006)

Source
Central Valley (Delta outflow)
Local tributaries
Wastewater discharge
Within-Bay erosion of buried sediment
Atmospheric deposition

The source-specific PCB contributions would then be loaded into the food web uptake model (Subtask 2b). As with the fate model, the food web model simulations would estimate the proportionate contribution of PCBs from each source to modeled fish and wildlife. Of particular interest here will be the potential differences between sediment and water column as reservoirs of PCBs, and consequent differences in bioaccumulation for benthic vs. pelagic foraging wildlife. Additionally, the potential influence of differences in prey types among locations would be evaluated. Results from the dietary study (Subtask 1b) would be incorporated into segment-specific estimates of prey proportions for forage fish. This would allow evaluation of whether varying fish diets in different segments appear to affect PCB uptake rates.

Once the models have been parameterized to include segment specific information, we would be able to evaluate impact of specific management actions on the different segments (Subtask 2c). Actions to be evaluated would be developed in coordination with Regional Board staff and the RMP TRC. Potential scenarios to be tested would include: 1. the source curtailments proposed in the relevant TMDL (SFBRWQCB 2004); 2. remediation of in-Bay contamination; and 3. monitored natural recovery.

Task 3. Parameterize and run models for PBDEs

Task 3 would be structured similarly to Task 2, including segment-specific source allocation (Subtask 3b), food-web model simulations (Subtask 3c), and evaluation of management scenarios (Subtask 3d). However, PBDEs are a relatively recent concern in the Bay (Oros *et al.* 2005), and have received considerably less attention in RMP modeling efforts. Therefore, in addition to the Tasks described above, development of model parameters specifically for PBDEs would be required as an additional subtask (Subtask 3a). This subtask would include summarizing recent literature on PBDE fate and bioaccumulation properties (e.g., Henry's Law constant, K_{ow}, degradation rates), generating estimates of loading, and synthesizing recent RMP data on status and trends.

Task 4. Technical report of findings

Once Tasks 1 through 3 are complete, a Technical Report would be drafted. This Technical Report would outline the methodology and results from the literature review, field study, and modeling work. It would include graphic presentation of food-web conceptual models and simulation results. This document would be made available to the TRC and other RMP participants for peer review and revised according to review comments.

REFERENCES

Burkhard, L. P., P. M. Cook, and D. R. Mount. 2003. The relationship of bioaccumulative chemicals in water and sediment to residues in fish: a visualization approach. Environ. Toxicol. Chem. **22**:2822-2830

Darnerud, P. O., G. S. Eriksen, T. Jóhannesson, P. B. Larsen, and M. Viluksela. 2001. Polybrominated diphenyl ethers: occurrence, dietary exposure, and toxicology. Environmental Health Perspectives **109**:49-68

Davis, J., F. Hetzel, and J. J. Oram. 2006. PCBs in San Francisco Bay: Impairment Assessment/Conceptual Model Report. Clean Estuary Partnership, Oakland, California

Davis, J. A. 2004. The long term fate of polychlorinated biphenyls in San Francisco Bay (USA). Environ. Toxicol. Chem. **23**:2396-2409

Goals Project. 2000. Baylands Ecosystem Species and Community Profiles: Life histories and environmental requirements of key plants, fish and wildlife. Prepared by the San Francisco Bay Area Wetlands Ecosystem Goals Project. P.R. Olofson, editor. San Francisco Bay Regional Water Quality Control Board, Oakland, CA. http://www.abag.ca.gov/bayarea/sfep/reports.html

Gobas, F. A. P. C., and J. Arnot. 2005. San Francisco Bay PCB food-web model. RMP Technical Report Simon Fraser University, Vancouver, BC

Gobas, F. A. P. C., and J. Wilcockson. 2002. San Francisco PCB food-web model. RMP Technical Report SFEI Contribution #90, Simon Fraser University, Vancouver, BC. http://www.sfei.org/rmp/reports/pcb/pcbfoodweb_final.pdf

Greenfield, B. K., and J. A. Davis. 2005. A PAH fate model for San Francisco Bay. Chemosphere **60**:515-530. http://www.sfei.org/rmp/reports/PAH/PAHfatemodel_BG.pdf

Grigg, E. K. 2003. Pacific Harbor Seals (*Phoca vitulina richardii*) in San Francisco Bay, California: a review of the literature. San Francisco Estuary Institute, Oakland, CA

Leatherbarrow, J. E., N. David, B. K. Greenfield, J. J. Oram, and J. A. Davis. 2006. Organochlorine pesticide fate in San Francisco Bay. RMP Technical Report 433, SFEI, Oakland, CA. http://www.sfei.org/rmp/reports/No433_RMP_OCPModel.pdf

Oram, J. J., J. E. Leatherbarrow, and J. A. Davis. 2006. Multi-box PCB model documentation v 2.0b. San Francisco Estuary Institute, Oakland, CA

Oros, D. R., D. Hoover, F. Rodigari, D. Crane, and J. Sericano. 2005. Levels and Distribution of Polybrominated Diphenyl Ethers in Water, Surface Sediments, and Bivalves from the San Francisco Estuary. Environ. Sci. Technol. **39**:33-41

Oros, D. R., W. M. Jarman, T. Lowe, N. David, S. Lowe, and J. A. Davis. 2003. Surveillance for previously unmonitored organic contaminants in the San Francisco Estuary. Marine Pollution Bulletin **46**:1102-1110

Orsi, J. J. 1999. Report on the 1980-1995 Fish, Shrimp, and Crab Sampling in the San Francisco Estuary, California. Technical Report 63, The Interagency Ecological Program for the Sacramento-San Joaquin Estuary (IEP), Sacramento, CA. http://www.estuaryarchive.org/archive/orsi_1999

Roberts, C., M. A. Sigala, R. Dunn, R. Fairey, and E. Landrau. 2002. Data report for the investigation of bioaccumulation of PCBs in San Francisco Bay. Draft Report San Francisco Regional Water Quality Control Board, Oakland CA

SFBRWQCB. 2004. PCBs in San Francisco Bay. Total Maximum Daily Load Project Report. Project Report San Francisco Bay Regional Water Quality Control Board, Oakland, CA. http://www.amsa-cleanwater.org/advocacy/tmdlhb/reg/2003-12-22.pdf

Table 2. Project tasks and budget. BG – Ben Greenfield (Scientist I billing rate). JO – John Oram (Scientist II billing rate). AJ – Andy Jahn (subcontractor – billed by task). Any combination of the food web review, PCB model, and PBDE model could be funded, depending on RMP priorities and funding allocation.

		Hours BG	Hours JO	Allocation AJ	Total Cost
Task 1	**Synthesize food web information**				
Subtask 1a	Literature and local information review	40		$3,000	$6,000
Subtask 1b	Field study of prey fish diets	40		$6,000	$9,000
Subtask 1b	Equipment and laboratory costs				$1,000
Task 2	**Run coupled fate and bioaccumulation models for PCBs**				
Subtask 2a	Quantify contaminant loads at individual sites		80		$6,400
Subtask 2b	Quantify food web uptake	60			$4,500
Subtask 2c	Test management scenarios	40	40		$6,200
Task 3	**Run coupled fate and bioaccumulation models for PBDEs**				
Subtask 3a	Develop model parameters for PBDEs	80	60		$10,800
Subtask 3b	Quantify contaminant loads at individual sites		80		$6,400
Subtask 3c	Quantify food web uptake	60			$4,500
Subtask 3d	Test management scenarios	40	40		$6,200
Task 4	**Technical report**				
Subtask 4a	Report food web results	40		$1,000	$4,000
Subtask 4b	Report PCB model results	100	100		$15,500
Subtask 4c	Report PBDE model results	100	100		$15,500
	Total				**$96,000**
	Total - food web study only				**$20,000**
	Total - PCB model only				**$32,600**
	Total - PBDE model only				**$43,400**

STUDY Emerging Contaminants in San Francisco Bay

The Emerging Contaminants Workgroup met on June 1, 2006 to discuss chemicals of concern and to review pilot and special studies for 2007. The Workgroup recommended that the following two studies on pharmaceuticals and the presence of emerging contaminants in biota be funded totaling $60,200. The Workgroup recommended that the third study of pyrethroids in the Bay be referred for consideration under the episodic toxicity program.

