Item 7

2015 RMP Special Studies Budget Recommended by the RMP Technical Review Committee

Updated 7/11/2014

Proposed 2015 RMP Special Studies

Study	Cost	TRC Recommendation	
1 CEC in Effluent	$55,000	$55,000	
2 CUPs in Napa/North Bay	$55,000	$0	Consider for 2016
3 Microplastics	$9,000	$9,000	
Subtotal CEC	*$119,000*	*$64,000*	
4 STLS Wet weather characterization	$415,000		
5 STLS RWSM	$35,000		
6 STLS Trends strategy	$35,000		
7 STLS Coordination	$26,000		
Subtotal STLS	*$511,000*	*$470,000*	Specific projects to be scaled and RMP deliverables determined.
8 Nutrient modeling	$100,000		
9 Nutrient moored sensors	$300,000		
10 Nutrient coordination	$20,000		
11 Nutrient program development	$50,000		
11.5 Conceptual model update	$30,000		
Subtotal Nutrients	*$500,000*	*$470,000*	Specific projects to be scaled and RMP deliverables determined.
12 SQO Pacific Dry Dock	$45,000	$0	Consider for 2016
13 Dioxin synthesis	$40,000	$0	Consider for 2016
15 Selenium in plugs and eggs	$20,000	$20,000	
16 Selenium Strategy support	$10,000	$10,000	
17 PCB: PMU conceptual models	$100,000	$85,000	
Subtotal	*$215,000*	*$115,000*	
Total	*$1,345,000*	*$1,119,000*	
Budget		*$1,028,000*	Budget from Multi-Year Plan. The budget may increase after savings due to S&T program changes are fully understood.
Shortfall		*-$91,000*	The SC should consider the use of Unencumbered Funds for this shortfall.

Note: Proposals for recommended studies are provided on the following pages.

EVALUATING EMERGING CONTAMINANT PATHWAYS: WASTEWATER DISCHARGES

Rebecca Sutton and Meg Sedlak, SFEI, Richmond, CA

ESTIMATED COST: $55,000
OVERSIGHT GROUP: Emerging Contaminants Work Group (ECWG)

PROPOSED DELIVERABLES AND TIMELINE

Deliverable	Due Date
Task 1. Project Management (write and manage sub-contracts, track budgets)	Summer – Dec 2014
Task 2. Collection of wastewater effluent	Fall 2014
Task 3. Laboratory analysis	Fall 2014
Task 4. QA/QC and data management	Dec 2014
Task 5. Draft and final manuscript	Mar 2015

Background

The State Water Resources Control Board's Chemicals of Emerging Concern (CECs) Science Advisory Panel has directed agencies to include sampling wastewater treatment plant (WWTP) effluent and stormwater when screening for emerging contaminants (Anderson et al. 2012). The follow-up state pilot study, now under development, similarly emphasizes examination of these contamination pathways as an important means of providing policymakers with the data they need to make sound, science-based decisions regarding CECs and environmental management (Advisory Panel Meeting 2013). To expand our knowledge of the role of WWTP effluent in contaminating the Bay environment, we propose monitoring high priority and newly identified CECs in this matrix.

This study will expand on already-approved WWTP effluent monitoring for alternative flame retardants and estrogenic contaminants (Denslow et al. 2012; Sutton and Sedlak 2013). Measurements made as part of this study may provide an indication of the relative importance of wastewater as a contamination pathway for specific CECs in San Francisco Bay, especially when compared to local stormwater discharges analyzed as part of ongoing studies (fipronil) or previously characterized in the literature (PFCs; Houtz and Sedlak 2012). In the case of fipronil, comparison of influent to effluent can provide information regarding the effects of treatment processes on contaminants of interest. By encouraging a collaborative monitoring effort among dischargers, it may be possible to avoid implementing new, costly permit requirements.

Applicable RMP Objectives and Management Questions

This study will address the following RMP Objectives and Management Questions:

MQ.1 Are chemical concentrations in the Estuary at levels of potential concern and are associated impacts likely?

- A: Which chemicals have the potential to impact humans and aquatic life and should be monitored?

MQ.2 What are the concentrations and masses of contaminants in the Estuary and its segments?

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

MQ.3 What are the sources, pathways, loadings, and processes leading to contaminant-related impacts in the Estuary?

- A: Which sources, pathways, and processes contribute most to impacts?

Detailed Outline of Study Objectives

1. Describe the distribution and trends of pollutant concentrations in the WWTP effluent pathway leading to the Estuary.

- This study will provide some of the first data to determine the distribution of concentrations of CECs in effluent discharged to the Estuary, and to place these concentrations in context with those observed in other locations.

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

- The relative significance of this exposure pathway in Bay contamination may suggest potential future trends, particularly in combination with time trends observed in biota.

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

- Policymakers need to know which pathways lead to Bay CEC pollution to evaluate whether management actions are needed.

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

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

Relationship of the Study to the ECWG Priority Question and Current RMP List of Emerging Contaminants

The Emerging Contaminants Workgroup is focused on answering the following question: "What emerging contaminants have the greatest potential to adversely impact beneficial uses in the Bay?"

The State Water Resources Control Board's CEC Science Advisory Panel has directed agencies to include sampling contamination pathways when screening for emerging contaminants (Anderson et al. 2012). For PFOS and fipronil, CECs of moderate concern to San Francisco Bay (Tier III), an evaluation of the effluent pathway of contamination is a logical next step in producing the science that policymakers need to make decisions that maintain Bay health. Comparison of effluent PFOS, PFC, and precursor concentrations from the South Bay with those

of other regions may establish whether this pathway could be a factor in the persistence of South Bay PFOS contamination despite a nationwide production phase-out. Limited data on concentrations of fipronil in influent and effluent suggest this is an appropriate data gap to fill via monitoring.

Finally, some new CECs under consideration for monitoring via special studies might be best examined in effluent first, to determine whether ambient Bay sampling is advisable. These include specific new PPCPs and plastic microbeads.

Approach

PFOS and fipronil (and its degradates), both Tier III (moderate concern) CECs, are strongly recommended as analytical targets for WWTP effluent monitoring as an initial means of assessing the importance of wastewater as a pathway for Bay contamination. As described in the Rationale in Table 1, gaps in knowledge about the importance of the effluent pathway for each of these contaminants could be filled, providing information relevant to potential management actions.

In addition, some new CECs that may merit initial monitoring via a special study might be best examined in effluent to determine whether ambient Bay sampling is advisable. These include specific new PPCPs and plastic microbeads. A specific funding request for these analyses is not included here. Funding limitations necesitate careful consideration as to the utility of each additional target, and for this reason PBDEs are not recommended for effluent monitoring (see Rationale, Table 1).

Samples of WWTP effluent voluntarily provided by up to eight Bay Area dischargers will be characterized. A replicate sample will be collected as well, for a total of up to nine WWTP effluent samples. Effluents obtained via secondary and advanced treatments must be included in the study. An ideal group of WWTPs would include facilities in South, Central, and North Bay, with an emphasis on South Bay dischargers due to the lower levels of dilution and resulting higher concentrations of contaminants in that region. The persistence of high levels of PFOS in South Bay wildlife (Sedlak and Greig 2012) provides another rationale for contrasting South Bay effluents with those from other parts of the Bay. An emphasis on high volume dischargers is also recommended. Finally, inclusion of WWTPs that discharge into wetlands is recommended, as different physical, chemical, and biological processes may occur in wetlands relative to the greater Bay environment.

For PFCs and precursors, an effluent grab sample is considered preferable to a 24-hour composite sample because the equipment used to aggregate samples could expose sample water to potential sources of contamination. In addition, grab samples that pass through teflon pipes at the point of collection will not be suitable for these analyses. Samples will be collected during diurnal peak flow. PFCs/precursors analyses will be conducted by AXYS (~$1,670/sample). Samples will be analyzed for total suspended solids as well.

In contrast, for fipronil and degradates, a composite effluent sample is preferable because any contamination will not interfere with analysis, and a composite sample will assure a

representative measurement should there be diurnal variation in discharge levels. Composite influent samples will also be collected, to further explore findings from a limited number of studies that suggest wastewater treatment does little to reduce concentrations of this pesticide in effluent (Heidler and Halden, 2009; Weston and Lydy, 2014). Fipronil analyses will be conducted by the California Department of Fish and Wildlife or a comparable laboratory (~$400/sample). Samples will be analyzed for total suspended solids as well.

Dischargers are not specifically identified here, and they will have the option to keep their identities confidential in subsequent reporting of the data. Measurements for each discharger will be reported individually using unique identifiers should dischargers request their identities be withheld. Through cooperative relationships with wastewater dischargers, we can obtain and share data about concentrations of CECs in effluent without implementing expensive permit requirements.

Reporting

Results of these proposed study elements will be reported as a RMP Technical Report and/or manuscript in 2015. A conference poster and web-based presentation of said poster (using Prezi software) may also be appropriate deliverables. Comparisons will be made to past screening efforts in the Bay and in the literature from other locations, as well as to relevant toxicological information on these emerging contaminants available at that time. Estimates of the relative contribution of wastewater and stormwater derived contamination will be provided, using stormwater data from ongoing studies or the literature (e.g., Houtz and Sedlak 2012).

Proposed Budget

The budget is presented as separate tasks that can be performed as separate elements or combined.

Task	**Estimated Cost**
Analysis of 2014 WWTP effluent for PFCs and precursors (n=8+1 replicate), data management and reporting	$36,000
Analysis of 2014 WWTP influent and effluent for Fipronil and degradates (n=8+1 replicate for each), data management, and reporting	$19,000
Total	**$55,000**

References

Advisory Panel Meeting – State of California Pilot Study: Monitoring Constituents of Emerging Concern (CECs) in Aquatic Ecosystems. September 12-13, 2013: Costa Mesa, CA.

Anderson, P.D., N.D. Denslow, J.E. Drewes, A.W. Olivieri, D. Schlenk, G.I. Scott and S.A. Snyder. 2012. Monitoring Strategies for Chemicals of Emerging Concern (CECs) in California's Aquatic Ecosystems. Costa Mesa, CA.

Denslow N., Maruya K., Bay S. 2012. Linkage of *In Vitro* Assay Results with *In Vivo* End Points. Proposal for the RMP Emerging Contaminants Workgroup.

Heidler J., Halden R.U. 2009. Fate of organohalogens in us wastewater treatment plants and estimated chemical releases to soils nationwide from biosolids recycling. Journal of Environmental Monitoring 11:2207-2215.

Houtz E.F., Sedlak D.L. 2012. Oxidative conversion as a means of detecting precursors to perfluoroalkyl acids in urban runoff. Environmental Science & Technology 46:9342-9349.

Sedlak M.D., Greig D.J. 2012. Perfluoroalkyl compounds (PFCs) in wildlife from an urban estuary. Journal of Environmental Monitoring 14:146-154.

Sutton R., Sedlak M. 2013. Monitoring alternative flame retardants in SF Bay water, sediment, and biota: Pathway characerization – wastewater and stormwater. Proposal addendum requested by the RMP Steering Committee. September 2013.

Weston D.P., Lydy M.J. 2014. Toxicity of the insecticide fipronil and its degradates to benthic macroinvertebrates of urban streams. Environmental Science & Technology 48:1290-1297.

MONITORING MICROPLASTICS IN SAN FRANCISCO BAY

Ellen Willis-Norton and Rebecca Sutton, SFEI, Richmond, CA

ESTIMATED COST: $8,800
OVERSIGHT GROUP: Emerging Contaminants Work Group (ECWG)

PROPOSED DELIVERABLES AND TIMELINE

Deliverable	Due Date
Task 1. Project Management (write and manage sub-contracts, track budgets)	Summer – Dec 2014
Task 2. Collection of ambient sediment samples	Summer 2014
Task 3. Collection of ambient water samples	Fall 2014
Task 2. Collection of wastewater effluent	Fall 2014
Task 3. Laboratory analysis	Fall/Winter 2014
Task 4. Data management	Spring 2014
Task 5. Presentation to ECWG	Apr 2015

Background

General Background:
Microplastic is a term used to describe fragments of plastic that are less than 5mm (Wright et al., 2012). Microplastics can be pellets that are used as precursors for industrial products, microbeads used in consumer products (e.g. exfoliants), or fragments/fibers of plastics that are the breakdown products of larger plastic materials. Microplastics can enter the aquatic environment through wind, stormwater runoff, or illegal dumping of plastic materials (Eriksen et al. 2013). Additionally, both microbeads from cosmetic products and plastic fibers (e.g., polyester and acrylic) from clothing can be washed down the drain and enter wastewater treatment plants (European Commission 2012). Microplastics are not captured by wastewater treatment plants because they are buoyant and do not flocculate; therefore, they are released in wastewater (Hogue, 2013). It is important to note that both California and New York have proposed bans on microplastics found in cosmetics (Badore 2014). Additionally, Johnson & Johnson, L'Oréal, Colgate-Palmolive, and Procter & Gamble have pledged to phase out the use of microbeads in their skin cleansers (Hogue 2013). Therefore, the concentrations entering wastewater may decrease in the future.

Microplastics are found in surface waters, the water column, and sediment because of the varying density of plastic particles. They can also be found in the gut and circulatory system of aquatic organisms that ingest the particles. Studies have found that microplastics are also able to adsorb to organisms, blocking their feeding appendages (Wright et al., 2012). Ingestion of microplastics can block the digestive tract, reduce growth rates, block enzyme production, lower steroid hormone levels, affect reproduction, and cause the adsorption of toxins (Wright et al., 2012). The potential for ingesting toxins occurs because microplastics readily accumulate hydrophobic organic compounds, due to their high surface area to volume ratio (Teuten et al., 2007). In fact, the sorption of persistent organic pollutants (POPs) to microplastics exceeds sorption to sediments by two orders of magnitude (Mato et al., 2001); in one study, the concentration of POPs on microplastics was six orders of magnitude higher than the

concentration in the surrounding water column (Teuten et al. 2007). Therefore, the ingestion of microplastics by organisms can increase the exposure of aquatic life to toxic pollutants.

Microplastic Monitoring Studies

Plastic pollution has increased over the past several decades and is the dominant type of pollution in aquatic environments (Eriksen et al., 2013). Both industrial and densely populated coastal areas have been identified as microplastic hotspots (Wright et al., 2012). Most studies on plastic pollution in the United States have focused on macro-plastics (Ryan et al., 2010). Studies regarding microplastic pollution have been focused in the North Sea. However, there has recently been a handful of microplastic monitoring efforts in the United States, including a study in Santa Monica Bay, the Los Angeles River, and an on-going study in the Great Lakes.

The Santa Monica Bay study was completed in 2001 and was a partnership between the Algalita Marine Research Foundation and the Southern California Coastal Water Research Project. The study was noteworthy because it was the first microplastic monitoring effort that not only measured the abundance in the surface layer, but also at mid-depth and at the sediment-water interface (Lattin et al., 2004). The study monitored microplastics at varying depths because only 46% of microplastics are positively buoyant. The study observed microplastics at all depths and found that the abundance increased considerably after a storm event. Another microplastic study is just beginning in the Los Angeles area; Dr. Marcus Eriksen is monitoring microplastics in the Los Angeles River. The study will help determine if microplastics are entering Los Angeles' coastal waters through the urban watershed.

Microplastic pollution is also currently being measured in the surface waters of the Laurentian Great Lakes. The study found that microplastic pollution was greatest in Lake Erie, most likely because it is the most populated region (Eriksen et al., 2013). Unlike the Santa Monica Bay study, the microplastics were analyzed using scanning electron microscopy. Therefore, both abundance and the chemical composition of the particles were analyzed. The study is on-going and the researchers, including the project lead Sherri Mason (SUNY Fredonia), are currently considering adding effluent sampling to the monitoring effort.

Previous San Francisco Bay Monitoring

In 2011, microplastics were sampled in San Francisco Bay surface waters at six sites. The RMP partnered with Ian Wren at San Francisco Baykeeper and Joel Baker and Julie Masura at the University of Washington, Tacoma to complete the study. The study determined the mass of microplastic at sites in Central Bay that were suspected to be most influence by trash. The six sites were Oyster Bay, San Leandro Bay, Oakland Estuary, Berkeley Marina, Richmond Inner Harbor, and the San Francisco Waterfront. The concentration of microplastics ranged from 0.064 to 7.215 ug/L, similar to the concentration range observed in Puget Sound (LaRocque et al., 2011). However, the study only measured the mass of the microplastics, rather than the abundance and composition. Additionally, effluent has not yet been monitored in San Francisco Bay. Monitoring effluent would help identify whether personal care products were a significant source of microplastic pollution in the Bay.

Applicable RMP Objectives and Management Questions

This study will address the following RMP Objectives and Management Questions:

MQ.1 Are chemical concentrations in the Estuary at levels of potential concern and are associated impacts likely?

- A: Which chemicals have the potential to impact humans and aquatic life and should be monitored?

MQ.2 What are the concentrations and masses of contaminants in the Estuary and its segments?

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

MQ.3 What are the sources, pathways, loadings, and processes leading to contaminant-related impacts in the Estuary?

- A: Which sources, pathways, and processes contribute most to impacts?

Approach

San Francisco Bay is a densely populated area with a high potential for microplastic pollution. Given the risk of microplastic ingestion by aquatic life, monitoring the abundance and composition of microplastics in WWTP effluent and the ambient Bay would be worthwhile.

Two size fractions of microplastics will be sampled, > 0.355-mm and 0.125-0.355-mm (the size fraction that is characteristic of personal care product microbeads), in WWTP effluent and Bay sediment and water. Ambient Bay sediment sampling will occur during the 2014 RMP S&T sediment cruise (August 2014). Ten sediment samples will be collected throughout the Bay using a modified van Veen grab. The 10 stations will be a subset of the 27 stations sampled during the S&T sediment cruise and will emphasize Central and South Bay, where microplastic contamination is expected to be greater. Ambient Bay water sampling will occur soon after sediment sampling in Fall 2014. The samples will be collected from the same sites using planktonic nets. The samples will be collected separately from the sediment samples because it is logistically difficult to complete both types of field sample collections during one cruise.

WWTP effluent samples will be voluntarily provided by six Bay Area dischargers in Fall 2014. SFEI field staff will visit the sites and set-up a pump with a 0.355-mm sieve and pump water from the plant's effluent trough through the sieve for 24 hours. Dischargers are not specifically identified here, and they will have the option to keep their identities confidential in subsequent reporting of the data.

The effluent, water, and sediment samples will be sent to Dr. Sherri Mason at SUNY Fredonia for sample processing, visual sorting, and abundance measurements.

Reporting

Results of these proposed study elements will be reported to the Emerging Contaminants Workgroup during its Spring 2015 meeting. Comparisons will be made to monitoring efforts in other locations.

Proposed Budget

Task	**Estimated Cost**
Field collection of WWTP effluent and ambient Bay water for microplastics, vessel rental, and shipping	$5,400
Analysis of 2014 WWTP effluent (n=6), ambient Bay sediment (n=10), and ambient Bay water (n=10) for microplastics	$2,600
Project management and power point presentation to ECWG	$800
Total	**$8,800**

References

Badore, Margaret. "New York and California Propose Bans on Microplastics Found in Cosmetics." *Treehugger* 17 Feb. 2014: n. pag.

Eriksen, M., et al. Microplastic pollution in the surface waters of the Laurentian Great Lakes. 2013. Mar. Pollut. Bull., http://dx.doi.org/10.1016/j.marpolbul.2013.10.007

European Commission. "Microplastics from Washing Machine Wastewater Are Polluting Beaches." *DG Environment News Alert Service* 9 Feb. 2012: n. pag.

Fries, Elke, Jens H. Dekiff, Jana Willmeyer, Marie-Theres Nuelle, Martin Ebert, and Dominique Remy. 2013. Identification of polymer types and additives in marine microplastic particles using pyrolysis-GC/MS and scanning electron microscopy." Environmental Science: Processes & Impacts, 15.

Hogue, Cheryl. "Microplastic Beads Pollute Great Lakes." *Chemical and Engineering News*16 Sept. 2013, 91st ed.: 23-25.

LaRocque, C., Masura, J., Baker, J.E. 2011. Concentrations of Marine Microplastics in Puget Sound and Chesapeake Bay. University of Washington, Tacoma.

Lattin, Gwen L., Charles J. Moore, Ann F. Zellers, Shelly L. Moore, and Stephen B. Weisberg. 2004. A comparison of neustonic plastic and zooplankton at different depths near the southern California shore. *Marine Pollution Bulletin* 49, 291-294.