A. Evaluation of Pharmaceuticals in San Francisco Bay

Estimated Cost to RMP: $25,000
Add Cost Share: $35,000
Total Budget: $60,000

Oversight Group: Emerging Contaminants Work Group

Proposed by: Daniel R. Oros, SFEI

PROPOSED DELIVERABLES AND TIME LINE

Expected Accomplishments and Interim Milestones		
Task	Milestone	Completion Date
Task 1	Field Sample Collection	October 2006
Task 2	Chemical Analysis of Field Samples	February 2007
Task 3	Draft and Final Reports	June 2007
	Peer-Reviewed Paper	August 2007

BACKGROUND

Pharmaceuticals such as antibiotics (e.g., erythromycin and trimethoprim), analgesics (e.g., ibuprofen and acetaminophen), antiinflammatories (e.g., diclofenac and naproxen), antidepressants (e.g., Prozac), antihypertensives (e.g., atenolol and propranolol), anticancers (e.g., paclitaxel and tamoxifen), and sexual performance enhancers (e.g., Viagra and Levitra), among other drugs, are used to treat illness, disease, and medical conditions in humans and animals. They enter the environment from consumer use and actions and, in the case of industrial confined animal feedlots where antibiotics are used, from waste effluents. The primary pathway is ingestion followed by subsequent excretion into the municipal sewage system, while the secondary pathway is disposal of unused and outdated medications directly into the sewage system. These biologically active compounds and their metabolites are not completely removed by current wastewater treatment technologies and are often found in treated effluents and receiving waters. For example, the analgesic, acetaminophen, was previously found in the San Francisco Bay at a maximum estimated concentration of 390 ng/L [Oros et al., *Marine Pollution Bulletin*, 2003, 46, 1102-1110]. Because wastewater treatment plants discharge ~230 billion gallons of treated effluents into the Bay each year, this could represent a significant loading of pharmaceutically active drugs and other personal care products into the Bay. Discharged pharmaceuticals are diluted and even mixed with other pharmaceuticals from multiple discharge sites in the Bay. The concentration levels of pharmaceuticals are expected to peak during the dry season (summer months) when freshwater inflow to the Bay is at its lowest.

APPLICABLE RMP OBJECTIVES AND MANAGEMENT QUESTIONS

1. Describe the distribution and trends of pollutant concentrations in the Estuary
   - 1.1 Which pollutants should be monitored in the Estuary, in what media, and at what frequency?
   - 1.2 Are pollutants of concern increasing, decreasing, or remaining the same in different media?
   - 1.3 How are contaminant patterns and trends in the Estuary over time affected by remediation and source control or pollution prevention in the watersheds?
   - 1.4 Do pollutant concentration distributions indicate particular areas of origin or regions of potential ecological concern?

2. Project future contaminant status and trends using current understanding of ecosystem processes and human activities
   - 2.1 Can reasonably accurate recovery forecasts be developed for major segments and the Estuary as a whole under various management scenarios?
   - 2.2 Can potential impairment and degradation be better anticipated in the face of projected changes in land and water use and management, as well as product use and disposal?
   - 2.3 Which pollutant categories are predicted to accumulate in the Estuary faster then they can be assimilated?
   - 2.4 Do pollutant trends reflect historical changes in use patterns, transport and transformation processes, or control actions?
   - 2.5 How will the importance of each pathway change through time under various management and development scenarios?
   - 2.6 What is the projected future loading of pollutants of concern under various management and development scenarios?
   - 2.7 What are the likely consequences of various management actions or risk reduction measures?
   - 2.8 Do pollutants show existing distributions that fit our current understanding or models of their origin, loads, and transport?
   - 2.9 What changes in loadings or ecosystem characteristics (e.g., extent of restored tidal marsh, Estuary circulation and flushing, food web shifts) would reduce or increase pollutant exposures and effects?
   - 2.10 How are distributions and long-term trends in pollutants affected by current and predicted estuarine processes (e.g. sediment erosion, deposition, river inflows)?

3. Describe sources, pathways, and loading of pollutants entering the Estuary

3.1 Where are/were the largest pollutant sources, in what context are/were these pollutants applied or used, and what are/were their ultimate points of release into the aquatic environment?
3.2 What are the circumstances and processes that cause the release of pollutants from both internal and external source areas?
3.3 Once released, how do pollutants travel from source areas to the Estuary, what are the temporal and spatial patterns of storage, and are they transformed along the way or after deposition?
3.4 What is the annual mass of each pollutant of concern entering the Bay from each pathway?
3.5 Can data with high temporal resolution from a few watersheds be projected to other watersheds and the Basin as a whole?
3.6 For each pollutant of concern, what forms are released from each pathway and what are the magnitude and temporal variation of concentrations and loadings?
3.7 How do loads change over time in relation to management activities?
3.8 What is the relative importance of pollutant loadings from different sources and pathways, including internal inputs, in terms of beneficial use impairment?

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

APPROACH

This effort will include developing and implementing a special study to gather data on pharmaceuticals in the San Francisco Bay water column. The RMP does not currently monitor for pharmaceuticals in the Bay, so it is not known which pharmaceuticals are present and at what concentration levels but there is heightened concern now given that pharmaceutically active drugs have been found to occur in most U.S. water bodies. Therefore, the objective of this study is to evaluate the extent of the concentration levels and occurrence of pharmaceuticals in the San Francisco Bay water column. The pharmaceuticals that will be analyzed are shown in Table 1. This initial list can be expanded depending on any recommendations received from the RMP and its workgroups.

Several key questions that will be addressed in this proposed special study include: What pharmaceuticals and drug metabolites are present in the Bay? Are they present at concentrations that could potentially cause toxicity or endocrine system disruption to critical aquatic species? What are their major sources and levels of loading from those sources? Are some areas higher in concentrations than others?

The deliverable will be a RMP Technical Report and a paper to be submitted for potential publication in a peer reviewed scientific journal.

Proposed Start Date: Summer 2006

Time Sensitivity: This project will not exceed 1 year from start date.

TASK DESCRIPTIONS

This project will consist of three tasks:

Task 1 Field Sample Collection

Field collection of water samples (1 L volume) including wastewater treatment plant influent and effluent samples and San Francisco Bay ambient water samples will occur during the summer 2006. Samples will be collected at the Regional Water Quality Control Plant, Palo Alto and San Jose/Santa Clara Water Pollution Control Plant facilities. The number of samples that will be collected is the following: Influent – 5 samples from each plant, Effluent – 5 samples from each plant, ambient Bay water – 10 samples from various sites in the South Bay, for a total of 30 samples. Ambient Bay water samples will be collected at a depth of 1 ft below the water surface using 1 L amber glass bottles. Optimal tidal conditions will be identified for the ambient water sampling. Treatment plant water samples will be collected following procedures outlined in Standard Methods for the Examination of Water and Wastewater, 18th Edition. “Clean” sampling techniques will be used to mitigate potential contamination. The samples will be stored on ice and kept as cool as possible without freezing from collection to analysis to minimize the potential for biodegradation and vaporization. Strict quality assurance/quality control (QA/QC) program will also be employed and will include at a minimum the collection of equipment blank, field blanks, and field replicates.

Task 2 Chemical Analysis of Field Samples

The pharmaceuticals targeted for analysis in water samples are shown in Table 1. This initial list can be expanded based on any recommendations from the RMP. Water samples will be analyzed using liquid chromatography/mass spectrometry-mass spectrometry (LC/MSMS). This instrument provides high selectivity and mass resolution to reduce potential interferences and can routinely achieve very low levels of chemical detection. Furthermore, the level of confidence in data collected is much greater than for any data collected by conventional LC/MS and GC/MS methods. The method detection limits (MDLs) are in the very low ppt range for water samples.

Task 3 Write Draft/Final Reports and Peer-Reviewed Paper

This effort will include writing a draft report for internal and external peer-review and then delivery of a final report as an SFEI Technical Document. A paper will also be written and submitted to a peer-reviewed scientific journal for potential publication.

BUDGET

Activity	Description	Cost
Task 1	Field Sample Collection	$5,000
Task 2	Chemical Analysis of Field Samples	$30,000
Task 3	Draft and Final Reports	$25,000
	Paper to Peer Reviewed Journal	
	Amount Requested from RMP	$25,000
	Cost Share	$35,000
	Total Budget	$60,000

Cost Share

The City of Palo Alto will provide a cost share of $5,000 for field sample collection. AXYS will provide a cost share of $30,000 for chemical analysis as in-kind contribution to this project. The overall cost share makes up 58% of the total budget.

Table 1. Pharmaceuticals that will be analyzed in this study
Acetaminophen
Albuterol
Caffeine
Carbadox
Chlorotetracycline
Cimetidine
Ciprofloxacin
Codeine
Cotinine
Digoxigenin
Digoxin
Digoxin
Diltiazem
Doxycycline
1,7-Dimethyl Xanthine
Enrofloxacin
Erythromycin-H2O
Fluoxetine
Gemfibrozil
Ibuprophen
Lincomycin
Metformin
Norfloxacin
Norgestimate
Oxytetracyclin
Ranitidine
Roxithromycin
Sarafloxacin
Sulfachloropyridazine
Sulfadimethoxine
Sulfamerazine
Sulfamethazine
Sulfamethizole
Sulfamethoxazole
Sulfathiazole
Tetracycline
Triclosan
Trimethoprim
Tylosin
Virginiamycin
Warfarin

B. Investigation of the Presence of Perfluorinated Compounds in San Francisco Bay Seals

Estimated Cost: **$35,150**

Oversight Group: Emerging Contaminant Workgroup; Exposure and Effects Workgroup

Proposed by: Meg Sedlak, SFEI and Denise Greig, The Marine Mammal Center

PROPOSED DELIVERABLES AND TIME LINE

Deliverable	Due Date
Task 1. Sample collection and sample analysis	September 2006/January 2007
Task 2 Preparation of Draft Report	June 2007
Report finalized	August 2007

BACKGROUND

In the last 50 years, fluorinated alkyl substances have been used extensively in a variety of commercially available products including fire-fighting foams, refrigerants, stain repellants in textiles, and coatings for paper used in contact with food products. Their popularity in commercial and industrial applications results from their unique ability to be both hydrophobic and oleophobic, that is able repel both water and oil.

Fluorinated alkyl substances are synthesized from perfluornated sulfonyl fluoride and carbonyl fluoride intermediates by electrochemical fluorination process (ECF) or telomerization fluorination processes. Because these processes are not selective, numerous by-products are produced in the manufacture of these intermediates such as perfluorooctane sulfonate (PFOS) and perfluorooctanoic acid (PFOA).

As a result of their chemical stability and widespread use, fluorinated alkyl substances such as PFOS and PFOA have been detected in marine mammals and aquatic organisms throughout the world including relatively pristine environments such as the Arctic (Kannan *et al.* 2002). PFOS and related perfluorinated compounds have been associated with a variety of toxic effects including mortality, carcinogenity, and adverse development. Their widespread dispersal throughout the global and their potential toxicity has caused increasing concern among scientists and regulators. In response to this concern, the US Environmental Protection Agency banned the use of PFOS and 3M Corporation initiated a voluntary phase out of the carboxylated and sulfonyl-based perfluorinated chemicals; however, PFOA and perfluorinaed carboxylic acids (PFCAs) continue to be produced in the manufacture of fluoropolymers. It is thought that these compounds degrade to form PFOS.

APPLICABLE RMP OBJECTIVES AND MANAGEMENT QUESTIONS

1. Describe the distribution and trends of pollutants concentrations in the Estuary.

- This study will provide some of the first data to determine the distribution of concentrations of perfluorinated compounds in the Estuary and to place these concentrations in context with concentrations observed in other estuaries.

2. Project future contaminant status and trends using current understanding of ecosystem processes and human activities.

4. Measure pollution exposure and effects on selected parts of the Estuary ecosystem (including humans).

- 4.1. Perfluorinated compounds are considered an emerging contaminant. As such, it is important that we determine their concentrations in biota to evaluate whether management actions are needed.
- 4.4 Determining the concentrations of perfluorinated compounds in the upper trophic level is important for assessing both ecological and human health risks.

5. Compare monitoring information to relevant benchmarks, such as TMDL targets, tissue screening levels, water quality objectives, and sediment quality objects

- The concentrations detected in this study would be compared to known threshold effect levels, where possible.

APPROACH

The objective of this study will be to determine concentrations of PFOS and related compounds in Pacific harbor seals (*Phoca vitulina richardsi*). Harbor seals are an ideal indicator species for persistent bioaccumulative contaminants in the Estuary. Seals are apex predators that eat a diet consisting primarily of fish. Long-lived, they tend to forage in areas that are frequently impacted by contamination (e.g., heavy marine traffic, urban and agricultural runoff, etc.). Combined, these factors result in harbor seals being highly exposed to contaminants that can bioaccumulate.

Perfluorinated compounds are of particular concern because they are very stable compounds that are not known to undergo abiotic or biotic degradation (Martin *et al.* 2004). Perfluorinated compounds have been observed in blood collected from seals located in the Arctic and the Mediterranean seas (Kannan *et al*. 2002). FOSA, which is a metabolite of perfluorinated compounds (e.g., insecticides), was also detected in blood at concentrations that were one to five times greater that the PFOS concentrations (Kannan *et al.* 2002).

Researchers have identified contaminants such as PCBs, DDT, and PBDEs in the blood of Bay area seals at significant concentrations (Kopec and Harvey 1995 and Young *et al.*, 1998, Kajiwara *et al.*, 2001). PBDEs were identified in local seal populations at the highest levels reported for the species and at increased concentrations over the past ten years (She *et al.*, 2002).

At present, little information is available regarding the presence of PFOS and perfluorinated compounds in the Estuary. A research group at Stanford University has recently analyzed South Bay sediment and wastewater sludge for PFOS and its precursors (Higgins *et al.* 2005). PFOS observed in San Francisco Bay sediment is reported to range from 0.124 ng/g to 4.65 ng/g. The range of concentrations in wastewater sludge was approximately two orders of magnitude higher. Of particular interest was the elevated concentrations of PFOS precursors (i.e., 2-(N-methylperfluorooctanesulfonamido) acetate and 2-(N-ethylperfluorooctanesulfonamido) acetate) suggesting that it is important to monitor the precursors which may degrade to PFOS.

To date, no biological samples have been analyzed for perfluorinated compounds in the San Francisco Estuary. The Marine Mammal Center and Moss Landing Marine Laboratories plan to capture harbor seals in the summer of 2006. Seals will be weighed, measured, and tagged; blood samples will be collected for a battery of tests to assess health and fitness (e.g., blood cell count, exposure to infectious diseases, presence of pathogenic bacteria, etc.). Additional blood samples can be collected for chemical analyses. Animals targeted by this study will be young of the year pups that wean in May and feed on fish throughout the summer. Approximately ten young of the year seals will be tagged for a future study assessing health and survival. Although the focus of the Marine Mammal study will be young of the year, it is likely that seals of all ages will be captured and handled. Blood for perfluorinated compounds will be obtained from all age classes to ascertain whether age has an impact on contaminant loads. Previous studies by Kannan *et al.* (2002) did not show a correlation of PFOS concentrations with age.

Because the RMP has relatively few opportunities to analyze seal blood, it is proposed that PBDEs and hexabromocyclododecane be analyzed in addition to perfluorinated compounds. Hexabromocyclododecane is an alternative flame retardant for PBDEs. Levels of hexabromocyclododecane are increasing in Europe where the penta and octa mixes of PBDEs were banned in 2004. California recently implemented a ban on the use of penta and octa PBDEs. As indicated above, concentrations of PBDEs in harbor seals were the highest levels reported and show an increasing trend. Hexabromocylcododecane has not been measured in seals in the San Francisco Bay.

Although the funding for Pilot and Special studies is allocated for 2007, because 2006 presents a unique year for collection of blood samples, we would collect the samples in the summer of 2006 and archive the samples for analyses until 2007 (assuming that this study is funded).

The results of this study will be summarized in a technical report and a journal manuscript.

TASK DESCRIPTIONS

This project will consist of two tasks:

Task 1: Collection of Samples

The Marine Mammal Center based in Sausalito, California is conducting a study of harbor seal health that will commence in August 2006. In addition to collecting information of the physical aspects of the seals (e.g., weight, condition, etc.), staff will collect blood. The researchers at the Marine Mammal Center have indicated that they could collect approximately 30 grams of blood for analysis of perfluorinated compounds and brominated flame retardants. Unlike neutral compounds such as polychlorinated biphenyls which accumulate in fatty tissues, perfluorinated compounds tend to bind to protein in blood (Kannan *et al.* 2002). Samples will be sent to AXYS analytical in Sidney, British Columbia for analysis. A list of compounds is included in the Appendix of this proposal. Care will be taken by the staff to avoid the use of Teflon and related PTFE plastics (e.g., vial and tubing). A detailed cost estimate is presented below.

Task 2: Review of Results and Preparation of a Report

Results should be available approximately four months after submission of samples to the laboratory. The results will go through the RMP data validation process (see the 1999 QAPP). These results will be compared to similar studies conducted in the Arctic and elsewhere (e.g., Kannan *et al.* 2002, Giesy and Kannan 2001) and elsewhere to assist in determining whether these compounds present an emerging concern. A draft report and manuscript will be prepared and circulated to the TRC for review. Upon incorporation of comments, the report will be assigned a SFEI contribution number and posted on the SFEI website. The manuscript will be submitted to an environmental journal such as Environmental Science and Technology.

BUDGET

The estimated cost to complete this task is $35, 150. A detailed budget is presented below.

Cost for Analyses				
Laboratory Analyses				
	Chemical	Number of Samples*	Cost of Analyses	Subtotal
	Perfluorinated Compounds	11	500	$5,500
	Hexabromcyclododecane	11	600	$6,600
	PBDEs	11	550	$6,050
Direct Costs				
	Vials, gloves, misc.			$500
Labor				
	Field coordination and			$1,000

	logistics			
	Data QA/QC			$3,000
	Report Preparation			$12,000
	Final Report			$500
Total				**$35,150**

* Assumes ten samples plus one replicate.

REFERENCES:

Giesy, J.P. and K. Kannan. 2001. Global Distribution of Perfluorooctane Sulfonate in Wildlife. Environ. Sci. Technol. 35, 1339-1342.

Higgins, C.P., Field, J. A., Criddle, C.S., Luthy, R.G. 2005. Quantitative Determination of Pefluorochemicals in Sediments and Domestic Sludge. Env.Sci.Tech., 39, 3946-3956.

Kajiwara, N., Kannan, K., Muraoka, M., Watanabe, M., Takahashi, S., Gulland, F., Olsen, H., Blankenship, A.L., Jones, P.D., Tanabe, S., and J.P. Giesy. 2001. Organochlorine pesticides, polychlorinated biphenyls, and butyltin compounds in blubber and livers of stranded California sea lions, elephant seals, and harbor seals from coastal California, USA. Archives of environmental Contamination and Toxicology 41: 90-99.