Mato, Y., Isobe, T., Takada, H., Kanehiro, H., Ohtake, C., Kaminuma, T. 2001. Plastic resin pellets as a transport medium for toxic chemicals in the marine environment. Environ. Sci. Technol. 35, 308-324.

Ryan, Peter G., Charles J. Moore, Jan A. van Franeker, and Coleen L. Moloney. 2009. Monitoring the abundance of plastic debris in the marine environment. *Philosophical Transactions of the Royal Society B: Biological Sciences*, 364.

Teuten, Emma L., Steven J. Rowland, Tamara S. Galloway, and Richard C. Thompson. 2007. Potential for plastics to transport hydrophobic contaminants. *Environmental science & technology* 41, 7759-7764.

Wright, S.L., et al., The physical impacts of microplastics on marine organisms: A review. 2013. Environmental Pollution, http://dx.doi.org/10.1016/j.envpol.2013.02.031

SMALL TRIBUTARIES LOADINGS

Lester McKee, Jennifer Hunt, Alicia Gilbreath, and Jing Wu, SFEI, Richmond, CA

ESTIMATED COST: $511,000
OVERSIGHT GROUP: Sources Pathways and Loading Work Group (SPLWG)

PROPOSED DELIVERABLES AND TIMELINE

Task	Deliverable	Due date															
		2014				2015											
		S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
1	Small tributaries wet weather characterization [MQ 1]																
1a	Wet season monitoring			!		!		!	!								
1b	Quality Assurance & Data Management																
1c	Interpretation & reporting													!		!	
2	Regional watershed spreadsheet model (RWSM) y5 [MQ 2]																
2a	Finalize work plan based on latest info. and priorities									!!							
2b	Compile latest data (GIS & stormwater data (Task 1)										!	!	!				
2c	Recalibrate model, estimate loads, & update model report													!	!	!	
3	Watershed loadings trends strategy support [MQ 3]																
3a	Devise & prioritize study questions (STLS oversight)					!	!										
3b	Identify analysis/interpretative methods (SPLWG oversight)							!!									
3c	Complete analysis & present prelim. findings to SPLWG								!	!!							
3d	Complete white paper (STLS/SPLWG review)										!		!				
4	Small tributaries loading strategy coordination support					!		!		!		!		!		!	

[MQ] = Municipal regional stormwater permit (MRP) and small tributary is loading strategy management questions
! = STLS check in for review and coarse corrections
!! = STLS/SPLWG oversight and review

Background

The San Francisco Bay Hg and PCB TMDLs call for a reduction in loads by 50 and 90% respectively. In response, the Municipal Regional Permit for Stormwater (MRP) Provision C.8.e. calls for a range of actions including gaining a better understanding of which Bay tributaries contribute most loading to sensitive areas of biological interest on the Bay margin, better quantification of loads of sediments and trace contaminants on a watershed basis and regionally, a better understanding of how and where trends might best be measured, and an improved understanding of which management measures may be most effective in reducing impairment. These same needs are reflected in the small tributary loading strategy (STLS) priority questions listed below. In addition, the Water Board, through provision C.11. and C.12. of the permit, called for PCB and mercury source and source area identification to identify a set of sites for pilot testing the efficacy of various best management practices for addressing loads and impairments.

Beginning with planning efforts in1999in 1999 -2002 (first report of the Sources, Pathways and Loadings Workgroup and the "Urban run-off literature review") and field studies beginning water year (WY) 2001 at Mallard island on the Sacramento River (which was then perceived as the largest single PCB and Hg loading pathway to the Bay), and continuing the following wet season with the instigation of a loading study on the Guadalupe River in San Jose (also perceived as a large loading pathway for both Hg and PCBs), the RMP made considerable progress on investigating the magnitude of loading to San Francisco Bay from WY 2001-2006. This effort continued with another fixed station loading study at a small 100% urban and industrial tributary called Zone 4 Line A in Hayward.

These studies provided basic information to inform TMDL implementation as well as providing a valuable dataset for many other purposes, including reevaluating study design in relation to the issuance

of the MRP in October 2009. As a result of this permit and the need to better understand which tributaries were contributing to greatest load per unit area (MQ 1), the RMP funded a reconnaissance study, the data from which (along with other information) supported the instigation of four additional fixed station loading studies in WY 2012 and two more, for a total of six, in WYs 2013 and 2014 that were deemed "no regret watersheds" and suitable for baseline information on which to measure future trends (MQ 3).

In addition the RMP funded the development of the Regional Watershed Spreadsheet Model (RWSM) as a tool for estimating regional and sub-regional loads (MQ 2) and an additional study component recommended by the STLS team to improve our understanding of source areas (GIS layer development) and event mean concentrations (EMC); the loading coefficients associated with each of the source areas (MQ 1).

The data obtained from the reconnaissance study (MQ 1) and the loading study (MQ 3) as well as efforts to better quantify the characteristics of our PCB and source areas (MQ 1)), together constituted an entire program of investigation. Of course, this was not occurring in a vacuum in relation to other strategies, in particular the Bay modeling strategy and the PCB and Hg strategies (and associated small fish studies) as illustrated in Figure 1. Indeed, the ongoing success of the STLS program component as a whole cannot occur without sustained support from the RMP and a programmatic vision with appropriate linkages across other strategies. As with all programs, the individual tasks must and do connect together as illustrated by the arrows (Figure 1). For example, characterization data obtained from field studies primarily aimed at answering MQ 1 are also needed to provide calibration data for the RWSM modelling effort being developed to answer MQ 2. The fixed station loading studies aimed at providing baseline data against which to measure future trends in relation to management actions (MQ 3), also provide data for helping to verify the RWSM. In addition, BASMAA utilized these data in Part C of their Integrated Monitoring Report to independently estimate regional loads and loads associated with specific land uses and provide the basis for predicting the effects of management actions (MQ 4). The development of GIS data and the back calculation of EMC data in relation to source identification (MQ 1) provide the necessary input data for the RWSM (MQ 2). Going forward, the small fish studies, the Bay margins conceptual model report, and the proposed conceptual model development for priority Bay margin units will provide an even greater linkage between sensitive biological areas on the Bay margin and upstream sources and potential management actions.

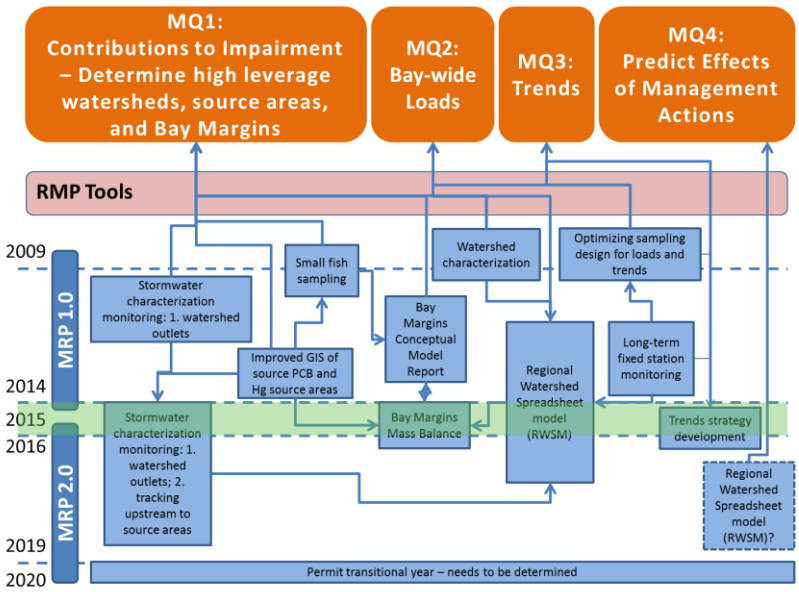


Figure 1. Key linkages between RMP funded studies within the overall small tributaries loading programmatic strategy. Highlighted in green are the proposed elements for 2015 put in context with previous funded elements and possible future elements.

Much has been learned over the past 15 years and many of the efforts during the first MRP term from 2009 to 2014 were very well supported by the massive amount of data and information collected by the RMP through the oversight of the Sources Pathways and Loadings Workgroup. The focus, in terms of RMP funding, has largely been devoted to better understanding loadings (MQ 2) (Figure 2).

However, during the next permit term (MRP 2.0), the Water Board and BASMAA are asking for an increased focus on identifying watersheds and areas within watersheds that are producing disproportional loads in relation to impairment in Bay margin areas (MQ 1) while maintaining some effort on the loadings question (MQ 2), and developing and implementing a plan to determine trends (demonstrating that management efforts are effective at reducing impairment).

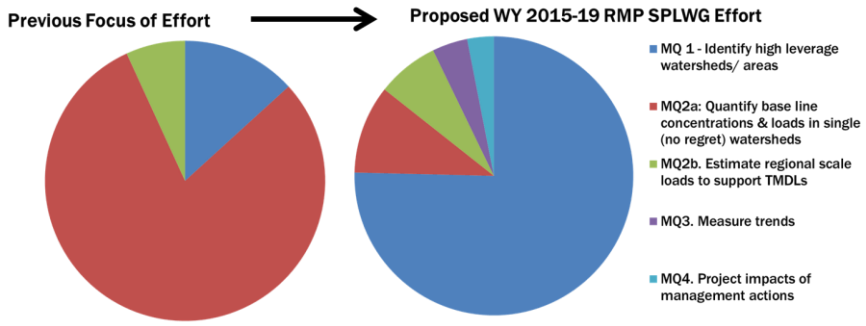


Figure 2. Illustration of the proposed programmatic change in focus between RMP STLS funded efforts during MRP 1.0 (2009-14) and proposed efforts during MRP 2.0 (2015-19). Note, direct effort by BASMAA through grants and their city/county resources are not included (but substantial).

At this time, the Water Board and BASMAA (through discussions within and outside the STLS) are not recommending any increased focus through the RMP on true source area identification (MQ 1) or predicting the potential effectiveness of management actions (MQ 4). Substantial efforts have been and are ongoing in relation to these management questions outside of RMP funding by BASMAA through a $5 million EPA Water Quality Improvement Fund grant called Clean Watersheds for a Clean Bay (CW4CB). Pending the results of these studies, it is possible that, in the next 6 to 18 months, RMP support could be requested to build upon the results from these efforts. Results from the proposed elements within the PCBmercury strategy will also likely mature and give further support for increased understanding of true sources and the potential of source control and overall program of load reduction towards meeting TMDL goals.

Applicable RMP, STLS / MRP Management Questions (MQs)

Level I RMP, Q3:	What are the sources, pathways, loadings, and processes leading to contaminant-related impacts in the Estuary?
Level II RMP, Q3C:	What is the effect of management actions on loads from the most important sources, pathways, and processes?
Level III SPL Q2:	What is the watershed-specific and regional total water flow, load of sediment, and load of contaminants entering the Bay from the urbanized small tributaries and non-urban areas draining to the Bay from the nine-county Bay Area and are there trends through time?
Level IV STLS Q1:	Impairment: Which are the "high-leverage" small tributaries that contribute or potentially contribute most to Bay impairment by pollutants of concern?
Level IV STLS Q2:	Loads: What are the loads or concentrations of pollutants of concern from small tributaries to the Bay?
Level IV STLS Q3:	Trends: How are loads or concentrations of pollutants of concern from small tributaries changing on a decadal scale?

Level IV STLS Q4: Support management actions: What are the projected impacts of management actions on loads or concentrations of pollutants of concern from the high-leverage small tributaries and where should management actions be implemented in the region to have the greatest impact?

Approach

Task 1. Small tributaries stormwater characterization field study [MQ 1]

- Monitoring Design: 1 composite/site, unless unexpected low concentration and methods development for one remote sampler type at 12 locations. Methods inter-comparison study using 12 fractionated water samples versus remote sampler sediment data.
- Site Selection: A balance between two overarching rationale:
    - Nested sampling design to track sources upstream in known polluted areas to help better define source areas and management options.
    - Finding new polluted watersheds or sub-watershed areas (watershed locations near the Bay margin or at least further downstream than the source tracking approach).
    - Possible use of ELISA this summer to support site selection (c.f. PCB strategy and SPL recommendations for increased source I.D. effort (using remaining 2014 POC funding).
    - Other section rationale:
        - 1 site/yr large watershed [MQ 2]
        - Re-sampling potential false negatives [MQ 1 & 2]
        - Contingency for resampling Guadalupe River for trends [MQ 3]
        - Filling gaps along environmental gradients in relation to source areas (most specifically to support RWSM development [MQ 2])
- Remaining questions before design and budget can be finalized:
    - Final decision on the choice of remote sampler (need further expert input)
    - Final decision on analyte list and D.L.s (PCBs, Hg, org. carbon, GS, TMs at select sites)
    - Data management costs?
    - Final total number of field sites (largely the result of all other decisions)

Task 2. Regional watershed spreadsheet model (RWSM) [MQ 2]

- Sub-regional scale loads needed to support TMDL updates and linked to PCB strategy a margins mass balance (2015 proposal)
- Pending the outcomes of the 2014 work plan, STLS to agree upon and recommend the workplan for 2015. 2014 work plan:
    - Use GIS databases incorporating the latest BASMAA improvements and fix anomalies (e.g. wrongly assigned open space or pervious areas land uses that don't make sense)
    - Coalesce small near homogeneous "watersheds" mostly on the Bay margin into nearby areas that correspond more directly to real-world land use zones
    - Use the uncalibrated parameters to explore ranking watersheds, sub-watersheds, or patches to support management prioritization
    - Rerun the model calibration based on the sediment base model, the GIS improvements, and an added data quality weighting factor, and regenerate watershed and regional load and sensitivity analysis
- Increase funding to ensure the model is completed? From $35 - $50k?
- Depending on 2014 outcomes, RMP 2015 funds might be used to:
    - Improve the basis of the model
        - Shift the model to a water-based starting point or
        - Complete further structural improvements to the sediment-based model including adding a hydrology parameter
    - Incorporate additional calibration watersheds (Task 1 [MQ 1] above) and BASMAA studies.

Task 3. Watershed loadings trends strategy support [MQ 3]
The SPL workgroup proposed an effort to define where and how trends may be most effectively measured in relation to management effort in the context of ensuring data collection methods deployed now [MQ 1] are able to support this future need. The SPL proposed development of a framework to define the long term trajectory of the STLS program and ensure that all MQs are answered in the timeframe needed.

- Develop a trends strategy White Paper (could include further power analysis of existing data).
  - Where (what scale) could trends be measured to demonstrate the effectiveness of management efforts in relation to environmental benefits?
  - What are the appropriate media and metrics upon which to measure trends and what constitutes a suitable baseline against which to measure future changes?
  - What data have been collected to-date which may serve as baseline data – is there a cost-effective and on to efforts to answer MQ 1? Is there a need for a fundamental rethink since the previous power analysis to support trends was based on fixed station monitoring data and large datasets?
  - What will be the reasonable temporal checkpoint for defining trends?
  - Develop a field work plan and costs, and set aside RMP contingency funds for sampling Guadalupe River under a large reservoir release event (which might end up being funded through task 1 or perhaps a request to the RMP on an as opportunity arises basis.
  - Develop a list of other potential sites for sampling trends under specific circumstances.

Task 4. Small tributaries loading strategy (STLS) coordination support.

- Local STLS meetings (agenda and meeting materials development)
- Phone conferences for product updates and review (agenda and meeting materials development)

Proposed Budget (will be revised pending planning efforts during June-August)

Task	Sub-Task	Deliverable	Estimated Budget
1. Small tributaries wet weather characterization [MQ 1]	1a	Stormwater monitoring	$415k
	1b	Quality Assurance & Data Management	
	1c	Interpretation & reporting	
2. Regional watershed spreadsheet model (RWSM) [MQ 2]	2a	Finalize work plan based on latest info. & priorities	$35k
	2b	Compile latest data (GIS & storm data (Task 1)	
	2c	Recalibrate model, estimate loads, & update report	
3. Watershed loadings trends strategy support [MQ 3]	3a	Devise & prioritize study questions	$35k
	3b	Identify analysis/interpretative methods	
	3c	Complete analysis & present prelim. findings	
	3d	Complete white paper	
4. Small tributaries loading strategy (STLS) coordination support			$26k

Note, the 6/9/14 STLS meeting reached agreement on proposed tasks but not absolute budget proportions. With the exception of Task 4, the tasks will be scoped according to budget available and better definition of priorities.

To:	RMP Technical Review Committee
From:	David Senn and Emily Novick
Re:	CY2015 Nutrient Proposals

June 22, 2014

Dear TRC:
Attached please find a set of proposals for San Francisco Bay Nutrient Science Program Projects. The proposed projects were identified with input from technical advisors and are aligned with recommendations laid out in the draft Conceptual Model Report, Monitoring Program Development Plan, and Modeling Development Plan. SFEI staff are working with collaborators, Water Board staff, and stakeholders to develop a Nutrient Science Plan. The Science Plan will be developed over the subsequent year and will be broadly vetted among technical advisors and stakeholders, and will eventually receive external review by an expert panel.

Until the draft Science Plan has been vetted, our plan is to continue moving nutrient work forward, recommending and carrying out work that can be considered "no regrets", as we have done over the past 2 years. By no regrets, we mean that the proposed work is considered to be broadly essential across all projects, or as both appropriately timed and falling along the critical path toward informing important management decisions.

Nutrient Science Program Funding: Currently, RMP and funding through the Nutrient Watershed Permit are the primary sources of revenue for San Francisco Bay Nutrient Strategy related work in the Bay. The RMP Multi-Year Plan from 2013 proposed $500,000 in funding for nutrient-related work in 2015, distributed among the focus areas presented in the table below. Total proposed funding for those focus areas is shown in the column second from the right. The accompanying packet contains a slate of proposed projects for the entire Nutrient Science Program Budget in FY2015, with the value identified in the second column from the left being the RMP support requested toward that activity. Any remaining funding will be requested through the Nutrient Steering Committee or other potential funders.

	RMP Allocation in Multi-Year Plan for CY2015 ($1000s)	Overall Proposed Nutrient Science Program Funding FY 2015 ($1000s)	Related Project among FY2015 projects
Modeling (forecasting):	$100	$500	P.1
Moored sensors:	$300	$340	P.3
Monitoring Program Development	$50	$270	P.4
Conceptual model (interpreted here as updates to conceptual models through data synthesis and interpretation)	$30		P.4 (i.e., data synthesis)
Science Coordination/Program Management	$20	$200	P.15
Total	$500	$1310	

				Program Area				Adverse Impact Pathway				
#	Project	Priority for FY2015	Estimated Cost ($1000s) FY2015	Monitoring	Special Study	Modeling	Assessment Framework	High Biomass LowDO Deep Subtidal	LowDO Shallow/Margin	HABs	Altered phytoplankton community	Low production
1	Modeling	High	500			X		X	X	X	X	X
2	Toxin measurements and phytoplankton composition	High	200	X	X		X			X	X	
3	Moored sensor program development/expansion	High	340	X				X	X	X		
4	Monitoring Program development, assessment framework: Analysis of historic data, program design	High	270	X				X	X	X	X	
5	Stratification scenarios for DO and HABs	High	110			X	X	X		X	X	
6	Using monitoring data in conjunction with existing hydrodynamic modeling output to inform monitoring program design	Medium	120	X		X		X		X	X	
7	DO objectives (lit review, data analysis)	High	100				X	X	X			
8	Dissolved Oxygen in shallow habitats	High	300		X				X			
9	Additional Monitoring at current main channel stations in SFB, USGS cruises: phytoplankton taxonomy, nutrients	High	100	X				X		X	X	
10	Suisun Phytoplankton Growth: Continuation of pure culture experiments	High	60		X							X
11	Contribution to shared Research Vessel Purchase, in collaboration with USGS and other potential partners	High	400	X				X		X	X	X
12	Targeted mechanistic studies of HABs, phytoplankton composition, related to nutrient concentrations, forms	Medium	200		X					X	X	
13	Fish/benthos studies in margin habitats to inform site specific DO objectives	Medium	200		X		X	X	X			
14	Sediment flux studies: Benthic oxygen demand, nutrient fluxes/transformations	Medium	250		X			X	X			
15	Program management/science coordination	High	200									
16	External Review	Medium/ High	50									
	Total		3,400									

P.1 Water Quality and Hydrodynamic Modeling	**Priority = HIGH**
FY2015 Cost = 500,000; Year 1 funding of a multi-year project. (Note: $350,000 already secured through RMP)	
Collaborators: SFEI, USGS-Menlo, UC Berkeley, Stanford, UC Davis, key consultants	

This project will begin the development of a water quality (WQ) model for San Francisco Bay to inform nutrient management decisions, and in parallel contribute to the development of the underlying hydrodynamic model through collaboration with USGS-led project CASCaDE II.[1] WQ modeling is the highest priority undertaking for FY2015 for two reasons:

- It will play fundamentally-important roles along the critical path toward informing most management decisions related to assessing health/impairment relative to primary indicators and identifying management actions that would mitigate or prevent impairment.
- Considerable work is needed to develop reliable WQ models

While there are numerous hydrodynamic models for the Bay, there are no WQ models coupled to hydrodynamic models that can be applied toward informing nutrient management decisions. Therefore, the primary Year 1 focus of this multi-year project will be on building regional capacity in WQ modeling. Hydrodynamic model development will move forward through collaboration with the CASCaDE II project, allowing the Nutrient Science Program to leverage ~$2mill in project funding from the Delta Science Program and USGS internal monies. WQ model development and application will be a multi-year effort, and that effort is anticipated to be among the more resource-intensive activities over the next several years. Fortunately, $350,000 in funding has already been allocated by the RMP toward developing this model (combined funds set aside from CY2012-2014) and can be used toward the total estimated cost in FY2015.