Kannan, K., Corsolini, S., Falandysz, J., Oehme, G., Focardi, S. and J.P. Giesy. 2002. Perfluorooctanesulfonate and Related Fluorinated Hydrocarbons in Marine Mammals, Fishes, and Birds from Coasts of the Baltic and the Mediterranean Seas. Environ. Sci. Technol. 36, 3210-3216.

Kopec, A.D. and J.T. Harvey. 1995. Toxic pollutants, health indices, and population dynamics of harbor seals in San Francisco Bay, 1989-1992. Moss Landing Marine Laboratories Technical Report 96-4. Moss Landing, CA. pp. 168.

Martin, J.W., Smithwick, M.M., Braune, B.M., Hoekstra, P.F., Muir, D.C. and S. Mabury. 2004. Identification of Long-chain Perfluorinated Acids in Biota from the Canadian Artic. Environ. Sci. Tech. 38, 373-380.

She, J., Holden, A., Tanner, M., Sharp, M., Adelsbach, T., and K. Hooper. 2004. Highest PBDE levels (max 63 ppm) yet found in biota measured in seabird eggs from San Francisco Bay. Organohalogen Compounds. 66: 3939-3944.

Young, D., Becerra, M., Kopec, D. and S.Echols. 1998. GC/MS analysis of PCB congeners in the blood of the harbor seal *Phoca vitulina* from San Francisco Bay. Chemosphere 37(4): 711-733.

APPENDIX
List of Perfluorinated Compounds
To be Analyzed

PERFLUORO-OCTANE SULFONATES

Compound	Acronym
Perfluorobutanoate	PFBA
Perfluoropentanoate	PFPeA
Perfluorohexanoate	PFHxA
Perfluoroheptanoate	PFHpA
Perfluorooctanoate	PFOA
Perfluorononanoate	PFNA
Perfluorodecanoate	PFDA
Perfluoroundecanoate	PFUnA
Perfluorododecanoate	PFDoA
Perfluorobutanesulfonate	PFBS
Perfluorohexanesulfonate	PFHxS
Perfluorooctanesulfonate	PFOS
Internal Standards	
13C-Perfluorododecanoate	PFDoA
13-CPerfluorosulfonate	PFOS
13C- Perfluorooctanoate	PFOA

Remote Observations of Episodic Sediment Transport Patterns in San Francisco Bay, CA.

John J. Oram

Project Cost Range: $42,000-$82,000

Oversight Group: Contaminant Fate Workgroup, Sources Pathways & Loadings Workgroup

Proposed Deliverables and Time Line

Deliverable	Due Date
Task 1. Identify and obtain ‘clear’ MODIS images of SF Bay.	
Task 2. Process images to produce true- and false-color images showing two-dimensional sediment transport patterns and quantifying relative concentrations of suspended matter.	
Task 3. When appropriate; utilize existing edge-detection algorithms to delineate the boundaries of plumes exiting the Golden Gate and estimate suspended sediment mass within plume.	
Task 4. Compare remote observations with in-situ USGS SSC measurements collected at Mallard Island to determine the fraction of material entering the Bay via the Delta that is lost to the Pacific Ocean during a given event.	
Task 5. Conduct field observations of Golden Gate plume.	
Task 6. Technical report of findings	

Applicable RMP Objectives and Management Questions

Many of the contaminants of concern to the RMP are particle associated and follow particle (i.e. sediment) transport pathways. Improved understanding of these particle transport pathways will help estimates of contaminant fate. In that light, this project most closely addresses the following RMP management questions:

2. Project future contaminant status and trends using current understanding of ecosystem processes and human activities.
    - 2.10 – *How are distributions and long-term trends in pollutants affected by current and predicted estuarine processes (e.g. sediment erosion, deposition, river inflows)?*
3. Describe sources, pathways, and loading of pollutants entering the Estuary.
    - 3.2 – *What are the circumstances and processes that cause the release of pollutants from both internal and external source areas?*
    - 3.2 – *Once released, how do pollutants travel from source areas to the Estuary, what are the temporal and spatial patterns of storage, and are they transformed along the way or after deposition?*
    - 3.4 – *What is the annual mass of each pollutant of concern entering the Bay from each pathway?*

Background

Monitoring suspended sediment concentrations, SSC, in coastal waters and estuaries is crucial for proper ecosystem management. Such monitoring is traditionally done in-situ, with measurements representing SSC at a few discrete points in space and time. However, recent advancement of satellite remote sensing allows for synoptic views of coastal and estuarine dynamics that would otherwise be unavailable. Results are drastically altering our perceptions of coastal ocean transport processes.

Ruhl et. al (2001) conducted a combined remote-sensing and *in-situ* study of San Francisco Bay using advanced very high resolution radiometers (AVHRR, 1km spatial resolution) aboard the NOAA polar-orbiting weather satellites and *in-situ* optical backscatter sensors. The authors were able to identify the effects of physical processes associated with freshwater flow, wind-waves, and the spring-neap tidal cycle. However, an estimate of an event-scale sediment budget was not made. Additionally, the authors note that results could be notably improved with higher resolution imagery.

This project proposes to do just that: to utilize moderate-resolution (250m, 500m, and 1000m) MODIS satellite imagery to investigate episodic sediment transport patterns in San Francisco Bay. Development of an event-scale sediment budget has the potential to significantly improve current estimates of contaminant loading from the Delta to the Bay. It is conceptualized that such episodic contaminant loads account for a significant portion of annual contaminant loads. However, at present we know very little regarding the percent of episodic sediment and contaminant loads that remain within the Bay.

Approach

The project includes three main components: 1) identify MODIS images with a high percentage of coverage in the Bay corresponding to periods of high Delta flow and process these images to produce true- and false-color images showing two-dimensional sediment transport patterns and quantifying relative concentrations of suspended matter, 2) where appropriate, utilize existing edge-detection algorithms (Oram et al. 2005) to delineate the boundaries of plumes exiting the Golden Gate and estimate mass of suspended sediment within the plume, and 3) compare remote observations with in-situ USGS SSC measurements collected at Mallard Island to determine the fraction of material entering the Bay via the Delta that is lost to the Pacific Ocean during a given event. An optional fourth component is also proposed to conduct field studies aimed at characterizing the biogeochemical properties of a plume exiting the Golden Gate and to calibrate/validate the remote-sensing methodology. The final product will be a technical document that describes episodic sediment transport processes. The document would include images illustrating two-dimensional sediment transport patterns and estimates of episodic material fluxes from the Bay to the Pacific Ocean.

Task Descriptions

Task 1. Identify and obtain 'clear' MODIS images of SF Bay.

The moderate resolution imaging spectroradiometer (MODIS) is a key instrument aboard the EOS Terra and Aqua satellites. These two satellites are capable of viewing the entire earth every 1 to 2 days. Task 1 would identify 'clear' MODIS images of San Francisco Bay from 1995 to the present. The definition of 'clear' will need to be established in this task. Essentially, an image will be designated 'clear' if the number of observed pixels within the Bay (or segments thereof) exceeds a certain threshold. Images identified as 'clear' will then be compared to precipitation and Delta outflow records. Images corresponding to periods of high precipitation and/or Delta outflow will be selected for further analysis.

Task 2. Process images to produce true- and false-color images showing two-dimensional sediment transport patterns and quantifying relative concentrations of suspended matter.

Task 2 will process images selected in Task 1 to produce true- and false-color images showing two-dimensional sediment transport patterns. The MODIS sensors aboard the EOS Terra and Aqua satellites acquire data in 36 spectral bands at resolutions of 250m, 500m, and 1000m. Estimates of various physical parameters are made by combining data from these various bands. For example, the 250m true color image of San Francisco Bay seen in Figure 1 and the 1000m false-color chlorophyll-a image seen in Figure 2 were generated using different subsets of the 39 spectral bands sensed by the MODIS sensor. Algorithms exist to estimate total suspended solids concentration, chlorophyll-a concentration, and sea-surface temperature from MODIS observations (e.g., SeaDAS, 2006).

Figure 1 MODIS 250m true-color image of San Francisco Bay taken January 9, 2006.

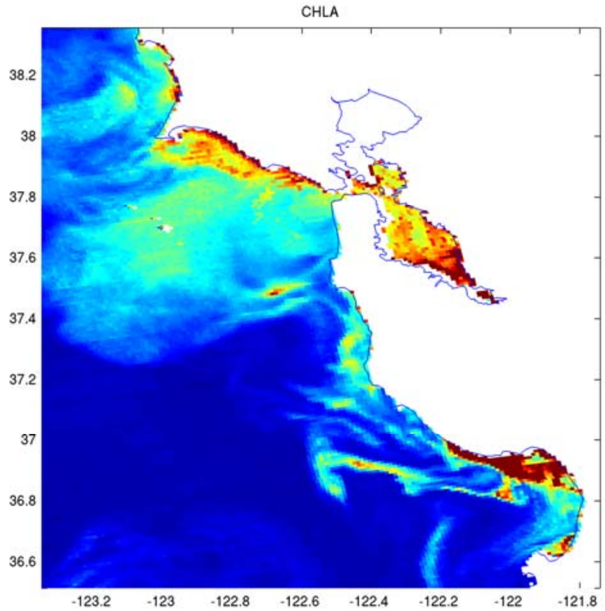


Figure 2 MODIS 1km false-color chlorophyll-a image of San Francisco Bay and the Central California Coast taken January 9, 2006.

Task 3. When appropriate; utilize existing edge-detection algorithms to delineate the boundaries of plumes exiting the Golden Gate and estimate suspended solids mass within the plume.

A subset of the images identified as 'clear' in Task 1 and processed in Task 2 will be further analyzed by an automated edge detection and feature classification algorithm (Oram et al., 2005). An image must meet certain criteria in order for the edge detection algorithm to work; for example, a candidate image must have a high percentage of clear pixels. The edge detection algorithm is capable of objectively locating the boundary of two distinct water masses. In the context of this project, the algorithm will be applied to detect the boundary between Bay waters exiting the Golden Gate and oceanic waters. With this boundary delineated, it is possible to estimate the surface area of the plume. With estimates of total suspended solids (TSS), estimates of the mass of suspended matter within the plum can be made. I acknowledge that significant uncertainty surrounds this estimate, as the MODIS image only yields information on the upper layer (usually the optical depth) of the water column. An additional, optional, task is therefore proposed to conduct a field study of one of these plumes (Task 5). Nevertheless, a crude estimate of the mass of total solids within the plume can be made by approximating the vertical distribution of suspended solids.

Task 4. Compare remote observations with in-situ USGS SSC measurements collected at Mallard Island to determine the fraction of material entering the Bay via the Delta that is lost to the Pacific Ocean during a given event.

Task 4 will compare estimates of the mass of suspended solids in the Golden Gate plume to estimates of event-scale suspended sediment loads entering the Bay from the Delta at Mallard Island. The method of estimating loads at Mallard Island is well documented by McKee et. al (2006). The end result of Task 4 will be a collection of estimates (i.e., one for each storm with coincident *in-situ* and remotely-sensed data) of the proportion of exported suspended solids mass to the suspended solids mass that entered the Bay via the Delta during a given event.

Task 5. Conduct field observations of Golden Gate plume.

Significant error is associated with using remotely-sensed surface suspended solids concentrations to estimate the mass of suspended solids in the water column. In an effort to calibrate and/or validate this estimation, Task 5 proposes to conduct a field study of an episodic suspended solids plume at the Golden Gate. The field study will involve contracting with an appropriate research institute (e.g., Romberg Tiburon, UCD Bodega Marine Lab, UCLA) or consultant (e.g., Applied Marine Sciences) for ship time and instrumentation. The research vessel selected must be able to sample within a few days notice. Ideally, the instrument used will be a towed-undulating profiler equipped with a transmisometer and fluorometer. If such an instrument is not available or is not within budget, a vertical profiler (i.e., CTD) equipped with a transmisometer and fluorometer would suffice. The plume would be sampled across both horizontal axes. The total mass of suspended solids within the plume would then be estimated by interpolating and integrating the filed data in three-dimensions (lon,lat,depth). Depending on the extent of the plume and weather conditions, we should be able to sample the plume in two days.

The budget for this field component is uncertain at this time since I was unable to contact two of the potential collaborators (Dr. Largier and Dr. Garfield) regarding budget estimation.

Task 6. Technical report of findings

Study results will first be documented in a draft report and submitted to the Contaminant Fate Workgroup and/or Sources Pathways and Loadings Workgroup for review. Comments will be addressed and a final technical report will be completed.

Budget

		Hours Oram	Hours Nezlin	Allocation	Total Cost
Task 1	Identify and obtain 'clear' MODIS (and possibly SeaWiFS) images of SF Bay.	40	40		$8,000
Task 2	Process images to produce true- and false-color images showing two-dimensional sediment transport patterns and quantifying relative concentrations of suspended matter.	40	40		$8,000
Task 3	When appropriate; utilize existing edge-detection algorithms to delineate the boundaries of plumes exiting the Golden Gate and estimate suspended sediment mass within plume.	60			$6,000
Task 4	Compare remote observations with in-situ USGS SSC measurements collected at Mallard Island to determine the fraction of material entering the Bay via the Delta that is lost to the Pacific Ocean during a given event.	60	20		$8,000
Task 5	Conduct field observations of			20,000	$20,000

	Golden Gate plume. *Cost can be significantly less if collaboration with Dr Largier.*				
Task 6	Draft & Final Technical Reports				
	Remote-Sensing Study	80	40		$12,000
	Field Study	100	100		$20,000
	Total – including field work				$82,000
	Total – without field work				$42,000

Potential Collaborators

Nikolay Nezlin, PhD, SCCWRP

Dr Nezlin and I are co-authors on a paper of the seasonal to sub-seasonal variability of surface waters in Santa Monica Bay, CA. Dr Nezlin is a remote-sensing specialist with excellent knowledge of coastal and estuarine processes.

John Largier, PhD, UCD Bodega Marine Lab

Dr Largier is well versed in coastal and estuarine dynamics and has a special interest in characterizing the episodic plume at the Golden Gate. He has expressed interest in using the Bodega Marine Lab's research vessel to sample high Delta flow events. Unfortunately I was unable to contact Dr Largier before finalizing this proposal. If there is interest in field observations (Task 5), Dr. Largier will be an excellent resource.

Dr. Toby Garfield, SFSU Romberg Tiburon Center

Dr. Garfield has expressed interest in such a study. He is an expert in oceanographic instrumentation and can provide guidance on methods and instrumentation during the field study (Task 5).

References

McKee, L, Ganju, N, and DH Schoellhamer. (2006). Estimates of suspended sediment entering San Francisco Bay from the Sacramento and San Joaquin Delta, San Francisco Bay, CA. *Journal of Hydrology*, 323, 335-352.

Nezlin, NP and ED Stein. (2005). Spatial and temporal patterns of remotely-sensed and field-measured rainfall in southern California. *Remote Sensing of Environment*, 96, 228-245.

Oram, JJ, McWilliams, JC, and KD Stolzenbach. (2005). Gradient based edge detection and feature classification of sea-surface images of the Southern California Bight. *Remote Sensing of Environment*, submitted.

Ruhl, CA, Schoellhamer, DH, Stumpf, RP, and CL Lindsay. (2001). Combined use of remote sensing an continuose monitoring to analyse the variability of suspended-sediment concentrations in San Francisco Bay, California. *Estuarine, Coastal and Shelf Science*, 53, 801-812.

SeaDAS. (2005). The SeaWiFS Data Analysis System. http://oceancolor.gsfc.nasa.gov/seadas

Turner, A and GE Millward. (2002). Suspended particles: Their role in estuarine biogeochemical cycles. *Estuarine, Coastal and Shelf Science*, 55, 857-883.

Contents

Monitoring Bioavailable Mercury in San Francisco Bay Open-water Habitats: Using the Food Web to Assess Interannual and Spatial Trends

Ben Greenfield and Letitia Grenier, SFEI, Andy Jahn (Independent consultant)

Current Budget Allocation : $40,000 in 2006, $40,000 in 2008

Oversight Group: TRC, EEPS Scientific Review Committee

SUMMARY

This document includes the work plan for the RMP small fish monitoring program. The current sampling design and potential augmentations are presented on pp. 7 – 12. The current plan for the study entails sampling seven fixed stations in 2005, 2006, and 2008. In response to high stakeholder interest in this project, a number of potential augments are presented (Table 2). These include adding monitoring in 2007 and several potential expansions of the core study: additional monitoring focused on evaluating exposure to avian predators, additional spatial coverage around the Bay, special studies to evaluate mechanisms driving differences among fish species, and determining organics in fish.

BACKGROUND

Mercury contamination is one of the highest-priority water quality issues for the Bay (Johnson and Looker 2004). Methylmercury is toxic to biota and accumulates to high concentrations in organisms high in the food web, including fish, wildlife, and humans. The greatest health risks are faced by humans and wildlife that consume fish. Significant management actions are underway that are likely to cause changes in mercury concentrations in fish in the Bay. The mercury TMDL is a major effort designed to reduce mercury accumulation in Bay fish. However, major tidal marsh restoration projects are underway that may increase mercury in the food web (Davis *et al.* 2003). Wetlands are sites of methylmercury production, and landscapes with higher percentages of wetlands are associated with higher methylmercury export (St. Louis *et al.* 1994). Plans are presently in place to restore 49,000 acres of wetlands in the North and South Bay (SFEI 2006). Adaptive implementation of the mercury TMDL and adaptive management of habitat restoration will depend heavily on appropriate monitoring of impacts on water quality (Mumley and Looker 2004).

Small fish are the best tool available for monitoring inter-annual changes in methylmercury in aquatic ecosystems. The California Bay-Delta Authority, recognizing the potential impacts of habitat restoration on mercury exposure in the Bay-Delta watershed, assembled a team of international mercury experts to develop a “Mercury Strategy for the Bay-Delta Ecosystem: A Unifying Framework for Science, Adaptive Management, and

Ecological Restoration" (Wiener *et al.* 2003). A centerpiece of this Strategy is monitoring mercury in small fish.