The phrase “water quality modeling”, as used here, covers a wide range of parameters and processes, and would be more accurately called biogeochemical (or reactive-transport) modeling plus ecosystem or ecological modeling. Numerous parameters/state variables and processes will be included within the WQ model:

- Predicted nutrient concentrations, and the loads, transformations between nutrient forms, uptake, and losses that create the predicted concentrations
- Phytoplankton biomass (i.e., total biomass) and production rate, loss rate (settling, death, grazing)
- Benthic grazer abundance and grazing rates (e.g., filter feeding clams) and pelagic grazer abundance and grazing rates
- Dissolved oxygen concentrations and the various process add or remove oxygen (+ primary production, air:water exchange; – phytoplankton and planktonic microbial respiration, sediment oxygen demand, nitrification, etc.)

[1] http://cascade.wr.usgs.gov/

- Nutrient and DO fluxes between the water column sediments, and similar reactions as above within the sediments that drive these fluxes
- Phytoplankton community composition: abundance of several classes of phytoplankton, class-specific growth requirements and growth rates
- Light availability, based either on suspended sediment output from the hydrodynamic model, or specified through a seasonally/spatially varying input file

WQ modeling will proceed in a phased approach (see schematic on p.2), as recommended by a team of modeling experts. After thorough examination of modeland potential platforms, the team recommended that we proceed with Deltares suite of models.[2] The Year 1 focus will be on addressing several key questions related to ecosystem response in simplified-spatial-domain subembayment models (important questions in South/Lower South Bay and Suisun Bay), allowing us to focus more energy on understanding the complex water quality processes, biological response, and physical drivers. In addition to building a solid quantitative-conceptual foundation over that year, work will proceed on gathering/building the key input files and setting up higher spatial resolution models at subembayment and whole-bay scales that will be the focus of work in Year 2 and beyond. While the primary hands-on modeler will be a new SFEI staff person, we plan to continue convening a technical advisors (including experts from Deltares, who will be major collaborators), some providing high level technical guidance and some providing hands-on support.

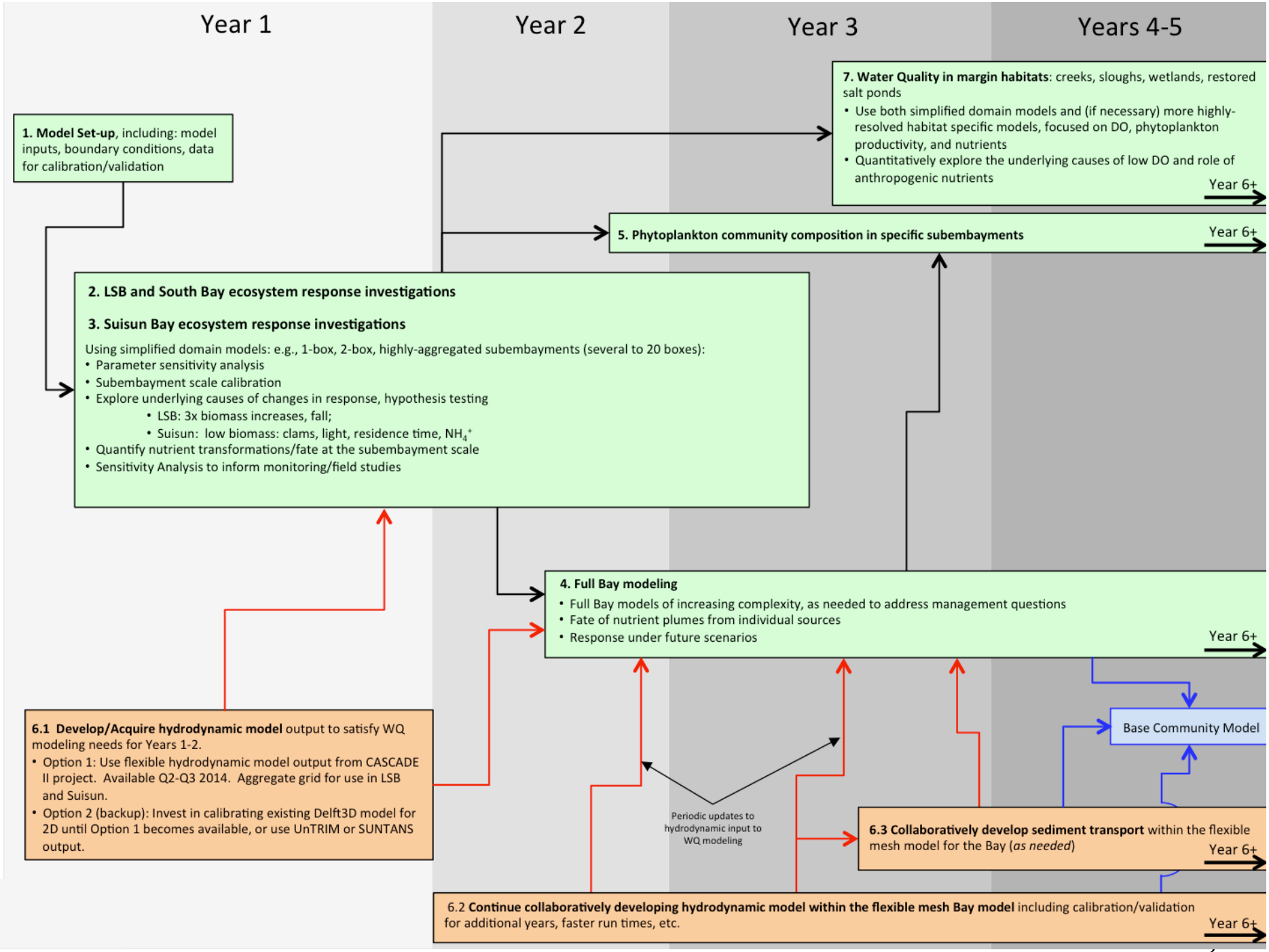
Year 1 Deliverables

A technical report document will be produced in June 2015 to describe Year 1 progress, and to identify recommended next steps next steps.

Budget

The majority of the salary will be directed toward a full time WQ modeler and collaborating staff (~$300k). The remainder will go toward technical collaborators ($100k) and hydrodynamic model development through the collaboration with USGS ($100k).

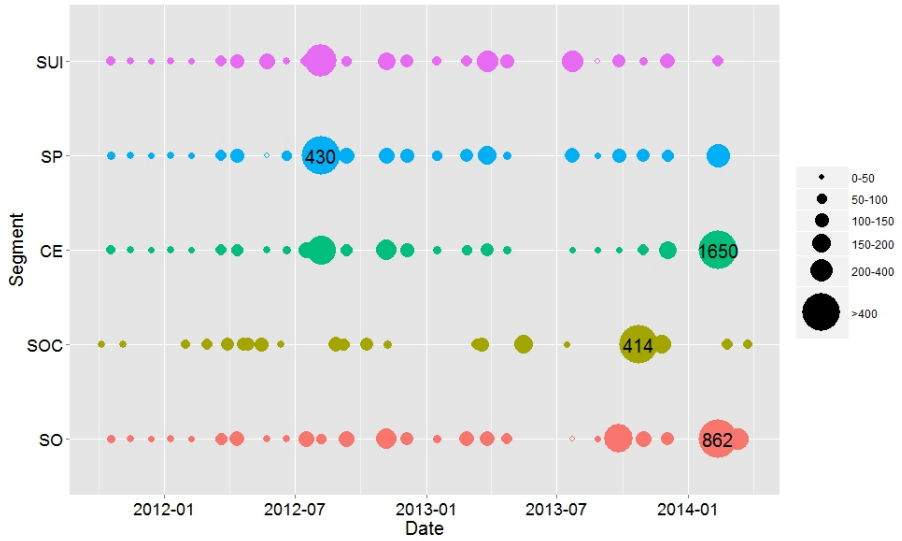
[2] http://www.sfei.org/sites/default/files/Nutrient_Modeling_Approach_draftFINAL_Jan212014.pdf


Year 1
Year 2
Year 3
Years 4-5
1. Model Set-up, including: model inputs, boundary conditions, data for calibration/validation
7. Water Quality in margin habitats: creeks, sloughs, wetlands, restored salt ponds
• Use both simplified domain models and (if necessary) more highly-resolved habitat specific models, focused on DO, phytoplankton productivity, and nutrients
• Quantitatively explore the underlying causes of low DO and role of anthropogenic nutrients
Year 6+
5. Phytoplankton community composition in specific subembayments
Year 6+
2. LSB and South Bay ecosystem response investigations
3. Suisun Bay ecosystem response investigations
Using simplified domain models: e.g., 1-box, 2-box, highly-aggregated subembayments (several to 20 boxes):
• Parameter sensitivity analysis
• Subembayment scale calibration
• Explore underlying causes of changes in response, hypothesis testing
• LSB: 3x biomass increases, fall;
• Suisun: low biomass: clams, light, residence time, NH4+
• Quantify nutrient transformations/fate at the subembayment scale
• Sensitivity Analysis to inform monitoring/field studies
4. Full Bay modeling
• Full Bay models of increasing complexity, as needed to address management questions
• Fate of nutrient plumes from individual sources
• Response under future scenarios
Year 6+
Base Community Model
6.1 Develop/Acquire hydrodynamic model output to satisfy WQ modeling needs for Years 1-2.
• Option 1: Use flexible hydrodynamic model output from CASCADE II project. Available Q2-Q3 2014. Aggregate grid for use in LSB and Suisun.
• Option 2 (backup): Invest in calibrating existing Delft3D model for 2D until Option 1 becomes available, or use UnTRIM or SUNTANS output.
Periodic updates to hydrodynamic input to WQ modeling
6.3 Collaboratively develop sediment transport within the flexible mesh model for the Bay (as needed)
Year 6+
6.2 Continue collaboratively developing hydrodynamic model within the flexible mesh Bay model including calibration/validation for additional years, faster run times, etc.
Year 6+

P.2 Develop a 3-yr monthly time-series of algal toxins and phytoplankton community composition in San Francisco Bay	Priority = HIGH
FY2015 Cost = $200,000	
Collaborators: UC Santa Cruz, USGS, SFEI	

In this study, we propose to measure algal toxin concentrations in ~300 archived water column samples collected throughout the Bay between 2011-present; additional water column samples collected during FY2015; and a limited number of bivalve samples. All of the archived water column toxin samples have co-located algal pigment samples, and have been analyzed as part of a currently-funded project, which will allow us to explore the relationship between toxin abundance, chl-a, and phytoplankton community composition.

Developing an improved understanding of the relationship between HABs/toxins and nutrients in San Francisco Bay – and ambient conditions related to toxins and HAB-forming species – are among the highest priority science and monitoring needs for San Francisco Bay. Some phytoplankton species form harmful algal blooms (HABs) that produce toxins that adversely impact both aquatic life and humans. Links between nutrients and HABs/toxins have been shown in some estuaries. However, the relationship is complex, numerous factors contribute to the probability or frequency of HAB occurrence, and there has been limited investigation to date in the Bay exploring these linkages. To better understand both the linkages between nutrients and HABs/toxins in the Bay and ecosystem condition, substantially more data on toxins and phytoplankton composition are needed. Although no HABs have been noted in the Bay over the past few decades, potentially harmful species are commonly detected in low numbers by the USGS. The frequent presence of seed organisms, and the Bay's abundant nutrients, mean that HABs could develop if appropriate physical conditions prevail (stratification, temperature), as evidenced by the Fall 2004 red tide bloom in South Bay (Cloern et al., 2005). Pilot studies (2012-present) carried out by USGS-UCSC, in collaboration with RMP (2013-present), have found that the toxins domoic acid and microcystin commonly occur throughout the Bay. These pilot studies used a



Domoic acid (DA) concentration captured by resin (ng DA/g resin). On some cruises South Bay and Central Bay were combined. SO=South Bay (including LSB); SOC = South + Central Bays; CE = Central Bay; SP = San Pablo Bay; SUI = Suisun + Lower Sacramento River. Numbers represent values of samples greater than 400 ng/g. Data: R Kudela

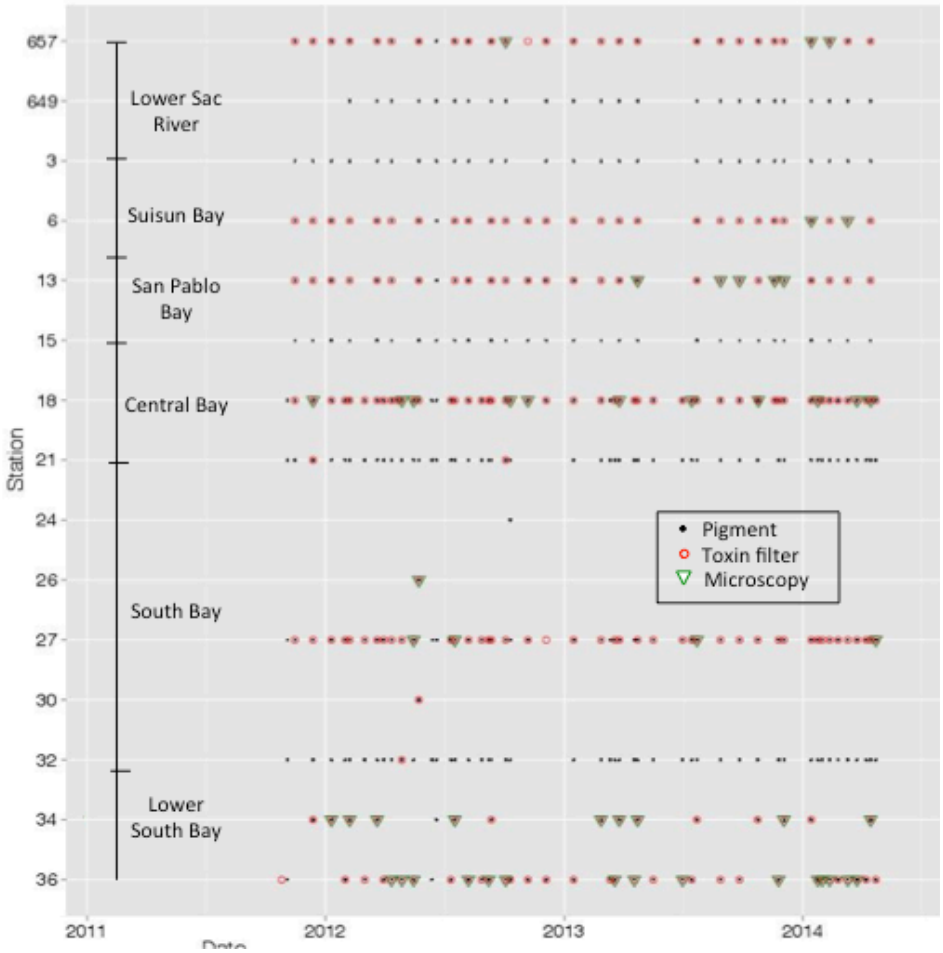
resin that binds several common toxins, and collected subembayment-integrated samples by continuously pumping water from the Bay past the resin while the ship was underway. This approach provides a cost-effective survey for toxins. However, the subembayment-integrated samples are likely too spatially-coarse to improve our understanding both about the magnitude of toxin plumes and the conditions under which toxins were created. An additional difficult with this resin-based technique is that extrapolations back to ambient concentrations are highly uncertain.

The project will achieve the following goals:

- Substantially advance our understanding about current conditions and important mechanisms in SFB with respect to algal toxins.
    - Determine how algal toxin concentrations vary seasonally and spatially, and, to some degree, how they vary interannually (over this relatively short period of record);
    - Assess how toxin concentrations compare to thresholds known to adversely impact ecological health;
    - To the extent possible, develop an improved understanding of, and testable hypotheses for, the physical/chemical/biological factors that contribute to the occurrence of higher/lower toxin abundance.
- Inform monitoring program requirements for toxin measurements, including:
    - Necessary spatial/temporal sampling resolution to adequately describe variability and to capture "events of concern" through comparison of discrete filter samples and subembayment–integrated measurements ;
    - Appropriate analytical methods (e.g., integrated resin-based samples vs. discrete locations) and optimized analytical techniques (e.g., methodologies for extracting the most relevant spectrum of toxins from a single sample).

Sample Collection and Measurement: This project will include several "Definite" (D) sets of analyses and one or more "Optional" (O) analyses. The choice among optional activities would depend both on available time and resources, and on indications from early measurements about which direction(s) would be most informative. Activities will include:

1. Measure toxin concentrations in filters collected during past or on-going monitoring at existing USGS sites
    - D.1 Archived filters collected beginning in 2008, after salt ponds were breached, through Apr 2014, generally at monthly or greater frequency, at stations in Lower South Bay (40 samples). Salt ponds are hypothesized to act as an incubator for harmful phytoplankton species.
    - D.2 Archived filters collected monthly from Nov 2011-Jun 2014 at one station per subembayment on a monthly basis (~240 samples, including 40 from Lower South Bay noted above). At all of those stations, pigment filters were also collected and recently analyzed in 2013-2014 as part of a related project.
    - O.1 Filters collected at 6-12 stations per full-Bay cruise from Jul 2014-May 2015 (100+ samples)



Locations and dates for archived toxin samples, along with co-located pigment and microscopy samples

2. Measure toxin concentrations in bivalve samples
    - D.3 Archived samples from Mussel-watch sites, RMP sampling, and other relevant past sampling activities (12 samples from 2012, 10-15 samples from 2014)
3. As part of other planned field activities in Fall 2014 (P.8), collect filter samples at 6-9 sites on a monthly basis. (2-3 sloughs, 3 sites per slough, and 1 station at the down-estuary end of Coyote Creek; Aug-Nov = 30-40 samples)
    - O.2 These samples could be collected during other fieldwork and would not require their own field campaign. For any newly-collected samples, pigment samples will also be analyzed.