Small fish are an essential monitoring tool for mercury contamination for the following reasons.

1. Small fish accumulate the form of mercury (methylmercury) that causes the most toxicological effects in biota. Close to 100% of the mercury present in small fish is methylmercury. Methylmercury is the form that biomagnifies in the food web and poses toxicological risks at the top of the food web.

2. Small fish mercury concentrations integrate the net amount of methylmercury in the lower levels of the food web in their foraging area. Exposure of organisms in the food web to methylmercury is the primary problem with Hg in aquatic ecosystems (Wiener *et al.* 2003). Therefore, measuring methylmercury in fish is a direct measurement of the problem, whereas water and sediment methylmercury concentrations do not always correlate directly with food web mercury.

3. Small fish integrate exposure over a defined period of time (e.g., one year), making them a cost-effective and informative monitoring tool. Fish accumulate mercury over their entire lifespan. One-year-old fish are an ideal indicator of inter-annual variation because they accumulate their mercury during a well-defined interval. Older fish are not as valuable for inter-annual trend monitoring because they accumulate over multiple seasons, resulting in a less distinct signal. Fish are integrative indicators because their body burden is a function of all of the temporal and spatial variation in methylmercury that occurs in a habitat. Monitoring with an integrative indicator is much more cost-effective than the intensive water and sediment sampling that would be required to obtain a similar representative index of overall contamination.

4. Small fish can indicate spatial patterns over relatively small scales (including near-shore areas). Small fish with relatively small home ranges indicate food-web mercury over small spatial scales. Larger sport fish generally move throughout the Bay and, thus, are not useful for regional spatial comparisons. Furthermore, small fish are present in near shore areas and tidal marshes where methylmercury production is hypothesized to be greatest. Transplanted bivalve sampling in the RMP serves this purpose for organic contaminants, but transplanted bivalves are not an effective tool for mercury monitoring.

5. Small fish are indicators of health risks faced by piscivorous wildlife. The sport fish sampled by the RMP are generally too large to be consumed by seals and birds. Small fish, such as gobies, anchovies, and smelt, comprise the bulk of piscivore diets in the Bay. Published thresholds exist for contaminant concentrations in prey that pose health risks to piscivorous wildlife.

For these reasons, small fish are an essential indicator to include in a program of adaptive management for mercury contamination in the Bay. They are an excellent tool for evaluating long-term trends, spatial patterns, and wildlife health risks. They provide a valuable complement to other methylmercury monitoring tools being employed in the RMP: sport fish, avian eggs, water chemistry, and sediment chemistry. While this proposal focuses on mercury, the same arguments can be made for the value of small fish in monitoring other bioaccumulative contaminants of concern, such as PCBs and PBDEs. Samples taken for the proposed mercury study could be archived for future analysis of other contaminants. Small fish sampling is crucial to tracking whether mercury concentrations are increasing or decreasing in response to management actions and to determining the local and regional impacts of load reductions and restoration projects.

APPLICABLE RMP OBJECTIVES AND MANAGEMENT QUESTIONS

RMP Objective 1 Describe the distribution and trends of pollutant concentrations in the Estuary.

Management Questions

1.2 Are pollutants of concern increasing, decreasing, or remaining the same in different media? – *Small fish are the best tool for assessing inter-annual variation in food-web mercury in aquatic habitats.*

1.3 How are contaminant patterns and trends in the Estuary over time affected by remediation and source control or pollution prevention in the watersheds? – *Sampling small fish over several years will indicate spatially explicit changes in methylmercury, which is the mercury species of interest.*

1.4 Do pollutant concentration distributions indicate particular areas of origin or regions of potential ecological concern? – *Small fish will provide information on variation in food-web mercury over relatively small spatial scales.*

1.5 What effects on beneficial uses or attainment of Water Quality Standards will occur due to large-scale habitat restoration in the Estuary in decades to come? – *Data from small fish can be correlated with the location and timing of major restoration projects to detect regional changes in food-web mercury that may be related to wetlands restoration.*

RMP Objective 2 Project future contaminant status and trends using current understanding of ecosystem processes and human activities.

Management Question

2.8 Do pollutants show existing distributions that fit our current understanding or models of their origin, loads, and transport? *Small fish will indicate where and when mercury is taken up into the food web, which can be analyzed in relation to abiotic trends in mercury.*

RMP Objective 4 Measure pollution exposure and effects on selected parts of the Estuary ecosystem (including humans).

Management Questions

4.2 Which (co-)factors (e.g., food web structure) influence exposure and effects of specific pollutants on biota? – *By sampling benthic and pelagic small fish from Suisun to the South Bay, we will gain information on habitat and salinity cofactors that may influence Hg exposure.*

4.3 What ecological risks are caused by pollutants of concern? – *Small fish are wildlife prey, and threshold concentrations in prey have been identified.*

RMP Objective 5 Compare monitoring information to relevant benchmarks, such as TMDL targets, tissue screening levels, water quality objectives, and sediment quality objectives.

Management Question

5.2 Which segments should be considered impaired and why, and how do segments compare in terms of recovery targets? – *Small fish will be an excellent indicator of regional variation relative to tissue threshold concentrations for wildlife prey.*

APPROACH

Small fish will be sampled from three habitat types, nearshore demersal (benthic), nearshore pelagic, and mid-channel benthic. These fish will provide information about the mercury exposure of piscivores that specialize on either type of small fish prey. The nearshore benthic species are less mobile and have smaller home ranges than the pelagic species. Therefore, this sampling design will provide both fine-scale and sub-embayment-level information on spatial variation. Sampling in 2005 resulted in multiple species collected, with some degree of site overlap among species (Table 1). Based on these results, primary target species for future years are as follows:

1) Nearshore benthic habitat – arrow goby and cheekspot goby. Results from 2005 indicated that both are sufficiently abundant to be feasibly collected (Table 1).
2) Nearshore pelagic habitat – topsmelt (saline) and Mississippi silversides (brackish). These species overlap in range and are abundant in the Bay.
3) Mid-channel benthic - bay goby. These are collected by the CDFG San Francisco Bay Midwater Trawling study (in kind) (Orsi 1999).

Young-of-the-year fish will be collected in early fall, allowing capture of as much of the summer increase in growth, consumption, and consequent mercury uptake as possible. The number of sites sampled will be based on budgetary allotment. Given the current budget, fish can be collected from seven sites in each sampling year. Sites will be fixed, rather than randomly located, to allow analysis of trends in bioaccumulation of mercury over time.

Table 1. Species captured in 2005 for Hg analysis. Euhaline = inhabits waters of marine salinity (approximately 30 ppt). Polyhaline = inhabits waters of brackish salinity (approximately 18 to 30 ppt). Number of sites indicates number of sites at which the species was captured, of 8 sites sampled in 2005.

Common name	Scientific name	Habitat	Salinity affinity	Number of sites	Vagility	Target size (mm) [a]
Topsmelt	*Atherinops affinis*	Shallow water pelagic	Euhaline	5	Vagile	20 – 100
Mississippi silverside	*Menidia beryllina*	Shallow water pelagic	Polyhaline	6	Unknown	20 – 80
Bay goby	*Lepidogobius lepidus*	Deep channel benthic	Euhaline	5	Moves Baywide	20 – 40
Cheekspot goby	*Ilypnus gilberti*	Shallow water benthic	Euhaline	4	Strong site affinity	20 – 40
Arrow goby	*Clevelandia ios*	Shallow water benthic	Euhaline	2	Strong site affinity	20 – 50
Shimofuri goby	*Tridentiger bifasciatus*	Shallow water benthic	Polyhaline	2	Strong site affinity	40 – 70

a. total length

Four to six composites of whole fish from each species from each location will be analyzed for total mercury. Five to ten fish will be included in each composite. Total mercury will be analyzed rather than methylmercury, because most mercury assimilated by fish is methylmercury (Huckabee *et al.* 1979) and these species are not likely to have much sediment (containing inorganic Hg) in the gut.

The sampling design for 2006 and 2008 includes a larger number of composite samples per site than the 2005 design. Additional samples are being collected to enable partitioning of samples into two size categories (20-50 mm and 50-80 mm). The use of multiple size categories is in response to a local management need for data on Hg concentrations in fish that may serve as prey to small avian predators (e.g., clapper rail and least tern) (Carrie Austin, SFBRWQCB, *Pers. comm.*). Multiple size categories will also facilitate development of statistical models that partition Hg variance according to spatial location vs. fish size (Tremblay *et al.* 1998).

This is being coordinated with other fish sampling projects in the Bay to avoid duplication of effort and reduce costs. Other relevant projects include the CDFG Bay Study previously mentioned, the CALFED-funded USGS study of mercury in birds and their prey, the Port of Oakland fish studies, and any future mercury monitoring in biota by the South Bay Salt Pond Restoration Project.

This work will provide standard protocols and initial data that will form a foundation upon which a future small-fish monitoring program can be built. This proposal focuses only on mercury. A companion proposal (attached Appendix A) focuses on the trace organic contaminants, PCBs, PBDEs, and legacy pesticides.

SAMPLING DESIGN

Core design: Fixed monitoring stations

Based on stakeholder feedback, the original project work plan focused on multiple fixed monitoring stations. These stations were chosen to be representative of both large-scale wetland restoration areas and reference stations (Figure 1). The original plan was to monitor eight fixed stations annually[1]. This design has two primary advantages: the ability to detect interannual variation in specific locations, and high statistical power for detecting long-term trends. The primary drawback to this design is that analogous to the original fixed RMP status and trends program: as stations were not selected probabilistically, from a strictly statistical perspective, they don't represent Bay-wide conditions. For 2005, the following seven fixed locations were successfully sampled:

- Benicia State Park
- China Camp
- Middle Harbor Oakland or Seaplane Lagoon (Alameda)
- Eden Landing
- Bird Island (NW of Bair Island)
- Newark Slough
- Mouth of Alviso Slough

The status quo project plan would be to continue sampling these locations on an annual basis. The anticipated cost of continuing this design for seven stations is $40,000 per year (Table 3a).

Alternate designs/Project additions

Based on management priorities of the Regional Board and RMP stakeholders, a number of modifications or additions could be made for the EEPS Small Fish Project. These are summarized in Table 2.

Focus on wildlife risk

The Mercury TMDL includes a target of 0.03 µg per gram in fish tissue to be protective of least tern and clapper rail. In the first sampling year, 39 samples of 97 (i.e., 40%) had mercury concentrations above this target. The Regional Board or other stakeholders may consider it a high priority to gather additional data relevant to the potential risk to these wildlife. The EEPS Small Fish Project could be modified or augmented to accommodate this, if this information need isn't sufficiently met by other programs.

A sampling design focusing on risk to least tern and clapper rails would include the following components:

- focus on collection of very small fish (less than 50 mm)

[1] Due to funding constraints, no monitoring is currently scheduled for 2007

- focus on species known to be prey for least tern and clapper rails (e.g., anchovy, topsmelt, jacksmelt, herring)
- focus exclusively on sampling known foraging locations for these avian predators (e.g., Alameda shoreline and South Bay)
- selection of stations could be fixed or based on a probabilistic design. The use of the probabilistic design would result in a distribution of prey concentrations representing current expected exposure of target wildlife.

This design could be incorporated by replacing the fixed station design during one of the sampling years. Alternatively, it can be added to the fixed station design and an additional cost of approximately $3600 per station (Table 3b).

Figure 1. Location of fish collection stations in 2005. No target fish were captured at the Napa River station; as a result, it has been removed from the design.

Additional Bay wide coverage

The fixed stations were selected to achieve Bay-wide coverage of a mixture of restoration and reference sites. If the Regional Board or RMP stakeholders consider it a priority to obtain more extensive spatial coverage of San Francisco Bay, additional fixed stations can be added to the program.

A cost-neutral way to accomplish this would be to conduct biennial monitoring of two alternating sets of fixed stations. If this design were requested, seven to eight new stations would be selected and would be sampled in alternating years with the current fixed stations. These new stations could be selected probabilistically, to be more representative of Bay-wide mercury concentrations. With alternating years and stations, it would probably take at least 6 years to be able to partition spatial vs. interannual variation in this design. There would be no additional cost to alternate between two sets of fixed stations.

A more powerful way to achieve additional coverage would be to simply increase the budget allotment for individual stations. As indicated above, additional stations could be added to the current stations at a cost of $3,600 per station (Table 3b).

Additional San Pablo Bay coverage

Currently, the US Fish and Wildlife Service conducts biweekly beach seine surveys for juvenile salmon in multiple Bay-Delta locations. Their sampling includes nine fixed stations around the perimeter of San Pablo Bay. Discussions with the project manager indicate that they frequently catch other species as by-catch and would be glad to provide our project with samples in exchange for sampling assistance (Rick Wilder, USFWS, Stockton, *Pers. comm.*). This provides a cost-effective opportunity to obtain more detailed data on methyl mercury exposure in San Pablo Bay. The estimated cost of adding seven additional sites in coordination with Fish and Wildlife Service is $9,500 (Table 3c).

Spatial gradients of mercury bioavailability

The 2005 results suggested that small scale spatial variation may strongly influence bioavailability of mercury. In particular, concentrations were higher in silversides than many other species. Silversides are more of a brackish species than the other species sampled. The higher concentrations of mercury in silversides may have resulted from a tendency to inhabit locations further upstream where there was more bioavailable methylmercury.

The hypothesis that mercury bioavailability increases upstream in Bay sloughs could be explicitly tested. This would be accomplished by sampling silversides in multiple locations upstream of the stations exhibiting highest silverside mercury concentrations: Alviso Slough and Newark Slough. If concentrations increased in fish sampled further upstream along these channels, this would suggest that elevated silverside concentrations result from their proximity to higher methylmercury exposure upstream.

The cost of a spatial gradient study, including four locations at each of two stations, would be approximately $8,000 (Table 3d).

Dietary variation among small fish

An alternative hypothesis to explain the elevated concentrations in silversides is dietary differences among the species. This hypothesis has been proposed for evaluation as part of a separate RMP special study. The cost of doing the dietary study alone would be $13,000.

Trace organic concentrations in small fish

Another important data gap is potential wildlife exposure to PCBs, legacy pesticides, and PBDEs as a result of consuming small fish. At a total cost of $10,000-$18,000, the small fish mercury study could also be augmented with analysis and trace organics (Appendix A).

Table 2. Summary of EEPS Small Fish Project and potential add-ons.

Component	Cost	# Sites	Details
Core monitoring program	$40K/yr	7	Fixed monitoring design focusing on restoration and reference stations throughout the Bay (Figure 1). Currently planned for 2006 and 2008. Additional funding for this work in 2007 is proposed.
Wildlife risk evaluation	$3.6K/site; $25K for 7 sites	Flexible	Sample stations known to be wildlife foraging areas. Focus on very small prey. Random or fixed design, depending on specific objectives.
Additional Bay wide coverage	$3.6K/site/yr	Flexible	Increased spatial coverage of the program by sampling six to eight new locations. Additional annual stations can be added, or, at no cost stations can be sampled biennially in alternating years.
Additional San Pablo Bay coverage	$1.3K/site/yr; $9K for 7 sites	1-9	Increased spatial coverage of the program by sampling six to eight new locations. Cost leverage achieved by collaborating with USFWS Salmon beach seine program.
Spatial gradient of Hg bioavailability	$8K	4 sites in 2 stations	Answer question of whether mercury exposure increases moving upstream in mercury loading areas.
Dietary variation among small fish	$13K	4	Answer question of whether Hg differences among small fish species are associated with diet differences.
Organics monitoring	$10K - $18K	8 samples	Evaluate concentrations of PCBs, pesticides, and/or PBDEs in small fish. See Appendix A for further details.

A fully funded program

For planning purposes, here is the calculated cost of funding all of the listed project additions, as well as the core program. A fully funded program would have a portfolio and cost as follows:

- 7 core monitoring stations, with the general program management and reporting ($40K)
- 7 additional randomly selected wildlife risk stations in high-priority foraging areas ($25K)
- 5 additional Bay-wide stations ($18K)
- 7 San Pablo Bay stations ($9K)
- The spatial gradient and dietary studies ($21K)
- The organics study for all target compounds in 8 samples (PCBs, PBDEs, legacy pesticides; $18K)

Summing these, the total cost would be $131,000.

Table 3. Detailed Project Budget (following page). The budget is broken down into the core monitoring program and project add-ons. **a)** The core program including project management, study design, report preparation, sampling (7 stations plus bay gobies), analysis, and write up. **b)** Additional stations assume lower cost due to leverage, only requiring field sampling and lab analysis. The budget assumes that fish will be captured on shore using a beach seine and minnow traps. **c)** Additional stations with USFWS sampling program only require one staff day and lab analysis. **d)** Examination of spatial gradient in Hg at two sites. See also, Tables in the Appendices.