Deliverables

- Progress update at 6 months
- Technical report at project's completion

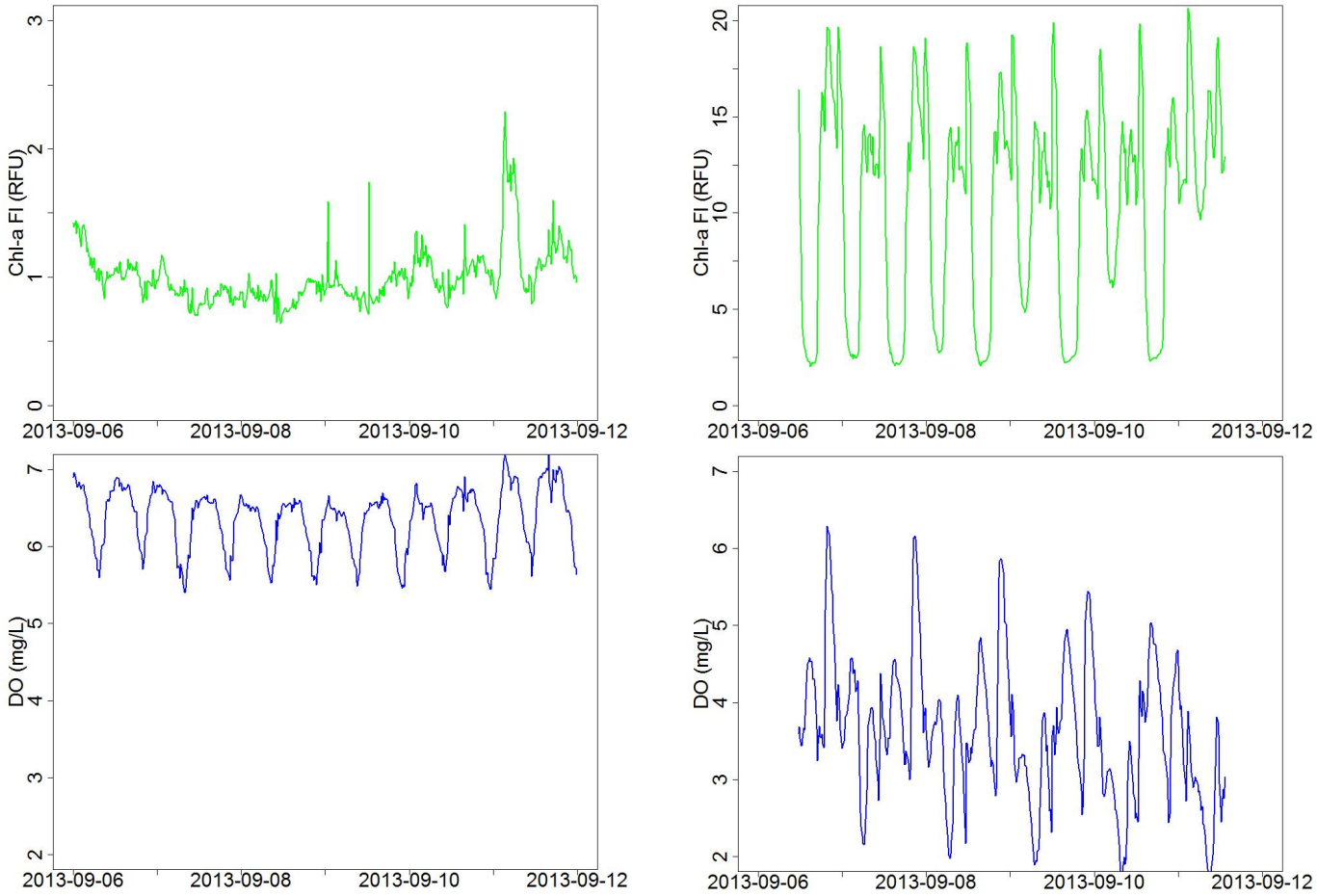
Budget

Funding will support a 1-year postdoc at UCSC to carry out sample analysis, data interpretation, and report preparation; analytical costs (lab supplies and consumables); collaborator support/supervision (total: $170k); and SFEI staff support (30k).

P.3 Moored sensor program development/expansion	Priority = HIGH
FY2015 Cost = $340,000	
Collaborators: SFEI, USGS-Sac, USGS-Menlo, SanJose	

While scientific studies and monitoring by the USGS, DWR-EMP, and RMP provide us with several decades of water quality data in the Bay, most of that data has been collected at weekly-monthly time intervals. Phytoplankton biomass and related parameters such as nutrients, dissolved oxygen, and suspended sediments vary strongly over much shorter time scales (hours) due to diel cycles, mixing, biogeochemical processes, and tides. To better assess the Bay's condition, and to collect high-frequency data to calibrate water quality models, the RMP began funding a moored sensor network in 2013. This proposed study will: maintain existing stations; add one additional station; and continue data analysis and on-line data. visualization/download work; and inform on-going monitoring program development.

In Summer 2013, sensors for chl-a, dissolved oxygen, turbidity, temperature and other parameters were deployed at 3 stations in Lower South Bay and South Bay in



Chl-a (relative fluorescence units; RFU) and Dissolved Oxygen (mg/L) at Dumbarton Bridge and Alviso Slough (4km upslough from confluence with Coyote Creek) over a 5 day period. At both sites, chl-a fluorescence varied tidally, but maximum values were 10-15 times greater at Alviso than Dumbarton (note different y-axis scales. Although the fluorescence signal is prone to interferences, the large differences here suggest that maximum phytoplankton biomass at Alviso (~50 µg/L) was substantially greater than at Dumbarton (3-5 µg/L), and emphasize the strong spatial and temporal variability in chl-a. DO also varied tidally at both sites. The DO minima at Dumbarton occurred at low tide, which could be the result of low DO draining shallow margin habitats mixing with open-bay water and moving past the sensor. DO was substantially lower at Alviso than Dumbarton and exhibited a multiple strongly-periodic maxima and minima.

collaboration with the USGS's sediment group, who already have infrastructure for continuous monitoring for a subset of parameters in these areas. One of the sites, the Dumbarton Bridge, telemeters data every 15-minutes to a server, which will allow for eventually viewing data in near-real time. Year 1 efforts focused on installation, developing capacity for moored sensor maintenance and operation (including creating procedures for maintenance and data processing/management), and interpreting data to identify sites for network expansion. At present, moored sensors have been installed at Dumbarton Bridge, San Mateo Bridge, and in Alviso Slough.

In FY2015, we propose to add a 4th station in South Bay or Lower South Bay. Potential locations include Coyote Creek near where it enters Lower South Bay, or on a channel marker in the southern quarter of Lower South Bay, based on the strong north-south gradients in nutrients, chl-a, and suspended sediments in Lower South Bay. To allow for improved estimates of chl-a and phytoplankton biomass, we will design and execute experiments to better constrain the chl:fluorescence relationship and estimate uncertainty. We will also add telemetry to new and existing stations, where possible given site-specific logistical constraints. Due to increasing data, we will also invest further in developing standard procedures for data management and processing, including automation where possible, and developing a database. We will also further develop a web-accessible data visualization and download tool for accessing real-time and historic sensor data (pilot project begun in year 1). The goal is for this web interface to host data from multiple programs (SFEI/RMP, 2 USGS groups, and possibly others) and allow for intuitive data visualization, including viewing time series data from multiple stations and multiple parameters simultaneously.

Deliverables

A progress report will be submitted June 2015. In that report, we will analyze data to inform system understanding, identify lessons learned from year 2 of the program, and make recommendations for moored sensor priorities in year 3.

Budget

The budget for this task for FY2015 is $340,000. $250,000 of this is for personnel support across a range of tasks: sensor installation, maintenance and operation; data processing and management; data visualization; and data analysis and reporting. $70,000 will be used to purchase equipment for a 4th station, including telemetry, as well as to purchase one additional nitrate sensor. $20,000 will be used for field logistics support for our collaborators at USGS-Sacramento.

P.4.A Analysis of historic data to inform monitoring program development, assessment framework development, and synthesis/mechanistic interpretations **P.4.B On-going development of monitoring program structure**	**Priority = HIGH**
FY2015 Cost = $270,000	
Collaborators: SFEI, UC SantaCruz, USGS-Menlo, RTC, other technical advisors, SCCWRP	

P.4.A Analysis of historic data to inform monitoring program development, assessment framework development, and synthesis/mechanistic interpretations

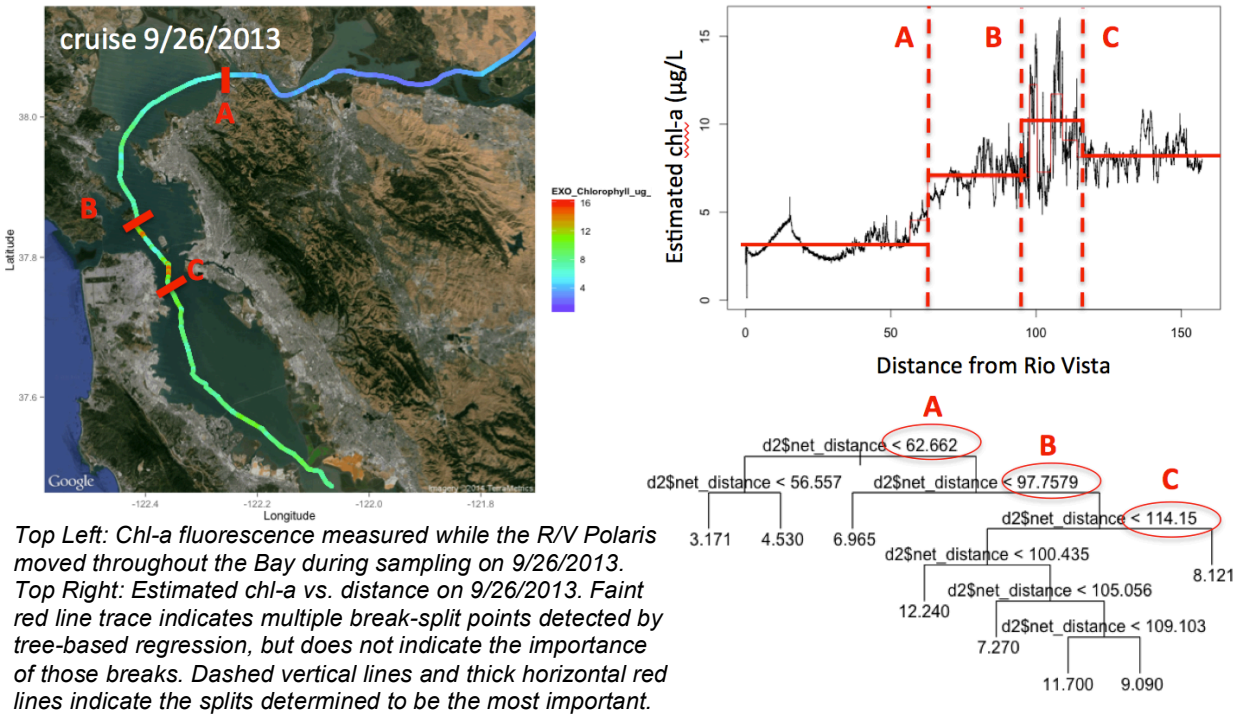
Summing over the many years of anticipated water quality monitoring ahead, the monitoring program will likely account for the largest portion of overall nutrient program costs. Therefore, there is considerable benefit to carefully planning and designing the most efficacious yet cost-effective program. We are also fortunate - for monitoring and assessment framework development and on-going synthesis/mechanistic interpretations - that long-term systematically collected monitoring data (~40 years) exist, plus data from a number of special studies, that can be extensively mined.

Through this project we will use historic monitoring data and other more focused data sets to explore key questions that technical advisors identified as important for informing monitoring program design, assessment framework development, and our overall understand of ecosystem response to identify data gaps and priority studies. Example questions include:

1. What is the optimal spatial/temporal resolution of sampling?
    a. What sampling spatial resolution is needed along the longitudinal axis of the Bay to capture most of the variability across a range of relevant parameters, seasons, etc.?
    b. What sampling spatial resolution is needed laterally, as a function of subembayment and season?
    c. In South Bay, what is the minimum temporal sampling during important periods (e.g., spring blooms)?
    d. What are characteristic scales (space/time) of phytoplankton blooms in Suisun Bay?
    e. Where should moored sensors be placed? What is the optimal blend of ship-based sampling and moored sensors?
2. Identifying spatial/temporal resolution of priority “events” (i.e., what are we trying to detect?)
    a. What levels of toxin concentration are problematic? How do these translate into spatial, concentration, and duration scales?
    b. What changes in phytoplankton composition or occurrence of potentially harmful species do we need to detect?
    c. What sampling resolution (lateral, longitudinal) is required to capture the priority “events” described above?

3. How has phytoplankton community composition in South Bay, Central Bay, and Lower South Bay changed over the past 20 years? What changes in physical, chemical, or biological drivers can explain those changes?
4. How frequently (and under what conditions) does the relationship used to estimate productivity in SFB (based on chl-a concentration and PAR, i.e., Cole and Cloern 1987) need to be validated/calibrated?

As each of these questions is explored, the results will be summarized as technical reports and, where appropriate, peer-reviewed publications. These technical reports will either be stand-alone documents, or included as sections within other reports related to monitoring program development or assessment framework development.



Top Left: Chl-a fluorescence measured while the R/V Polaris moved throughout the Bay during sampling on 9/26/2013. Top Right: Estimated chl-a vs. distance on 9/26/2013. Faint red line trace indicates multiple break-split points detected by tree-based regression, but does not indicate the importance of those breaks. Dashed vertical lines and thick horizontal red lines indicate the splits determined to be the most important. Bottom Right: This tree illustrates the relative importance of splits, with A, B, and C representing the largest splits. Similar analyses will be carried for multiple dates/seasons, multiple parameters (chl-a, turbidity, T, salinity, nutrient concentrations) to identify the optimal spacing of stations along the Bay's axis.

P.4.B On-going development of monitoring program structure

In March 2014, we completed a draft monitoring program development plan with input from a team of technical advisors. That plan is being circulated to stakeholders and other collaborators in June 2014 for additional input. The report lays out a number of priority activities – from analysis of existing data to inform optimal program design (spatial/temporal sampling frequency) to identifying a set of tiered recommendations for program implementation (new analytes, methods, costs, etc.).

During FY 2015, 2 meetings will be held with technical advisors, and 2 meetings with the Nutrient Technical Workgroup to obtain feedback from a group with a range of perspectives. With guidance from the technical advisors and the NTW we will

undertake the highest priority activities, using those recommended in the program development plan as a starting point.

Deliverables

Interim progress reports and updates will be produced in the form of powerpoint presentations or memos in advance of technical advisor or NTW meetings. Meeting summaries will also be prepared. An annual progress report on program development will also be prepared, bringing together results/recommendations for program structure (based on data analysis) with other programmatic advances (e.g., new analytes, methods, costs, tiers). An additional option is to produce an Nutrient Science Program annual report that summarizes progress on multiple fronts, describes monitoring-related observations (status, trends), and presents noteworthy results from special studies. If this product is viewed as a high priority, the budget/planning for this task may need to be reevaluated.

Budget

Funding will support staff effort on data analysis, program development, and report preparation (~235k), technical advisors/collaborators (35k).

P.5 Stratification scenarios for DO and HABs	**Priority = HIGH**
FY2015 Cost = $80,000	
Collaborators: UC Berkeley, SFEI, SCCWRP, USGS-Menlo	

The frequency and duration of water column stratification events in SFB is an important determinant of whether low DO and harmful algal blooms could become problems in deep subtidal habitats, in particular in South Bay and Lower South Bay. Initial worst-case-scenario calculations indicate that phytoplankton blooms of realistic magnitude could translate into low DO in bottom waters. However, those calculations assume that the water column stratifies for a long enough interval that the bloom can develop, and remains stratified long enough to allow low DO to develop and persist such that adverse impacts occur. Prolonged stratification also creates conditions under which HABs can form: e.g., the Fall 2004 red tide bloom in South Bay (Cloern et al, 2005). Under current conditions, stratification in San Francisco Bay is known to be variable at a wide range of timescales due to the strong tidal forcing and seasonal cycle in river flows and associated density gradients. This study will examine the relation and competition between the drivers that cause and break down stratification, assess the potential for this relationship to change such that stratification persists long enough to cause adverse impacts. More specifically, this study will address the following questions:

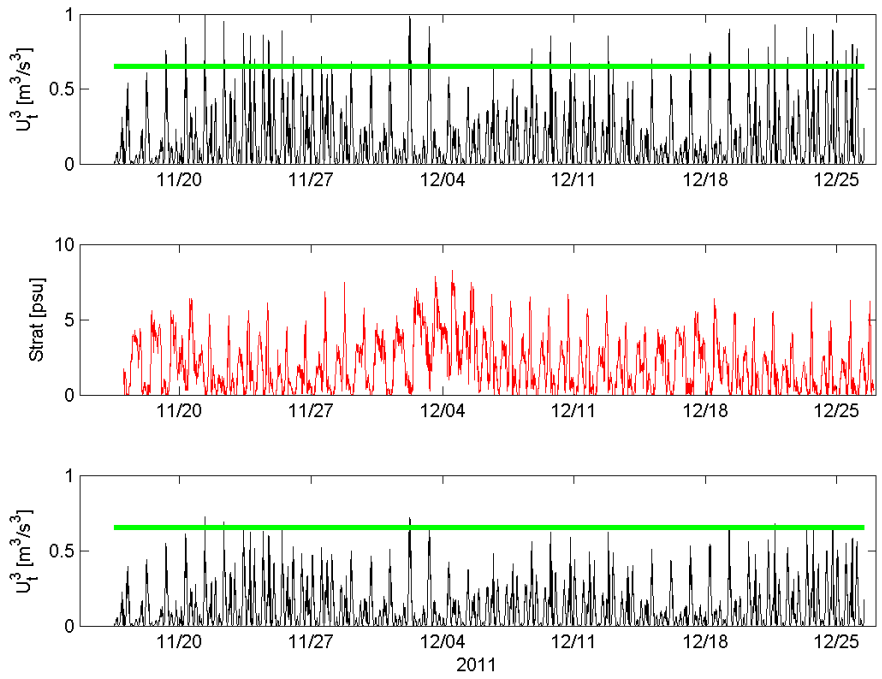
1. How frequently does stratification develop in different areas of the Bay and for how long does it typically persist?
2. What combinations of physical forcings lead to the set-up and break-down of stratification in key areas of SFB? What regulates the magnitudes of these opposing forcings, in particular around periods when shifts between stratified and destratified tend to occur? What could alter the magnitudes of these forcings?
3. How would changes in forcings translate to changes in stratification duration as determined through simplified domain modeling?

Analysis of long-term observations from Suisun Bay and South Bay will be combined with highly detailed shorter observation periods from the same basins to establish current stratification conditions. A focus of this analysis will be on establishing the relationship between stratifying processes that vary on seasonal, hydrographic (i.e., freshwater flow) event and tidal (semi-diurnal, diurnal and spring-neap) timescales and mixing processes that act to maintain an unstratified water column. We anticipate that both basins experience tidally-periodic stratification, with some persistence across multiple tidal cycles occurring during neap tides. We will explore the likelihood of stratification persisting for a spring-neap period (14+ days) under current conditions. The persistence of stratification across the spring-neap cycle is a critical threshold, since once stratification persists across one spring-neap cycle, it is likely to persist across multiple, potentially resulting in stratification that lasts for months.

To evaluate how future scenarios of change will influence the variation of stratification, we will build on the observational analysis using a combination of theoretical and numerical analysis. The theoretical analysis will compare stratifying and destratifying processes using dimensionless groups and evaluate the probability of

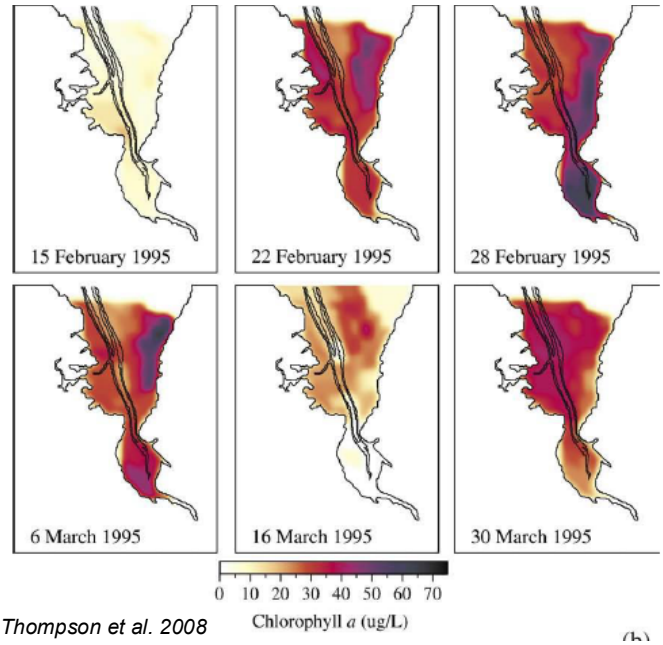
various lengths of stratification persistence under scenarios of climate change. Combining this analysis with simplified numerical models, which resolve the vertical structure of the density and flows (i.e., for a water column), will allow us to explicitly evaluate future scenarios and determine under what set of future conditions stratification may persist across the spring-neap cycle. Future scenarios will probe variation in stratification that may arise from changes to (a) freshwater flows/density gradients; (b) shorelines (whether by management action or sea level rise) and associated changes to the tides; (c) atmospheric heating; and (d) wind mixing. The future scenarios will be described by changes in tidal forcing (informed by considering scenarios for shoreline change; and analysis of sea level rise and inundation performed under separate funding) and alterations to the local buoyancy forcing (salinity gradients induced by freshwater flows). The balance between stratifying and destratifying processes will be evaluated using the numerical water column analysis with a particular focus on the threshold for stratification to persist across an entire spring-neap cycle.

To illustrate the importance of these analyses, preliminary analysis of data from a Suisun Bay site indicates the potential for long-term persistent stratification under future scenarios. The top panel presents a metric of mixing (turbulent velocity cubed) and the second panel shows the co-located stratification (top-bottom salinity difference). The stratification is seen to be strongly periodic tidally, but a period of persistent stratification develops around December 4. Based on this stratification record, an estimated threshold for destratification is overlaid on the top panel (green horizontal line). In the bottom panel, the same comparison is made as in the top panel, but now with the tidal velocities uniformly reduced by 10%. If the threshold for destratification remains the same, even this minor change in tidal forcing is expected to lead to stratification that would persist for 2 weeks or more, as only a few tidal periods have sufficient energy to pass the threshold for destratification.



P.6 Apply hydrodynamic modeling output to inform monitoring program design	**Priority = MED**
FY2015 Cost = $120,000	
Collaborators: SFEI and collaborators	

The vast majority of water quality data collection in San Francisco Bay occurred in deep habitats along the Bay's main channel. However, it is well known that phytoplankton blooms commonly begin along the Bay's broad shoals. The Bay is generally considered to be a light-limited system throughout most of its area and much of the year. Along the shoals, the shallow water column allows for higher light levels, and higher phytoplankton growth rates. Other processes, such as biogeochemical transformations at the sediment:water interface, likely also have a more pronounced effect on water column chemistry than in deep subtidal areas.



Thompson et al. 2008

Tidal and wind-driven mixing also exert strong influences on the measured concentrations of various constituents. In that sense, the water mass at any location in the Bay is actually a time- and space-integrated sample, a mixture of water masses from different locations that contribute unique amounts to the final concentration of constitute. Therefore, designing the optimal monitoring program – one that captures the desired degree of spatial and temporal variability in key parameters and is capable of detecting "events of concern" (e.g., a phytoplankton bloom of a certain size; a plume of algal toxins) – will require hydrodynamic modeling.

Motivated by a similar goal as P.4, this project will combine output from existing hydrodynamic simulations with event scenarios or historic water quality data to achieve the following goals:

1. Introduce events of concern, such as major blooms or algal toxin events, and identify the optimal sampling scheme to reliably capture a range of priority events
2. Using backward trajectory modeling, identify the sources of water (space, time) that contributed to ambient concentrations at existing stations along the Bay's main channel; constrain the originating conditions that could have created observed conditions; and reveal zones that are poorly captured by the current program design.

Existing hydrodynamic model outputs that could be considedered include 1-2 years of Bay-wide SUNTANS simulations, or multiple years (up to 20) of output from UnTRIM.

P.7 DO objectives (lit review, data analysis)	**Priority = HIGH**
FY2015 Cost = 100,000	
Collaborators: SCCWRP, SFEI, technical advisors	

This project will be a data analysis and literature review study focused on identifying what DO levels are protective beneficial of beneficial uses. It will address the following questions:

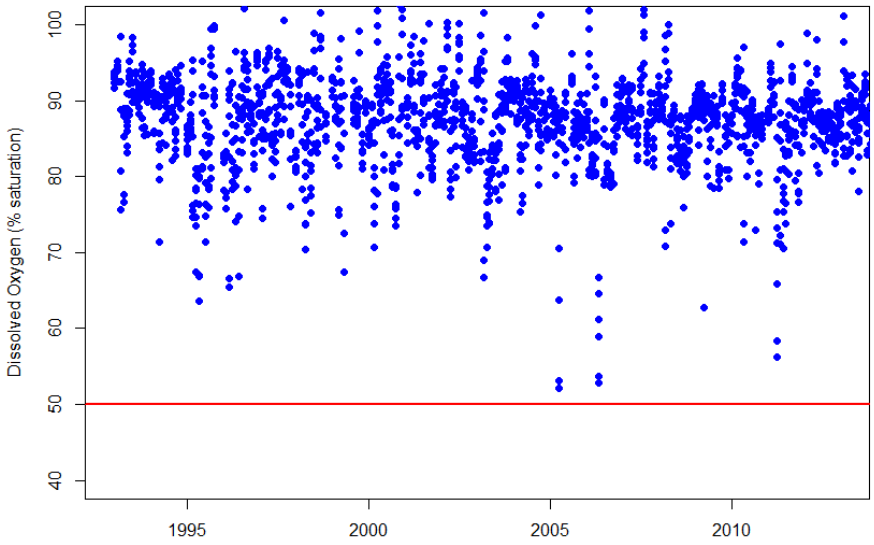
- What beneficial uses, and more specifically, what aquatic organisms are we aiming to protect in various habitats (deep subtidal, sloughs, creeks, wetlands)?
- What levels of DO are optimal or protective for those beneficial uses and organisms during life stages when they utlize those habitats?
- What low DO conditions would adversely impact those habitats/organisms - DO concentration, duration of events, spatial extent, seasonality (eg., relative to critical life stages)?
- How have other estuaries or coastal zones addressed the issue of site-specifc DO criteria, and “naturally” low DO in margin/shallow habitats?

The San Francisco Bay Regional Water Quality Control Board has secured $100,000 for this project, will support SCCWRP and SFEI staff and technical team for data analysis, literature review, and report preparation.

P.8 Dissolved oxygen in shallow margin habitats	**Priority = HIGH**
FY2015 Cost = 300,000 This is a 1-year funding request for a project that would likely continue over 2+ years.	
Collaborators: SFEI, SanJose Santa Clara Valley Wastewater Agencylester, USGS-Sac	

This proposed project will install, maintain, and interpret results from a several-station network of continuous monitoring stations for DO and other parameters in shallow margin habitats (creeks, sloughs) in Lower South Bay to assess condition with respect to DO and inform our understanding of major drivers.

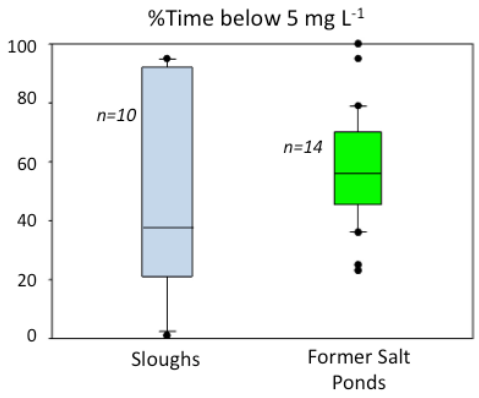
Low dissolved oxygen (DO) is a common symptom of excessive nutrient loads to estuaries and other water bodies, and results from oxygen consumption during

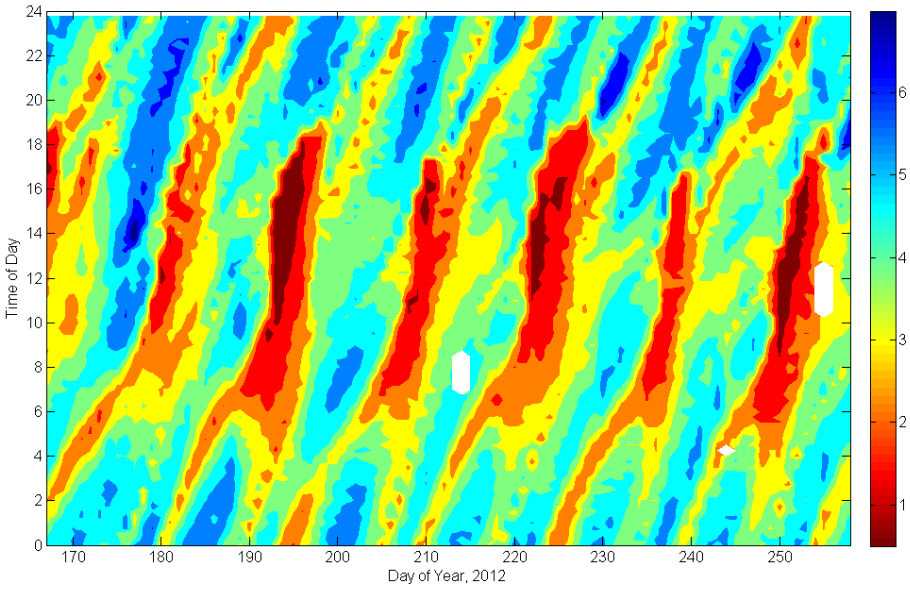


DO %saturation in bottom waters in deep subtidal areas at all USGS stations south of the Bay Bridge, 1993-2013. 100% saturation corresponds to 8.5±1.5 mg/L depending on temperature and salinity.

microbial degradation of organic matter (e.g., phytoplankton). Because of its well-established mechanistic link to nutrients, dissolved oxygen concentration is among the likely indicators of nutrient-related ecosystem health in San Francisco Bay. Most data on dissolved oxygen concentrations over the past ~20+ years have been collected in deep subtidal habitats, and DO concentrations, in general, have substantially exceed the Basin Plan criterion of 5 mg/L. Considerably less data is available for shallow margin habitats in San Francisco Bay, including sloughs, creeks, tidal wetlands, and former salt ponds undergoing restoration. Although these areas represent important habitats for aquatic organisms at certain life stages, there is no coordinated, systematic monitoring across a representative set of sites.

A recent survey of existing continuous DO data collected over a 12 year period by assorted programs in South Bay and Lower South Bay margin habitats showed that DO was frequently below 5 mg/L (40% and 55% of the time, averaged across sites, in slough and former salt ponds, respectively). Low DO occurs naturally in margin habitats like wetlands and sloughs. However there is currently insufficient information to characterize the frequency, duration, and severity (how low) of events, or to explore the underlying causes (importance of natural vs. anthropogenic factors). One excellent data set, collected in Alviso Slough demonstrates that low DO exhibits strong periodicity and persists at levels <2-3 mg/L for 12 hours or more over several days. This station is, however, 2.5 miles upslough from the confluence with Coyote Creek, and the spatial extent of low DO there, and how representative this condition of other sites, are unknown.





DO (contours; mg/L) as a function of date and time of day, Jun 15 –Sep 14 2012. Sensor was ~2 ft above the bottom. Low DO occurred during strongly periodic windows that coincided with weak neap tides. During these windows, DO was lowest during daylight hours when oxygen production would otherwise be expected, and DO increased during highest tide of the day, which occurred during the late evening. One hypothesis that can explain the daily pattern is that stratification developed due to low tidal mixing energy during these weak neap tides, and oxygen was rapidly consumed in the bottom layer due to sediment oxygen demand. An alternate hypothesis is that the entire water column had low DO concentrations, and the low DO water mass was pushed further upstream during high tide. Data: M Downing-Kunz; SFEI 2014.

Funding is being requested for Year 1 of a 1-2 year field study to determine the frequency, duration, and spatial extent of low DO in representative margin habits (sloughs, creeks) using moored sensors complemented by field sampling/calibration. This project's major goals, include:

1. Characterize temporal (tides, diel) and spatial patterns in DO and related parameters across a sites having a representative range of physical/biological characteristics;
2. Determine the frequency and duration of events with DO < 5 mg/L (and other relevant thresholds);
3. Through additional field measurements (vertical profiles during longitudinal transects), characterize the spatial extent of noteworthy events or common conditions,

4. Through the use of basic modeling and field data, semi-quantitatively test hypotheses for why low DO occurs.

Instruments will be installed at up to 6 sites, and will require maintenance and data download approximately every 2-4 weeks, depending on the time of year and rate of biofouling. During regular maintenance trips and some special field trips (to coincide with events), DO will be measured in vertical profiles at stations along longitudinal transects in creeks and sloughs to spatially-characterize conditions.

Ideally, 2-3 of the sites for this project would be installed in August-September 2014, since low DO is most pronounced in Summer/Fall.

Deliverables

Progress updates will be given in the form of presentations and meeting materials at technical team meetings and NTW meetings. A final technical report will be produced at the project's completion.

Budget

Funds will be directed toward instrumentation and equipment (110k), staff time for maintenance and data interpretation (150k), and field support for USGS (40k).

P.9 Additional Monitoring at current main channel stations in SFB, USGS cruises: phytoplankton taxonomy, nutrients	**Priority = HIGH**
FY2015 Cost = $100,000	
Collaborators: USGS, SFEI/RMP	

Currently, the USGS analyses samples for phytoplankton composition on only a limited number of stations, and only under certain conditions (typically only when chl-a exceeds 5ug/L), typically <5 stations per full-Bay cruise. Much more information – and collected consistently at a defined set of stations – is needed on community composition to determine if adverse shifts in phytoplankton composition are occurring, or harmful species are present at concerning levels, and to explore the underlying mechanisms leading to such shifts.

Similarly, nutrients are not a core part of the USGS research program and "optional"; therefore the full suite of analytes (i.e., no TN or TP) is not measured and spatial/temporal frequency is lower than is needed.

Deliverable and Budget
This project would support the measurement of 300 sets of nutrient analyses ($35k) and taxonomy on 300 samples for phytoplankton community composition and biovolume ($65k).

The results of these analyses would be made publicly available through USGS's website.

P.10 Physiological Assessment of the "Bad Suisun" Phenomenon: Light and Nutrient Interactions	Priority = HIGH
FY2015 Cost = $60,000	
Collaborators: UCSantaCruz, AMS	

Ammonium (NH_4^+) inhibition of phytoplankton productivity in Suisun Bay has been inferred from increases in chlorophyll during mixed-assemblage incubations, coinciding with depletion of ammonium and increasing use of nitrate during the incubation period (Dugdale et al. 2007, Parker et al. 2012). These results may be confounded by changes in irradiance, growth rates and species composition between ambient and test conditions. To tease apart environmental and community effects from physiological effects, and to determine if elevated concentrations of NH_4^+ directly cause a decline in primary production under controlled conditions, this project will test 1) the NH_4^+ tolerance, 2) the influence of differences sources of nitrogen (N), and finally 3) the relative importance of N sources versus irradiance in regulating growth of individual phytoplankton species endemic to Suisun Bay.

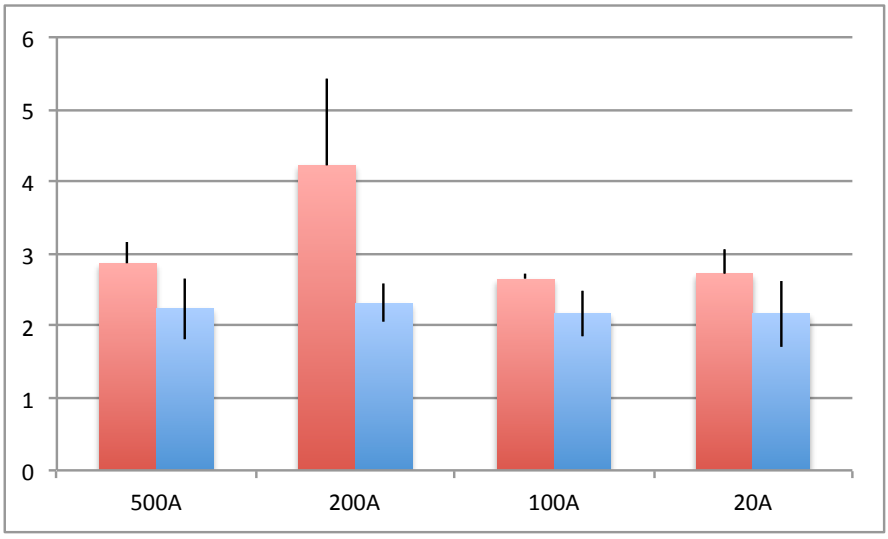


Figure 1. Carbon fixation (μg C μg Chl a-1 hr-1 on the y-axis in the diatom *Thalassiosira weissflogii* as a function of NH_4^+ (red bars) or NO_3^- (blue bars) at concentrations of 20-500 μmoles L^{-1} on the x-axis.

To date, eight species of phytoplankton from Suisun Bay have been isolated into pure culture. Only three of these have been tested for their tolerance to NH_4^+, as well as for growth on NH_4^+ relative to nitrate (NO_3^-). In one of the tested species, the diatom *Thalassiosira weisflogii*, the rate of carbon fixation was similar when grown on NH_4^+ compared to NO_3^-, and optimal NH_4^+ concentration for growth was 200 µmoles NH_4^+ L^{-1}. No inhibition of growth occurred in the range of NH_4^+ concentrations (20-500 µmoles L^{-1}) tested here (Figure 1). We would like to test the remaining five species for their NH_4^+/ NO_3^- tolerance levels, and to perform irradiance-nutrient interaction experiments on three of the eight species isolated. One of the eight species of phytoplankton isolated is the diatom *Thalassiosira pseudonana*. This diatom is also in culture at the National

Center for Marine Algae (NCMA) and has had its genome sequenced (Abrust et al. 2004). It was originally isolated in 1958 from Moriches Bay in Long Island, NY, and we would like to compare the tolerance levels of the freshly isolated *T. psedonana* strain from Suisun Bay with that from NCMA to determine whether NH_4^+ tolerance levels are similar or dissimilar in these two cultures. This comparison will give us information on how large a role acclimation to culture conditions over a period of more than four decades may play in modulating the NH_4^+ tolerance thresholds of algae.

Using a similar rationale, we would like to isolate two-four species of phytoplankton from the southern part of San Francisco Bay (South Bay) in order to test their NH_4^+ tolerance thresholds. Comparison of tolerance levels between species already isolated from Suisun Bay with those from South Bay will tell us whether phytoplankton tolerance levels are similar or dissimilar in species from the two endpoints of the Bay. Both the comparison of phytoplankton isolated from Suisun with a species in the NCMA culture collection, and with species from South Bay, will help us understand whether NH_4^+ tolerance thresholds are largely genetically determined and/or how much a role acclimation to different regions and conditions play. These comparisons between literature, cultures and endpoints of the Bay will provide a mechanistic understanding of the interactions between NH_4^+ concentration and phytoplankton productivit, information that is necessary to make sound management decisions regarding the degree to which nutrients forms and concentrations exert negative control over the food web in Suisun Bay.

P.11 Contribution to shared Research Vessel Purchase, in collaboration with USGS and other potential partners	**Priority = HIGH** (but may not be possible this year)
FY2015 Cost = 400,000	
Collaborators: USGS, SFEI, multiple partners	

The USGS research vessel needs to be retired sometime within the next 2 years. USGS has a long-term personnel and operation budget to continue supporting a vessel and associated research and monitoring activities. However, USGS is limited in its access to funds to purchase another research vessel.

USGS has signaled its interest in partnering with organizations affiliated with the Nutrient Steering Committee on the purchase of a replacement research vessel. Contributing to the research vessel's purchase would secure the continuity of the 40-year water quality record for the Bay. USGS would continue docking, maintaining and operating the vessel. From a long-term (10 year) strategic and financial standpoint, contributing to the vessel purchase would ensure priority future research vessel use that could amount to a large cost savings for the region.

While directing funds toward this purchase may not be feasible with the current FY2015 budget, this is an important opportunity to ensure data collection continues through a federal-regional partnership. It is recommended that this remain a high-priority topic for discussion during the first half of FY2015, and that the Nutrient Steering Committee consider options for identifying or raising funds to support this collaborative effort.

P.12 Other targeted mechanistic studies exploring the role of nutrients in shaping phytoplankton community composition (including HABs), causing decreased primary production, or other effects	**Priority = MED** (wait for FY2016)
FY2015 Cost = 200,000	
Collaborators: xxx	

This project would test hypotheses of N:P, high NH4, and high NO3 on phytoplankton community, individual cell composition, etc. as one step along the path of evaluating whether these effects are occurring, and assessing their relative importance alongside other drivers.

While more studies on this topic will likely be needed to inform management decisions, given the number of recently completed (but still being written up) and on-going studies on this topic in the Suisun/Delta, it is proposed that no additional studies be sponsored during FY2015 from the Nutrient Steering Committee resources.

P.13 Fish/benthos field investigations in margin habitats to inform site specific DO objectives	**Priority = MED** (wait for FY2016)
FY2015 Cost = 200,000/yr, multi-year study	
Collaborators: UCDavis, SCCWRP, SFEI	

This project would conduct fish/benthos surveys in Lower South Bay (open waters) and in slough/creek habitats to identify species abundance and richness. The work would help inform several of the questions raised in P.7 related to habitat suitability with respect to DO for supporting fish and benthos. DO and T data would also need to be collected.