	2007			2008		
	Hours	Multiplier	Cost	Hours	Multiplier	Cost
Table 3a. CORE MONITORING PROGRAM						
SFEI		$	$		$	$
Project Management						
Analyst	40	51	$2,040	40	54	$2,142
Scientist	20	75	$1,500	20	79	$1,575
SUBTOTAL			$3,540			$3,717
Study Design						
Scientist	15	75	$1,125	15	79	$1,181
Field Work (14 days 2005, 7 (10 hr) days 2007 and 2008)						
SFEI Staff (2 people)	140	63	$8,820	140	66	$9,261
Boat rental (125/day; 2 days, 2007 and 8)			$263			$276
Truck rental (75/day)			$945			$992
Equipment, supplies, shipping			$1,000			$1,050
SUBTOTAL			**$11,028**			**$11,579**
Analysis and Write-up						
Scientist	60	75	$4,500	60	79	$4,725
CONTRACTOR						
Andy Jahn			**$7,000**			**$7,000**
LABORATORY						
12 Samples/site ($110/sample)			$9,240			$9,702
30 additional samples (IEP, etc)			$3,300			$3,300
GRAND TOTAL			**$39,733**			**$41,204**

	2007 Hours	2007 Multiplier	2007 Cost	2008 Hours	2008 Multiplier	2008 Cost
Table 3b. ADDITIONAL SITES						
SFEI						
Project management						
Analyst	8	51	$408	8	54	$428
Field Work (10 hr day)						
SFEI Staff (2 people)	20	63	$1,260	20	66	$1,323
Boat rental (125/day)			$131			$131
Truck rental (75/day)			$79			$79
Equipment, supplies, shipping			$100			$100
CONTRACTOR						
			$500			$550
LABORATORY						
10 Samples/site			$1,100			$1,100
PER ADDITIONAL SITE TOTAL			**$3,578**			**$3,711**

SEVEN ADDITIONAL SITES	**GRAND TOTAL**	**$25,046**	**$25,980**

Table 3c. USFWS SAN PABLO BAY SITES						
SFEI						
Field Work (8 hr day)						
SFEI Staff (1 person)	8	63	$504	8	66	$529
Truck rental (75/day)			$79			$79
Equipment, supplies, shipping			$100			$100
LABORATORY						
6 Samples/site			$660			$660
TOTAL			**$1,343**			**$1,368**
SEVEN ADDITIONAL SITES						
GRAND TOTAL			**$9,399**			**$9,576**

	2007			2008		
Table 3d. SPATIAL GRADIENT STUDY	Hours	Multiplier	Cost	Hours	Multiplier	Cost
SFEI						
Project management						
Analyst	8	51	$408	8	54	$428
Field Work (4 x 8 hr days)						
SFEI Staff (2 people)	32	63	$2,016	32	66	$2,117
Truck rental (75/day)			$158			$158
Equipment, supplies, shipping			$100			$100
CONTRACTOR						
			$1,000			$1,100
LABORATORY						
40 samples/location			$4,400			$4,400
TOTAL			**$8,082**			**$8,303**

LITERATURE CITED

Davis, J. A., D. Yee, J. N. Collins, S. E. Schwarzbach, and S. N. Luoma. 2003. Potential for increased mercury accumulation in the Estuary food web. San Francisco Estuary and Watershed Science **1**:Article 4. http://repositories.cdlib.org/jmie/sfews/vol1/iss1/art4

Huckabee, J. W., J. W. Elwood, and S. G. Hildebrand. 1979. Accumulation of mercury in freshwater biota. Pages 277-302 *in* Nriagu, editor. The biogeochemistry of mercury in the environment. Elsevier/North-Holland Biomedical Press

Johnson, B., and R. Looker. 2004. Mercury in San Francisco Bay Total Maximum Daily Load (TMDL) Proposed Basin Plan Amendment and Staff Report. California Regional Water Quality Control Board San Francisco Bay Region, Oakland, CA

Mumley, T. E., and R. Looker. 2004. Adaptive implementation of TMDLs – The mercury example. Pages 16 – 22 *in* The Pulse of the Estuary: Monitoring and Managing Water Quality in the San Francisco Estuary. San Francisco Estuary Institute, Oakland, CA. http://www.sfei.org/rmp/pulse/pulse2004.html

Orsi, J. J. 1999. Report on the 1980-1995 Fish, Shrimp, and Crab Sampling in the San Francisco Estuary, California. Technical Report 63, The Interagency Ecological Program for the Sacramento-San Joaquin Estuary (IEP), Sacramento, CA. http://www.estuaryarchive.org/archive/orsi_1999

SFEI. 2006. Wetland Project Tracker. *in*. San Francisco Estuary Institute Website, Oakland, CA. http://www.wrmp.org/projectsintro.html

St. Louis, V. L., J. W. M. Rudd, C. A. Kelly, K. G. Beaty, N. S. Bloom, and R. J. Flett. 1994. Importance of wetlands as sources of methyl mercury to boreal forest ecosystems. Can. J. Fish. Aquat. Sci. **51**:1065-1076

Tremblay, G., P. Legendre, J.-F. Doyon, R. Verdon, and R. Schetagne. 1998. The use of polynomial regression analysis with indicator variables for interpretation of mercury in fish data. Biogeochemistry **40**:189-201

Wiener, J. G., C. C. Gilmour, and D. P. Krabbenhoft. 2003. Mercury Strategy for the Bay-Delta Ecosystem: A Unifying Framework for Science, Adaptive Management, and Ecological Restoration (External Review Draft). Report to the California Bay Delta Authority.

Appendix A. Determining trace organic pollutants in wildlife prey fish in the San Francisco Estuary

Ben Greenfield and Letitia Grenier, SFEI, Andy Jahn (Independent consultant), and Dave Crane (CDFG-WPCL)

Background
The small fish mercury (Hg) pilot project monitors spatial and temporal patterns in Hg concentrations in small fish captured in the San Francisco Estuary. Fish are captured from eight shoreline locations. This study has been funded by the RMP for 2005, 2006, and 2008. Additional funding to perform this work in 2007 is proposed.

Proposal
The proposed project augmentation is to determine PCB, pesticide, and PBDE concentrations in additional fish collected during the 2007 sampling period. This would be a pilot study, focused on collecting composite samples of abundant prey species, including topsmelt, inland silverside, or other abundant fish at collection sites.

Justification
The findings from this study would fill identified data gaps in our understanding of the risks posed by these compounds in the Estuary. The Regional Water Board has requested information on PCB and pesticide residues to fill a data gap on wildlife exposure for the TMDLs. While there are currently extensive data on PCBs and pesticides in sport fish, there are virtually no data on these legacy pollutants in appropriately sized fish for consumption by least tern and other sensitive wildlife piscivores. Similarly, there has been substantial concern regarding PBDE exposure. Evidence of elevated concentrations in piscivorous wildlife, sport fish, and humans (She *et al.* 2002, Greenfield *et al.* 2003, Davis *et al.* 2006) has prompted a need for more data collection. The availability of such data would allow application of preliminary risk assessment models to estimate the potential risk posed to piscivorous wildlife. It should also allow preliminary estimation of the reductions necessary to achieve concentrations below TMDL established thresholds.

Methods
The collection locations are shoreline areas distributed throughout the San Francisco Estuary (Figure 1). A single-species composite sample would be targeted at each collection location, with the emphasis on collecting the most abundant pelagic prey species in each location. Based on the first year collection effort, inland silverside are likely to be available in polyhaline locations of salinity 20 to 26 psu, and topsmelt are likely to be available in the more euhaline locations (27 to 30 psu). Additional collection efforts would be undertaken to obtain composites including the necessary tissue amounts for these samples (10 – 30 g fresh tissue mass per sample).

Figure 1. Location of fish collection stations in 2005.

Laboratory analyses would be performed by the CDFG Water Pollution Control Lab, which currently performs organochlorine pollutant analyses for the RMP sport fish and avian egg monitoring. Analytical methods would be at the low reporting limits necessary to quantify these compounds in small fish (0.2 ng/g for 40 PCB congeners, < 0.8 ng/g for 10 PBDE compounds, 0.5 – 2.0 ng/g for 29 pesticides). The findings on tissue concentrations would be reported by SFEI scientific staff, along with the mercury concentration findings of the project. As the samples would be spatially distributed throughout the Estuary, the primary reporting objective would be to document the Estuary-wide distribution of observed tissue concentrations. It is expected that this information would be useful for the Regional Board in TMDL and other Bay-wide regulatory reporting.

References:

Davis, J. A., J. A. Hunt, J. R. M. Ross, A. R. Melwani, M. Sedlak, T. Adelsbach, D. Crane, and L. Phillips. 2006. Pollutant Concentrations in Eggs of Double-crested Cormorants from San Francisco Bay in 2002 and 2004: A Regional Monitoring Program Pilot Study: Draft Report. SFEI Contribution #434, San Francisco Estuary Institute Oakland, CA

Greenfield, B. K., J. A. Davis, R. Fairey, C. Roberts, D. Crane, G. Ichikawa, and M. Petreas. 2003. Contaminant concentrations in fish from San Francisco Bay, 2000. RMP Technical Report SFEI Contribution #77, San Francisco Estuary Institute, Oakland, CA. http://www.sfei.org/rmp/reports/fish_contamination/2000/FishStudy_finalv3.pdf

She, J., M. Petreas, J. Winkler, P. Visita, M. McKinney, and D. Kopec. 2002. PBDEs in the San Francisco Bay Area: measurements in harbor seal blubber and human breast adipose tissue. Chemosphere **46**:697-707

Budget

The project budget is indicated below. The budget may be modified based on the number of analytes desired. If additional funds were available, they would be used to increase sample sizes.

Laboratory costs			
	Cost/sample	Samples	Total analysis
PCBs	$490	8	$3,920
Pesticides *	$490	8	$3,920
PBDEs	$530	8	$4,240
Subtotal			$12,080
* Includes DDTs, chlordanes, toxaphene, dieldrin, and other legacy pesticide pollutants			
Project management/administration costs			
	Labor rate ($/hr)	Hours	
Collection/processing	$70	16	$1,120
QA/data management	$100	24	$2,400
Data analysis/reporting	$70	32	$2,240
Contract management	$70	8	$560
Total project management and administration			$6,320
Total PCBs only or pesticides only			$10,240
Total PCBs plus pesticides			$13,530
Total PCBs or pesticides plus PBDEs			$13,850
Total PCBs, pesticides, and PBDEs			$18,400