This project is a ultimately a high priority for determining if current conditions are supporting the expected habitat requirements of important species. Given budget constraints, this multi-year project could begin in FY2016. Starting in FY2016 would also allow DO data collected in FY2015 through P.8. to inform sampling design (and a continuation of P.8 during FY2016 would provide the necessary DO data to accompany biota survey data). However, if additional resources become available, the startup of P.6 and P.13 during the same year could allow for considerable overall cost savings.

P.15 Science Coordination/program management	**Priority = HIGH**
FY2015 Cost = 200,000	
Collaborators: SFEI	

This project supports science coordination across projects, coordination with Nutrient Steering Committee, regulators and stakeholders, outreach, project management, contract management, and basic reporting. Funding would support 40% the Nutrient Science Program Lead Scientist (the remainder of support for the Lead Scientist is included within individual projects) and other SFEI staff for program management.

As the Nutrient Science Program moves into its second (first official) year and the number of work products and general progress increase, it may be important to begin generating an annual report – to serve as a progress report and to disseminate information to targeted audiences (managers, regulators, politicians). In particular, the editorial committee of the *State of the Estuary* has inquired whether the Nutrient Science Program could take the lead an effort developing the nutrient section during FY2015 and FY2016 (report publication date in FY2016). The Nutrient Science Program is well-positioned to take on that role. However, guidance is sought from the NSC, both about whether this is indeed an appropriate role and how it ranks among other priorities. Note: Costs associated with either an annual progress report or the *State of the Estuary* effort have not been included in the above budget.

P.16 External Review	**Priority = MED/HIGH**
FY2015 Cost = 50,000	

Convene an external advisory panel to review key aspects of the Nutrient Science Program and key work products (science plan, etc.), hold meeting with the NSC, stakeholders, and collaborators/experts.

The question here is not whether external review is important. Instead the question is whether this should be carried out first in FY2015 or FY2016.

Approximately $30k from a FY2014 contract with BACWA for coordinating external review is being carried forward to FY2015,

November 2012

San Francisco Bay Nutrient Management Strategy

San Francisco Bay Regional Water Quality Control Board

1. Is SFB experiencing nutrient-related impairment, or is it likely to in the future?
   - What types of impairment?
   - What forms of nutrients?
   - What future scenarios?

2. What are the major nutrient sources?
   - POTWs ?
   - stormwater ?
   - agriculture ?

3. What loads/concentrations are protective?
   - most sensitive endpoint ?
   - transport, mixing ?
   - reactions (transformations, losses) ?

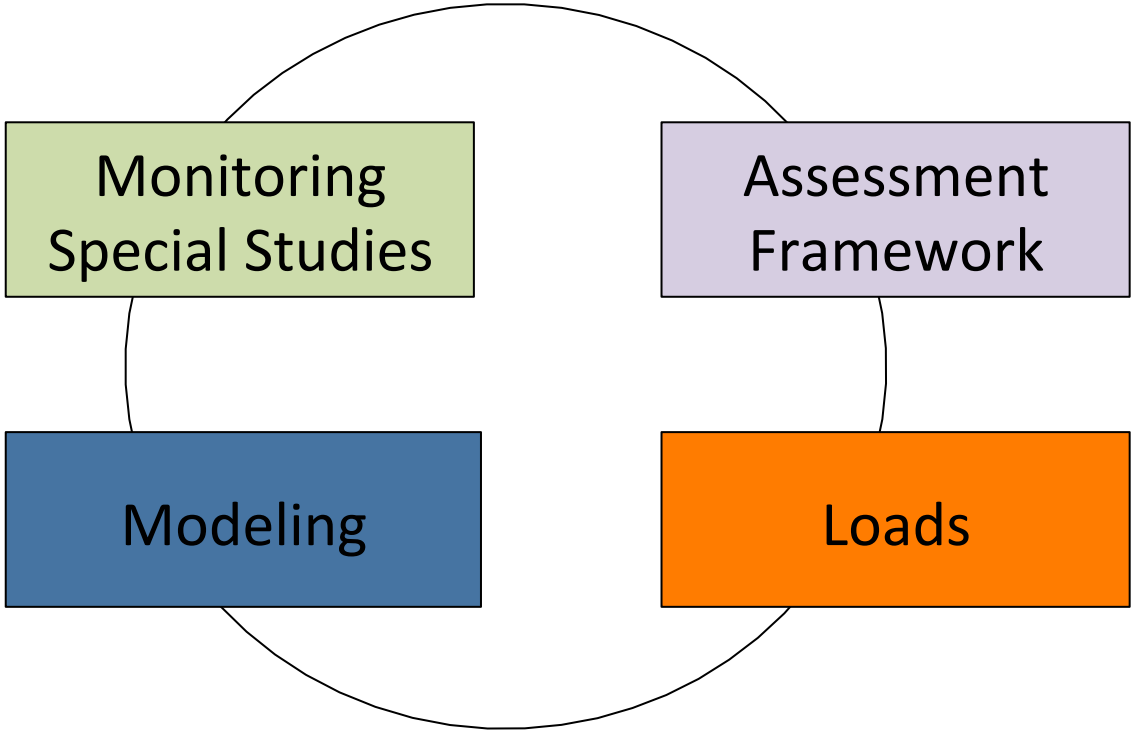
4. What reductions will protect ecosystems?
   - transport, mixing, reactions ?
   - benefit/cost ?

November 2012

San Francisco Bay Nutrient Management Strategy

San Francisco Bay Regional Water Quality Control Board

Nutrient Science Program

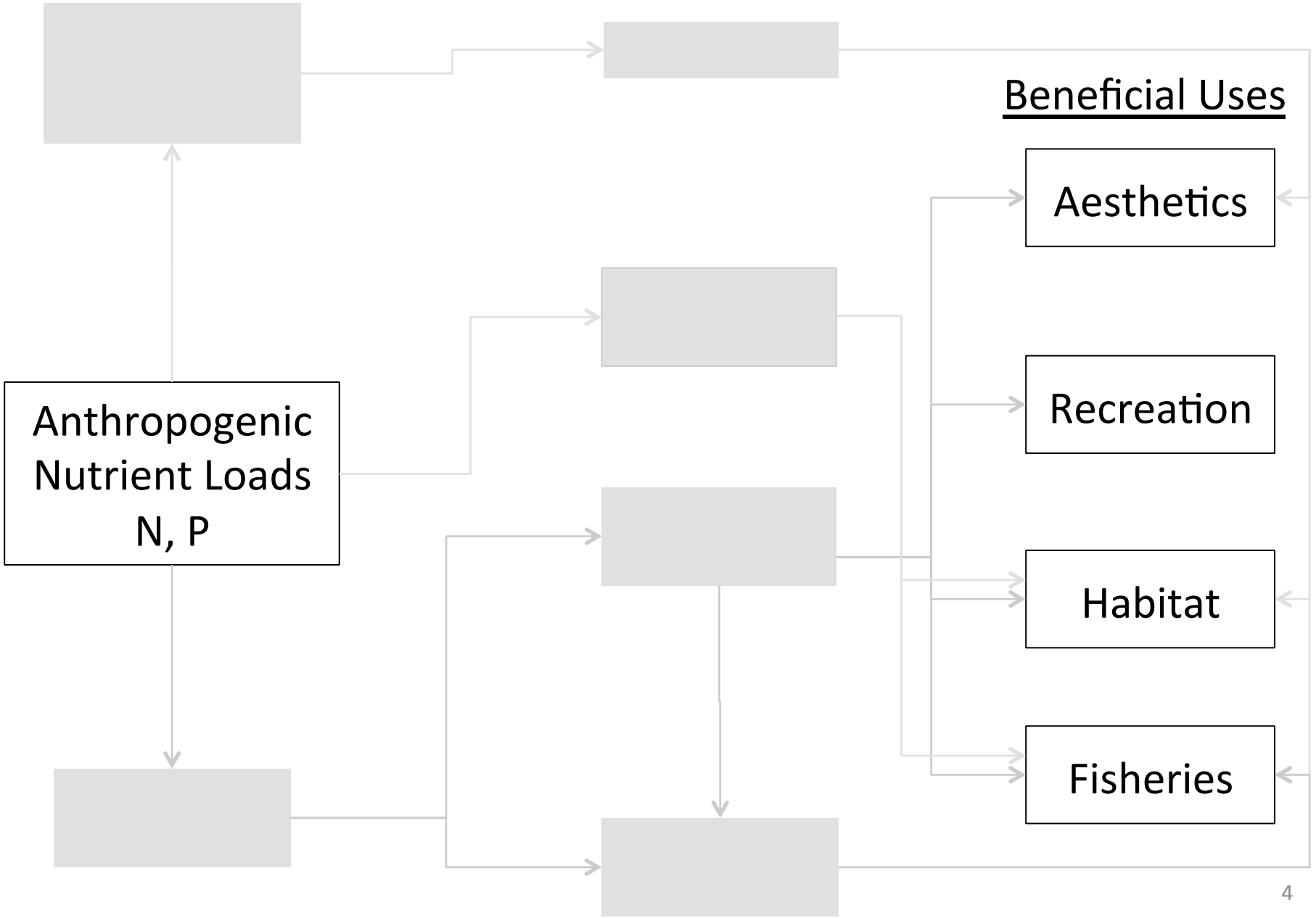


Highest Priority Nutrient Issues in SFB

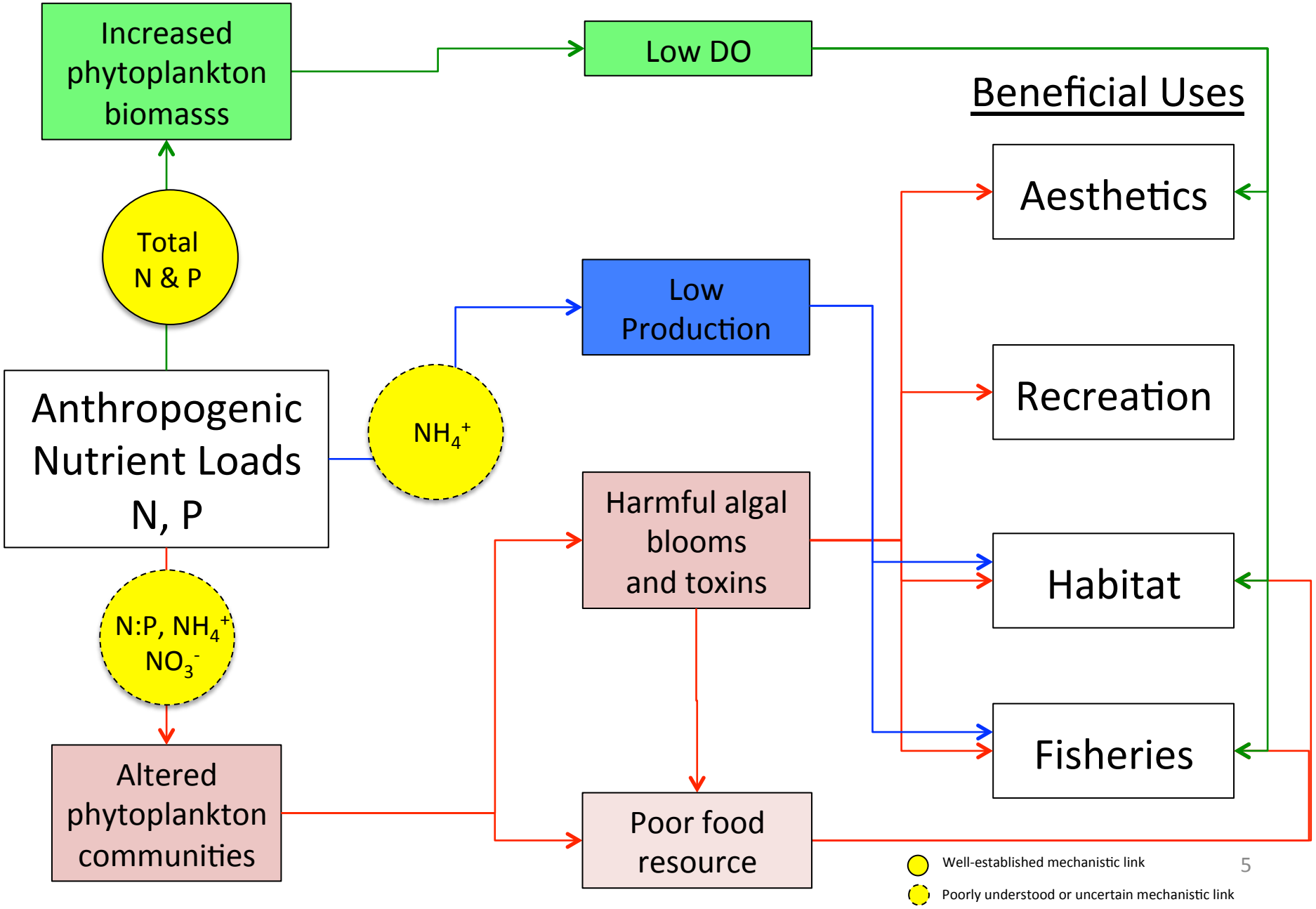
- Determine whether increasing biomass signals future impairment
- Quantify factors that adversely affect phytoplankton composition, including the potential for Harmful Algal Blooms and toxins
- Determine if low DO in shallow habitats causes impairment
  - Quantify role of nutrients
- Test future scenarios that may lead to worsening conditions
- Quantify nutrient contributions to different areas of the Bay
- Test mitigation/prevention scenarios

SFEI 2014b

Potential Pathways to Adverse Impacts



Potential Pathways to Adverse Impacts



2011-2014

Past Studies or Studies Underway

External Loads Study

Effluent Characterization

Effluent Characterization

Delta Loads

Hydrodynamic and Water Quality Modeling

NNE Report

Nutrient Strategy

Conceptual Model

Suisun Synthesis I

Science Plan

LSB Synthesis

Suisun Synthesis II

Assessment Framework Planning

Evaluate Assessment approaches

HAB Toxins

On-going monitoring

Suisun Field Studies

Suisun Field Studies

Pilot: Phyto pigments

Pilot: Moored Sensors

Data Analysis/ Interpretation

Program Design/ Development

On-going monitoring

Suisun phyto studies

Quantify Loads

Load Reductions: Scenarios

Modeling

Synthesis, Science Plan

Assessment Framework

Monitoring, Special Studies

Key Background Documents (and recommendations)

- Nutrient Strategy

http://www.waterboards.ca.gov/sanfranciscobay/water_issues/programs/planningtmdls/amendments/estuarineNNE/Nutrient_Strategy%20November%202012.pdf

- Scientific Foundation for a San Francisco Bay Nutrient Strategy (aka, Conceptual Model Report)

SFEI 2014a

Draft. Final in May 2014

http://www.waterboards.ca.gov/sanfranciscobay/water_issues/programs/planningtmdls/amendments/estuarineNNE/SAG-June-2013/Nutrients_CM_DRAFT_May12013.pdf

- Suisun Bay Ammonium Synthesis

http://www.sfei.org/sites/default/files/SuisunSynthesisI_Final_March2014_0.pdf

- External Nutrient Loads to San Francisco Bay

SFEI 2014b

http://www.sfei.org/sites/default/files/NutrientLoadsFINAL_FINAL_Jan232014_0.pdf

- Approaches to a Nutrient Assessment Framework

SCCWRP 2013

http://www.waterboards.ca.gov/sanfranciscobay/water_issues/programs/planningtmdls/amendments/estuarineNNE/SAG-June-2013/NNE_Framework_White_Paper.pdf

- Characterizing Nutrient Trends, Loads, and Transformations in Suisun Bay and the Delta.

SFEI 2014d

http://www.sfei.org/sites/default/files/IEP%202014%20ENovick%20FINAL.pdf

- Model Development Plan

http://www.sfei.org/sites/default/files/Nutrient_Modeling_Approach_draftFINAL_Jan212014.pdf

- Numeric nutrient endpoint development for San Francisco Bay – Lit review and data gaps analysis

http://www.sfei.org/sites/default/files/644_SFBayNNE_LitReview%20Final.pdf

- Approaches to a Nutrient Assessment Framework, Draft

http://www.waterboards.ca.gov/sanfranciscobay/water_issues/programs/planningtmdls/amendments/estuarineNNE/SAG-June-2013/NNE_Framework_White_Paper.pdf

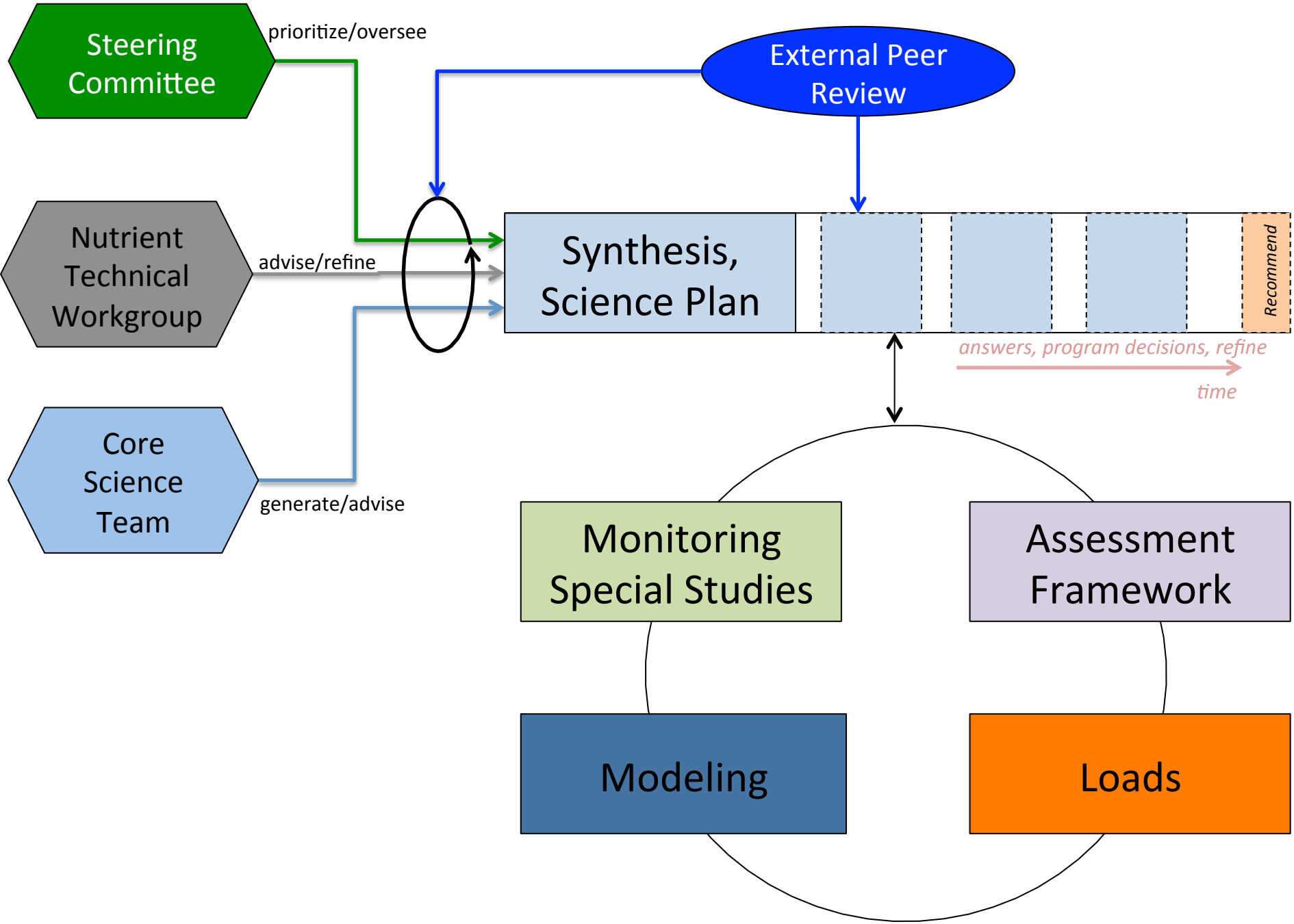
Available Funding for FY2015

Program	Amount	Notes
new		
Nutrient Steering Committee	~$800	
RMP*	$500	moored sensors, modeling
SFB Water Board	$65k	Science Plan Development
SFB Water Board	$100k	Dissolved oxygen objectives
Carry forward		
RMP Modeling	~$300k	From prior years
total	$1.8mill	

*Provisionally allocated

Science Plan

- The science plan will be developed over the coming year and will serve as a guide, prioritization, and workflow/schedule for major activities needed inform nutrient management decisions in SFB.
- Over the past two years, we've been identifying and prioritizing projects based on recommendations from the draft Conceptual Model Report, and recruiting input from technical advisors and stakeholders
- For the FY2015 proposed projects, while developing the longer term (5yr) Science Plan, we are following a similar approach, and ensuring that the proposed projects are "no regrets" studies that will ultimately be part of the Science Plan, and ones that would implemented in its early phases.
- It is expected that the Science Plan will be consistent with the broad recommendations laid out in the Nutrient Strategy. The Science Plan will, however, go into substantially more detail in terms of specific study and data needs, a proposed workflow schedule, and estimated costs. In large part, the Science Plan will actually integrate across recommendations laid out for the major Nutrient Science Program components…monitoring, modeling, special studies, assessment framework.
- While the Science Plan is not yet developed, several of the key reports whose recommendations will inform much of the Science Plan are complete or in draft form. Recommendations for FY2015 are based on recommendations or priorities identified in:
  - Conceptual Model Report
  - Suisun Synthesis I
  - Monitoring Program Development Plan
  - Modeling Plan
  - Assessment framework plan
- Relevant excerpts from those reports are included at the end of this document. The full Monitoring Program Development Plan is also included.


Steering Committee
prioritize/oversee
External Peer Review
Nutrient Technical Workgroup
advise/refine
Synthesis, Science Plan
Recommend
answers, program decisions, refine
time
Core Science Team
generate/advise
Monitoring Special Studies
Assessment Framework
Modeling
Loads

2) Correlating Selenium in Sturgeon Muscle Plugs and Eggs

Oversight Group: Selenium Strategy Team
Proposed by: Jay Davis, SFEI

Funding requested for 2015: $20,000

Introduction and Background

In April 2014 the RMP formed a Selenium Strategy Team to evaluate information needs that can be addressed by the Program in the next several years. The charge given to the Team by the RMP Steering Committee was to focus on low-cost, near-term monitoring elements that could provide information that provides high value in support of policy development and decision-making. A TMDL for the North Bay is in development by the Regional Water Board, with a staff report in preparation.

The TMDL will establish a target concentration in white sturgeon muscle tissue as the basis for evaluating impairment. White sturgeon is a bottom-feeding species that is considered to be at substantial risk for selenium exposure in the Bay (Beckon and Mauer 2008). White sturgeon are particularly at risk because their diet consists primarily of the overbite clam (*Potamocorbula amurensis*), which are selenium-rich relative to other prey (Stewart et al. 2004). Other increased risk factors for sturgeon include their longevity (they can live over 100 years), their year-round resident status, and long egg maturation times (several years) (Beckon and Mauer 2008). Green sturgeon are also considered to be vulnerable to selenium but their exposure could be limited. Adults and sub-adults spend a large portion of their lives in coastal marine waters outside of the estuary, and are only briefly exposed to high selenium diet during their infrequent spawning migrations through the Bay. In addition, green sturgeon are threatened species and fishing for them is prohibited.

White sturgeon have been routinely sampled (in 1997, 2000, 2003, 2006, 2009, and 2014) by the RMP sport fish monitoring element since 1997. The tissue analyzed has been muscle fillets. Future monitoring of white sturgeon is anticipated to focus on muscle plugs, as described in the 2014 proposal "Selenium in Sturgeon Muscle Plugs". Sampling of sturgeon eggs, although logistically more challenging, would provide a more direct metric of the risk to sturgeon reproduction. USEPA recently published draft selenium criteria for freshwater that highlight egg or ovary data as a preferred endpoint most directly tied to adverse effects. Data that would allow evaluation of the correlation between muscle concentrations and egg concentrations would enhance the application of muscle plugs as an impairment indicator.

An annual sturgeon fishing tournament in the Delta provides an opportunity to obtain a small number of female sturgeon in 2015. In this Sturgeon Derby, held on Super Bowl weekend, anglers attempt to catch sturgeon that come closest to a selected size. Fish that are close to the target size are brought in to a central location and sacrificed. For the past several years, the USFWS has collected tissues from these sturgeon and analyzed them for a suite of metals and organics, including selenium, in gonads (including ovaries), liver, and plasma. These data have not yet been published. But the USFWS study does not analyze muscle, because the USFWS has

not requested muscle tissue from the anglers. The average number of fish that are sampled in this effort is around 40, with about half being females. Eggs will be targeted in this proposed study if possible, with ovaries as an alternative if eggs can not be sampled. If eggs are collected, stage of egg development will be noted if possible.

This proposal is requesting funds to measure selenium in muscle plugs and eggs or ovaries from the sturgeon Derby in 2015.

Study Objective and Applicable RMP Management Questions:

This objective of this study is to obtain data to evaluate the correlation between muscle and egg or ovary selenium concentrations through a collaboration with USFWS, local fishermen, and USGS.

Selenium Strategy questions addressed:

2. Are the beneficial uses of San Francisco Bay impaired by selenium?

RMP Management Questions addressed:

1. Are chemical concentrations in the Estuary at levels of potential concern and are associated impacts likely?
   B. What potential for impacts on humans and aquatic life exists due to contaminants in the Estuary ecosystem?

Study Approach

The study would be performed in collaboration with USFWS and USGS. SFEI staff would plan the study, perform sampling, manage the data, and write a brief technical report. USGS (Robin Stewart and her team) would perform analysis of selenium and stable isotopes of C, N, and S in the plugs, and of selenium on the eggs or ovaries. The stable isotopes provide information on diet and habitat use by the sturgeon. The sampling would occur on Super Bowl weekend in 2015.

Fifteen white sturgeon muscle plugs will be collected and analyzed. Fifteen splits of their egg or ovary samples will also be obtained from USFWS for analysis by USGS.

Tasks and Budget

- Planning: decide on methods, coordination
  - SFEI: $1260 (2 days)
- Field work
  - SFEI: $2520 (1 person, 4 “days” - the Derby is two days but goes around the clock)
- Sample processing (including archiving)
  - USGS: $200
- Analysis
  - Selenium
    - USGS: $4,950 (30 samples @ $165)
  - Isotopes

        - UCD: $750 (15 samples @ $50)
- Data management and QA
    - SFEI: $7,350
- Reporting - short technical report to document methods and results, plot data with past data, examine correlation among tissues
    - SFEI: $2,625 (4 days)

Total Cost: $20,000 (rounded up from $19,655)

Deliverables and Timeline

Draft technical report	Jul 2015
Final technical report	Aug 2015

References

Beckon, W. and T. Mauer. 2008. Species at Risk from Selenium Exposure in San Francisco Estuary. Final report to the USEPA. US Department of the Interior, Fish and Wildlife Service. http://www.waterboards.ca.gov/sanfranciscobay/water_issues/programs/TMDLs/northsfbayselenium/Species_at_risk_FINAL.pdf

Stewart, R.A., S. Luoma, C. Schlekat, M. Doblin, and K. Hieb. 2004. Food web pathway determines how selenium affects aquatic ecosystems: a San Francisco Bay case study. Environ. Sci. Technol. 38. 4519-4526.

16) Selenium Strategy Coordination and Technical Support

Oversight group: Selenium Strategy Team
Proposed by: Jay Davis, SFEI

Funding requested for 2015: $10,000

Introduction and Background

In April 2014 the RMP formed a Selenium Strategy Team to evaluate information needs that can be addressed by the Program in the next several years. The charge given to the Team by the RMP Steering Committee was to focus on low-cost, near-term monitoring elements that could provide information that provides high value in support of policy development and decision-making. A TMDL for the North Bay is in development by the Regional Water Board, with a staff report in preparation. Development of a TMDL for the South Bay will be considered after the North Bay TMDL is completed. In the longer-term, the need for a greater investment in studies in support of managing selenium in the Bay will be considered.

Study Objective and Applicable RMP Management Questions

The objective of this task is to provide coordination and technical support for continuing development of the Selenium Strategy. This task would therefore address all of the questions articulated in the Strategy.

1. What are appropriate thresholds?
2. Are the beneficial uses of San Francisco Bay impaired by selenium?
3. What is the spatial pattern of selenium impairment?
4. How do selenium concentrations and loadings change over time?
5. What are the mechanisms of uptake from water and sediment to biota?
6. What is the relative contribution of each loading pathway as a source of selenium impairment in the Bay?
7. What future impairment is predicted for selenium in the Bay under different management scenarios?
8. What are the best opportunities for management intervention for the most important contaminant sources, pathways, and processes?

The task would also address many of the overarching RMP management questions.

Tasks for 2015

Funds for this task would enable SFEI to continue to convene the Selenium Strategy Team to allow discussions of plans for the North Bay TMDL and the consideration of a TMDL for South Bay, to develop RMP workplans to support these efforts, and for any small-scale synthesis of information that is needed to support these discussions. Datasets and literature that are relevant to these TMDLs will be compiled so they are readily accessible when they are needed for in-

depth analysis. The plan will include a multi-year schedule of budgets and deliverables aimed at providing a technical foundation for the TMDLs.

Timing and Deliverables: An updated selenium multi-year plan in June 2015. The plan will include a multi-year schedule of budgets and deliverables.

1) Priority Margin Unit Conceptual Model Development

Oversight group: PCB Strategy Team
Proposed by: Jay Davis, SFEI

Funding requested for 2015: $100,000

Introduction and Background

The RMP PCB Strategy Team formulated a PCB Strategy in 2009. The Team recognized that a wealth of new information has been generated since the PCBs TMDL Staff Report (SFBRWQCB 2008) was prepared. The Strategy articulated management questions to guide a long-term program of studies to support reduction of PCB impairment in the Bay. The PCB Team recommended two studies to begin addressing these questions. The first recommended study was to take advantage of an opportunity to piggyback on the final year of the three-year small fish mercury sampling in 2010. The second study recommended was a synthesis and conceptual model update based on the information that had been generated since the writing of the TMDL Staff Report.

The small fish monitoring revealed extremely high concentrations of food web PCBs in several areas on the Bay margins (Greenfield and Allen 2013), and highlighted a need to develop a more detailed conceptual model than the one-box model used as a basis for the TMDL. A model that would support the implementation of actions to reduce loads from small tributaries, a primary focus of the TMDL, would be of particular value. A revised conceptual model was developed that shifted focus from the open Bay to the contaminated areas on the margins where impairment is greatest, where load reductions are being pursued, and where reductions in impairment in response to load reductions would be most apparent (Davis et al. 2013).

The margins appear to be a collection of distinct local food webs that share some general similarities but are largely functionally discrete from each other. Monitoring, forecasting, and management should therefore treat these margin locations as discrete local-scale units. Local-scale actions within a margin unit, or in upstream watersheds, will be needed to reduce exposure within that unit. Better characterization of impairment on the margins through more thorough sampling of sediment and biota would help focus attention on the margin units where the need for action is greatest ("priority margin units"), and will also provide an important performance measure for load reduction actions taken in local watersheds. The Synthesis recommended a focus on assessing the effectiveness of small tributary load reduction actions in priority margin units, and provided an initial foundation for these activities.

The 2014 update of the PCB Strategy calls for a multi-year effort to implement the recommendations of the PCB Synthesis pertaining to identifying margin units that are high priorities for management and monitoring, development of conceptual models and sediment mass balances for margin units downstream of watersheds where management actions will occurand monitoring in these units as a performance measure. A thorough and thoughtful planning effort is warranted given the large expenditures of funding and effort that will be needed to implement management actions to reduce PCB loads from urban stormwater.

The work proposed for 2015 would consist of planning activities to prioritize margin units and select an optimal subset for detailed conceptual evaluation and monitoring. This would be followed by the implementation of monitoring in the one or two units of greatest interest in 2016, in parallel with development of conceptual models and monitoring plans for the other few units of greatest interest.

Study Objective and Applicable RMP Management Questions:

The objective of this study is to develop sensitive monitoring strategies to detect the effectiveness of watershed management actions in reducing PCB impairment in selected priority margin units (PMUs).

PCB Strategy questions addressed:

4. What is the total maximum daily load of PCBs that can be discharged without impairment of beneficial uses?
9. What are the effects of management actions on the potential for adverse impacts on humans and aquatic life due to Bay contamination?

RMP Management Questions addressed:

4. Have the concentrations, masses, and associated impacts of contaminants in the Estuary increased or decreased?
    B. What are the effects of management actions on the potential for adverse impacts on humans and aquatic life due to Bay contamination?

Study Approach

The proposed multi-year effort would include a year of planning activities in 2015 to:

1. prioritize and identify the margin units to focus on,
2. develop conceptual models and sediment mass balances for the one or two highest priority units, and
3. continue planning efforts to develop a multi-year workplan in support of the anticipated update of the TMDL in 2020.

Expected outcomes for the 2015 effort will be the identification and conceptual evaluation of one or two priority margin units that will be selected for monitoring, and the development of a monitoring strategy for these units.

It will be extremely valuable to begin implementation of baseline monitoring of the selected margin units in advance of the management actions. Initiating monitoring of the units will therefore be a priority for activities in 2016-2019. The monitoring will be designed to maximize sensitivity to detecting reduced impairment in the margin units. Identification and evaluation of additional priority margin units will also occur in parallel to the initial monitoring of the first one or two units. After the planning effort is completed, monitoring will continue to establish initial baseline conditions, and then to track improvement in response to management actions.

Tasks for 2015

Task 1: Prioritize margin units and select units for intensive evaluation ($30K)

This work would be done by the PCB Strategy Team with staff support from SFEI. An initial survey and prioritization of all the margin units will be conducted. Properties of the margin units to be evaluated will be determined through Team discussion. Data gathering and analysis will be needed to support the prioritization effort, including evaluation of data on contamination in the watersheds and in the Bay, mapping information to link watersheds with margin units, and mapping to delineate boundaries of margin units. All margin units will be considered in this prioritization phase, not just those for which data are already available. It is anticipated that task 1 will require two to three meetings of the PCB Strategy Team.

Timing and Deliverables: Some planning and data compilation will begin in 2014. Data analysis will begin in January 2015. A brief report on the prioritization effort will be drafted by March 2015.

Task 2: Develop conceptual site models and first order mass balances for the highest priority margin units ($60K)

The one or two highest priority margin units (PMUs) will be evaluated in detail in 2015. The following approach will be applied to each PMU. A relatively large Conceptual Site Model Workgroup (CSMW) will be assembled that includes members of the PCB Strategy Team, along with experts on potential biotic indicators, sediment movement from watersheds to margins to the open Bay, and local conditions. This CSMW will meet two to three times to develop and document conceptual understanding and a monitoring plan for the PMU. While ideally the site model evaluations will conclude that it is possible to detect reduced concentrations in the Bay, it is also possible that the CSMW will conclude that this is not feasible with a realistic effort given the relative magnitude of the reduced loading, the reservoir of PCBs already in the PMU, and environmental variation. Schedules for CSMW activities will be established with input from workgroup members and interested parties.

As conceptual models are developed for these PMUs, consideration will be given to whether a general model or family of models can be developed that could apply to margin units more broadly.

The labor required to conduct tasks 1 and 2 is difficult to estimate because this is a novel effort and the data gathering and analysis to be done will be determined through Strategy Team and CSMW discussions. If funds remain from task 1 after the task is completed, they will be applied to task 2. More detailed budgets will be developed and subject to Strategy Team, TRC, and Steering Committee approval as planning proceeds.

Timing and Deliverables: The goal will be to prepare technical reports documenting conceptual site models and monitoring plans for at least one PMU, and perhaps two PMUs, by December 2015. Whether two PMUs is possible depends on the amount of data gathering and analysis needed to develop a sediment mass balance and conceptual model for PMU #1.

Task 3: Development of multi-year plan in support of the TMDL $10K

Funds for this task would enable SFEI to continue to convene the PCB Strategy Team to allow discussions of plans for the next iteration of the TMDL and RMP activities that can inform the TMDL, and for any small-scale synthesis of information that is needed to support these discussions. The plan will include a multi-year plan schedule of budgets and deliverables aimed at providing a technical foundation for the next iteration of the TMDL. Depending on the outcomes of the site model evaluations, this RMP expenditure for continued Strategy Team discussions may need to be augmented or complemented by other forums for discussing TMDL revision.

Timing and Deliverables: An updated PCB multi-year plan in June 2015. The plan will include a multi-year plan schedule of budgets and deliverables.

Item 8: Five Year Planning Budget for New Unrestricted Revenue

	2013	2014	2015	2016	2017	2018	TOT '14-18
SPECIAL STUDIES TOTAL	**$1,228,000**	**$1,327,000**	**$1,162,000**	**$783,000**	**$983,000**	**$1,063,000**	**$5,318,000**
Mercury	$0	$0	$0	$0	$0	$0	**$0**
PCBs	$0	$0	$85,000	$120,000	$180,000	$160,000	**$545,000**
Dioxins	$0	$24,000	$0	$40,000	$0	$0	**$64,000**
Emerging Contaminants	$141,000	$183,000	$84,000	$75,000	$100,000	$100,000	**$542,000**
Small Tributaries	$468,000	$487,000	$470,000	$0	$0	$0	**$957,000**
Other SPL	$0	$0	$0	$0	$0	$0	**$0**
Exposure and Effects	$114,000	$80,000	$0	$45,000	$0	$0	**$125,000**
Forecasting	$100,000	$0	$0	$0	$0	$0	**$0**
Selenium		$33,000	$53,000	$33,000	$83,000	$83,000	**$285,000**
Nutrients	$405,000	$520,000	$470,000	$470,000	$620,000	$720,000	**$2,800,000**

SPECIFIC STUDIES	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**
Hg General Allocation						
PCB Margin Unit Prioritization			$30,000			
PCB Priority Margin Unit Conceptual Models			$45,000	$80,000	$80,000	
PCB Priority Margin Unit Monitoring				$30,000	$90,000	$150,000
PCB Strategy Development			$10,000	$10,000	$10,000	$10,000
PCB General Allocation						
Dioxins in S&T Indicators		$24,000				
Dioxins Modeling and Synthesis				$40,000		
EC PBDE Synthesis	$36,000					
EC Updating RMP EC Strategy	$20,000	$20,000	$20,000	$20,000	$20,000	$20,000
EC Current Use Pesticide Focus Meeting	$15,000					
EC Developing Bioanalytical Tools	$70,000	$56,000				
EC Alternative Flame Retardants		$107,000				
EC Microplastics			$9,000			
EC CECs in Effluent			$55,000			
EC CUPs in North Bay				$55,000		
EC General Allocation					$80,000	$80,000
STLS Regional Loadings: Spreadsheet Model	$25,000	$30,000	$35,000			
STLS Load Monitoring in Representative Watershe	$343,000	$352,000				
STLS Monitoring at Representative Land Use Sites	$80,000	$80,000				
STLS Management Support	$20,000	$25,000	$26,000			
STLS Watershed Screening (Wet Weather Charzn)			$374,000			
STLS Trends Strategy and Monitoring			$35,000			
SPL Central Valley Loads						
EE Benthic Assessment Tools	$76,000					
EE Causes of Sediment Toxicity: Follow up on Moderate Toxicity		$30,000				
EE Synthesis on Aquatic Life Impairment Drivers						
EE Hotspot Followup				$45,000		
EE Impacts of Dredging on Benthos		$50,000				
EE Effects of Copper on Salmon	$38,000					
F Nutrient and Contaminant Modeling: Model Deve	$100,000					
N Nutrient Conceptual Model and Loads	$50,000					
N Nutrients Coordination and Management	$20,000	$20,000	$20,000	$20,000	$20,000	$20,000
N Nutrients in Stormwater	$40,000	$35,000				
N Nutrient Loads and Data Gaps	$30,000					
N Nutrient Monitoring: Moored Sensor	$200,000	$215,000	$300,000	$350,000	$400,000	$500,000
N Monitoring: Algal Biotoxins	$65,000					
N Monitoring Program Development		$50,000	$50,000	$50,000	$150,000	$150,000
N Modeling		$200,000	$100,000	$50,000	$50,000	$50,000
N Nutrient General Allocation						
Selenium Strategy Development		$10,000	$10,000	$10,000	$10,000	$10,000
Selenium Sturgeon Plugs		$23,000	$23,000	$23,000	$23,000	$23,000
Selenium Sturgeon Derby			$20,000			
Selenium South Bay Synthesis					$50,000	
Selenium South Bay Food Web Sampling						$50,000
Selenium South Bay Model						

REGIONAL MONITORING PROGRAM FOR WATER QUALITY IN SAN FRANCISCO BAY

MULTI-YEAR PLAN

2014 ANNUAL UPDATE

January 2014 Edition

Revised: July 10, 2014

RMP ORIGIN AND PURPOSE

In 1992 the San Francisco Bay Regional Water Board passed Resolution No. 92-043 directing the Executive Officer to send a letter to regulated dischargers requiring them to implement a regional multi-media pollutant monitoring program for water quality (RMP) in San Francisco Bay. The Water Board's regulatory authority to require such a program comes from California Water Code Sections 13267, 13383, 13268 and 13385. The Water Board offered to suspend some effluent and local receiving water monitoring requirements for individual discharges to provide cost savings to implement baseline portions of the RMP, although they recognized that additional resources would be necessary. The Resolution also included a provision that the requirement for a RMP be included in discharger permits. The RMP began in 1993, and over the past 21 years has been a successful and effective partnership of regulatory agencies and the regulated community.

The goal of the RMP is to provide the high quality body of knowledge on estuarine contamination needed for managing water quality in this treasured aquatic ecosystem.

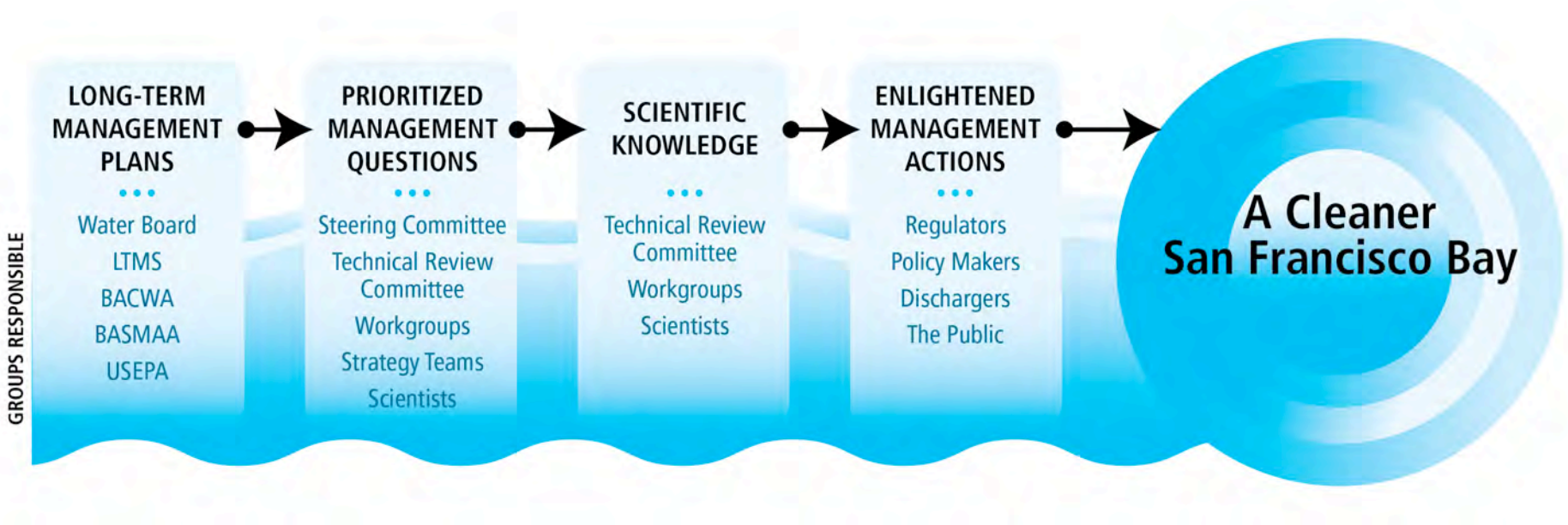
This goal is achieved through a cooperative effort of a wide range of regulators, dischargers, scientists, and environmental advocates. This collaboration has fostered the development of a multifaceted, sophisticated, and efficient program that has demonstrated the capacity for considerable adaptation in response to changing management priorities and advances in scientific understanding.

Figure 1. RMP Committees and Workgroups.

RMP PLANNING

This collaboration and adaptation is achieved through the participation of stakeholders and scientists in frequent committee and workgroup meetings. The Steering Committee (Figure 1) consists of representatives from discharger groups (wastewater, stormwater, dredging, industrial) and regulatory agencies (Regional Water Board, USEPA, and U.S. Army Corps of Engineers). The Steering Committee determines the overall budget and allocation of program funds, tracks progress, and provides direction to the Program from a manager's perspective. Oversight of the technical content and quality of the RMP is provided by the Technical Review Committee (TRC), which provides recommendations to the Steering Committee. Six workgroups report to the TRC and address the main technical subject areas covered by the RMP: sources, pathways, and loadings; contaminant fate; exposure and effects; emerging contaminants; sport fish contamination; and nutrients. The workgroups consist of regional scientists and regulators and invited scientists recognized as authorities in their field. The workgroups directly guide planning and implementation of pilot and special studies. RMP "strategy teams" comprise one more layer of planning activity. These stakeholder groups meet as needed to develop long-term RMP study plans for addressing high priority topics. Topics addressed to date include mercury, PCBs, dioxins, small tributary loads, and forecasting (modeling). A selenium strategy team will be convened in 2014.

Figure 2. Science in support of water quality management.



The RMP supports management efforts to protect and restore water quality in the Bay. It does this by developing the scientific understanding needed to answer the key questions on priority topics that underpin current and future management policies and actions. RMP stakeholders and scientists work closely together to ensure the linkage of science and management.

The annual planning cycle begins with a workshop in October in which the Steering Committee articulates general priorities among the information needs on water quality topics of concern. In the second quarter of the following year the workgroups and strategy teams forward recommendations for study plans to the TRC. At their June meeting, the TRC combines all of this input into a study plan for the following year that is submitted to the Steering Committee. The Steering Committee then considers this recommendation and makes the final decision on the annual workplan.

In order to fulfill the overarching goal of the RMP, the Program has to be forward-thinking and anticipate what decisions are on the horizon, so that when their time comes, the scientific knowledge needed to inform the decisions is at hand. Consequently, each of the workgroups and teams develops five-year plans for studies to address the highest priority management questions for their subject area. Collectively, the efforts of all these groups represent a substantial body of deliberation and planning.

PURPOSE AND ORGANIZATION OF THIS DOCUMENT

The purpose of this document is to guide efforts and summarize plans developed within the RMP. The intended audience includes representatives of the many organizations who directly participate in the Program. This document will also be useful for individuals who are not directly involved with the RMP but are interested in an overview of the Program and where it is heading.

The organization of this Multi-Year Plan parallels the RMP planning process (Figure 2). Section 1 presents the long-term management plans of the agencies responsible for managing water quality in the Bay and the overarching management questions that guide the Program. The agencies' long-term management plans provide the foundation for RMP planning (page 6). The first step the RMP takes to support these plans, is to distill prioritized lists of management questions that need to be answered in order to turn the plans into effective actions (page 7). The prioritized management questions then serve as a roadmap for scientists on the Technical Review Committee, the workgroups, and the strategy teams to plan and implement scientific studies to address the most urgent information needs. This information sharpens the focus on management actions that will most effectively and efficiently improve water quality in the Bay.

Section 2 provides an overview of the budget of the RMP, including where the funding comes from and how it is allocated among different elements of the Program. This section provides a summary of the priority topics to be addressed by the Program over the next five years.

Section 3 presents the five-year plans developed by the workgroups and strategy teams for specific priority topics: mercury, PCBs, dioxins, emerging contaminants, small tributary loads, exposure and effects, forecasting, nutrients, and status and trends. Led by the stakeholder representatives that participate in these groups, each workgroup and strategy team has developed a specific list of management questions for each topic that the RMP will strive to answer over the next five years. With guidance from the science advisors on the workgroups, plans have been developed to address these questions. These plans include proposed projects and tasks and projected annual budgets. Information synthesis efforts are often conducted to yield recommendations for a next phase of studies. For now, study plans and budget allocations for these strategies are largely labelled as "to be determined". Other pieces of information are also included to provide context for the multi-year plans. First, for each high priority topic, specific management policies or decisions that are anticipated to occur in the next few years are listed. Second, the latest advances in understanding achieved through the RMP and other programs on Bay water quality topics of greatest concern are summarized. Lastly, additional context is provided by listing studies performed within the last two years and studies that are currently underway.

Section 4 describes five-year plans for other elements that are essential to the mission of the RMP: communications, data management, and quality assurance.

A Living Document

The RMP Multi-Year Plan is updated annually to provide an up-to-date description of the priorities and directions of the Program. An annual Planning Workshop is held in conjunction with the October Steering Committee meeting. A draft Multi-Year Plan is prepared after the workshop, and approved by the Steering Committee at the January meeting.

More detailed descriptions of the elements of the RMP are provided in the annual Program Plan and in the annual Detailed Workplan (both available at **www.sfei.org/rmp/what**).

For additional information on the RMP please visit our website at **www.sfei.org/rmp**.

Please contact Jay Davis, RMP Lead Scientist, at jay@sfei.org with questions or suggestions for improving this document.

Figure 3. Annual planning calendar for the Steering Committee.

Annual Steering Committee Calendar

- **January**
  - Approval of Multi-Year Plan
  - Review of incomplete projects from the previous year
- **April**
  - Multi-year Plan: Focus on selected element(s)
  - Plan for Annual Meeting
  - Additional guidance to workgroups
- **July**
  - Multi-year Plan: mid-year check-in, workshop planning
  - Decision on special studies recommended by the TRC for next year
  - Plan for Annual Meeting
  - Report on SFEI financial audit
  - Brief discussion of fees for year after next
- **October**
  - Confirm chair(s)
  - Planning Workshop
  - Decision on fees for the year after next
  - Approve Program Plan and detailed budget for next year
  - Approval of Pulse outline for next year
  - Decision on workshops to be held next year

Agendas and meeting summaries available at http://www.sfei.org/rmp/sc

CURRENT AND ANTICIPATED MANAGEMENT DECISIONS, POLICIES, AND ACTIONS BY THE REGULATORY AGENCIES THAT MANAGE BAY WATER QUALITY

Decisions, Policies, and Actions	Timing
ONGOING AND EXISTING	
Determination of Reasonable Potential and Permit Limits	Ongoing
Long-Term Management Strategy for Placement of Dredged Material/Dredged Material Management Office Regional Sediment Management Strategy	Ongoing
Dredging Permits Bioaccumulation testing triggers and in-Bay disposal levels	Annual
Biennial 303(d) List and 305(b) Report	2016
Copper Compare levels to site specific objectives triggers Evaluation of the site-specific objectives	Annual Triennial (2015)
Cyanide Compare levels to site specific objectives triggers Evaluation of the site-specific objectives	Annual Triennial (2015)
Selenium North Bay Selenium TMDL South Bay Selenium TMDL	2014 > 2015
Dioxins Review 303(d) listings and establish TMDL development plan or alternative	2018
Mercury Review existing TMDL and establish plan to revise	2018
PCBs Review existing TMDL and establish plan to revise	2020

Decisions, Policies, and Actions	Timing
NEW AND FUTURE	
Nutrients Nutrient Management Strategy Nutrient Water Quality Objective	 Ongoing 2024
Legacy Pesticides (DDT, Dieldrin, Chlordane) Delist	2016
Pathogens Review Bay beaches 303(d) listings and establish TMDL development plan	2015
Sediment Hot Spots Review 303(d) listings and establish TMDL development plan or alternative	2016
Chemicals of Emerging Concern Review of RMP strategy	Annual
Toxicity New state plan on effluent and receiving water toxicity	2014
Sediment Quality Objectives 303(d) listings	2016
BAY WATERSHED PERMITS	
Municipal Regional Stormwater Permit	2014, 2019
Mercury and PCBs Watershed Permit for Municipal and Industrial Wastewater	2017
Nutrient Watershed Permit for Municipal Wastewater	2014, 2019

RMP Goal and Management Questions

RMP stakeholders have articulated an overarching goal and a tiered framework of management questions that organize and guide RMP studies. The management questions are closely linked to existing and planned regulations.

Level 1 (Core) Management Questions

1. Are chemical concentrations in the Estuary potentially at levels of concern and are associated impacts likely?
2. What are the concentrations and masses of contaminants in the Estuary and its segments?
3. What are the sources, pathways, loadings, and processes leading to contaminant-related impacts in the Estuary?
4. Have the concentrations, masses, and associated impacts of contaminants in the Estuary increased or decreased?
5. What are the projected concentrations, masses, and associated impacts of contaminants in the Estuary?

Level 1 (Core) Questions	**Question 1** Levels of concern and associated impacts	**Question 2** Concentrations and masses (spatial distribution)	**Question 3** Sources, pathways, loadings, and processes	**Question 4** Increased or decreased (trends)	**Question 5** Projected concentrations, masses, and impacts
Level 2 Questions	Q1 Which chemicals have potential for impacts?	Q1 Are there particular regions of concern?	Q1 Which sources, pathways, etc. contribute most to impacts?	Q1 Effects of management actions on concentrations and mass?	Q1 Impacts forecast under various management scenarios?
	Q2 What is the potential for impacts due to contamination?		Q2 Opportunities for management intervention for important pathways?	Q2 Effects of management actions on potential for adverse impacts?	Q2 Which contaminants predicted to increase?
	Q3 What are appropriate guidelines?		Q3 Effects of management actions on loads and processes?		
	Q4 What contaminants are responsible for impacts?				

General Goal of the RMP

Collect data and communicate information about water quality in the San Francisco Estuary in support of management decisions.

Consistent with, these general goals, the RMP addresses NPDES permit provisions for special studies and routine monitoring of the Bay

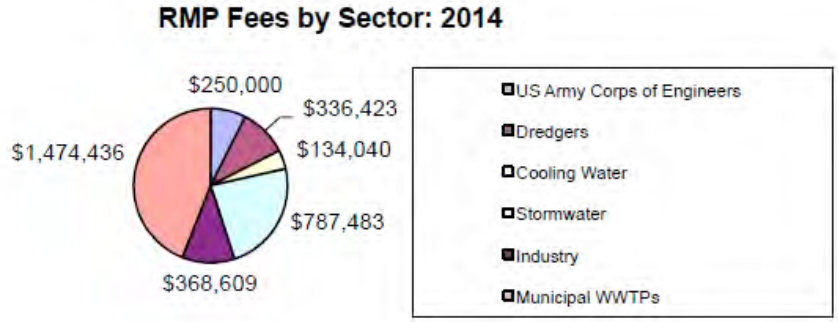
The following key criteria are used to evaluate potential RMP elements (in order of priority):

1) **addresses relevant NPDES permit requirements**
2) **supports policies and adaptive implementation**
3) **addresses scientific information needs**

BUDGET: Revenue – 2014

RMP fees were $2.99 million in 2005 and 2006, increased by 2% per year in 2007-2010, and were $3.24 million for 2010, 2011 and 2012. Fees increased by 1.5% in 2013, and will increase by 2% in 2014 and 2015.

RMP fees for 2014 are divided among the discharger groups as indicated. The proportion contributed by the Army Corps has decreased over the years as their contribution has stayed constant at $250,000 per year since 1993.



Year	Jun Bay Area CPI	% CPI Increase	Actual RMP Fee Increase	Basis	Target Fees
2005	201.2				$ 2,990,242
2006	209.1	3.9%	0.0%	Fixed %	$ 2,990,242
2007	216.1	3.3%	2.0%	Fixed %	$ 3,050,047
2008	225.2	4.2%	2.0%	Fixed %	$ 3,111,048
2009	225.7	0.2%	2.0%	Fixed %	$ 3,173,269
2010	228.1	1.1%	2.0%	Fixed %	$ 3,236,734
2011	233.6	2.4%	0.0%	Fixed %	$ 3,236,734
2012	239.8	2.7%	0.0%	Fixed %	$ 3,236,734
2013	245.9	2.5%	1.5%	Fixed %	$ 3,285,285
2014			2.0%	Fixed %	$ 3,350,991
2015			2.0%	Fixed %	$ 3,418,010
	AVERAGE	2.5%			
	22.2%	% INCREASE 2005-2013			9.9%

Data from ABAG: http://www.abag.ca.gov/planning/research/cpi.html

BUDGET: Expenses – 2014

Program Management, Contracts and Financial (page 31)	$ 567,722
Communications (page 32)	$ 297,378
Data Management and QA (page 33)	$ 167,613
Status and Trends (pages 28-30)	$ 1,390,235
Special Studies (pages 11-27)	$ 1,266,393
Direct Costs and Contingency	$ 185,000

Unencumbered Reserve

An unencumbered reserve of $200,000 is maintained to respond to unanticipated urgent priorities.

Unencumbered Funds

Higher than anticipated revenues and elimination or reduction of lower priority elements sometimes leads to accumulation of unencumbered funds ($532,000 as of January 2014, in addition to the $200,000 unencumbered reserve) that can be used for high priority topics at the discretion of the Steering Committee.

COORDINATION WITH OTHER ORGANIZATIONS AND PROGRAMS

Small Tributary Loads
- MRP cities, counties, and districts
- San Francisco Bay Water Board
- San Francisco Estuary Institute

Nutrients
- U.S. Geological Survey
- State Water Board
- San Francisco Bay Water Board
- Bay Area Clean Water Agencies
- Central Contra Costa Sanitation District
- Interagency Ecological Program
- State and Federal Contractors Water Agency
- San Francisco Estuary Institute

Forecasting
- U.S. Geological Survey
- Bay Area Clean Water Agencies
- San Francisco Estuary Institute

Emerging Contaminants
- State Water Board
- San Francisco Bay Water Board
- National Oceanic and Atmospheric Administration
- Southern California Coastal Water Research Project
- San Francisco Estuary Institute

Legacy Contaminants
- State Water Board (SWAMP)
- San Francisco Bay Water Board
- San Francisco Estuary Institute

Exposure and Effects
- State Water Board
- San Francisco Bay Water Board
- U.S. Environmental Protection Agency
- U.S. Army Corps of Engineers
- Bay Planning Coalition
- National Oceanic and Atmospheric Administration
- Southern California Coastal Water Research Project
- U.S. Geological Survey
- San Francisco Estuary Institute

Status and Trends
- U.S. Geological Survey
- State Water Board (SWAMP)
- San Francisco Bay Water Board
- Interagency Ecological Program
- San Francisco Estuary Institute

Communication
- San Francisco Estuary Partnership
- California Water Quality Monitoring Council
- San Francisco Estuary Institute

Data Management
- State Water Board (CEDEN)
- San Francisco Estuary Institute

RMP SPECIAL STUDIES: 2012-2018

RMP expenditures on special study topics. Figures for 2012-2014 are actual amounts. Figures for 2015 and beyond are estimates for planning. "Estimated annual total available for special studies" is what remains after projected amounts for program management and status and trends are accounted for. Funds from RMP Unencumbered Funds are often applied to special studies, but are not included in the projections for 2015-2018.

	Actual				Projected			
TOPIC	**2012**	**2013**	**2014**		**2015**	**2016**	**2017**	**2018**
Mercury	$0	$0	$0		$0	$0	$0	$0
PCBs	$0	$0	$0		$80,000	$160,000	$100,000	$100,000
Dioxins	$95,500	$0	$24,000		$40,000	$0	$0	$0
Emerging Contaminants	$117,000	$141,000	$183,000		$100,000	$100,000	$100,000	$100,000
Small Tributaries	$428,000	$468,000	$487,000		$475,000	TBD	TBD	TBD
Other SPL	$0	$0	$0		$0	$0	$0	$0
Exposure and Effects	$130,000	$114,000	$80,000		$50,000	TBD	TBD	TBD
Forecasting	$100,000	$100,000	$0		$0	$0	$0	$0
Selenium	$0	$0	$10,000		TBD	TBD	TBD	TBD
Nutrients	$150,000	$405,000	$520,000		$500,000	$470,000	$620,000	$720,000
ANNUAL TOTALS FOR SPECIAL STUDIES	**$1,020,500**	**$1,228,000**	**$1,304,000**		**$1,245,000**	**$730,000**	**$820,000**	**$920,000**
ESTIMATED ANNUAL TOTAL AVAILABLE FOR SPECIAL STUDIES					$1,028,589	$1,087,544	$1,100,836	$1,175,864
REMAINING					**-$216,411**	**$357,544**	**$280,836**	**$255,864**

TBD – To be determined through synthesis efforts and workgroup discussion.

Nutrient synthesis and monitoring, and **forecasting** of future scenarios for nutrients are high priorities. Characterization of **small tributary loads** of pollutant remains a high priority. Screening for and improving tools for monitoring **emerging contaminants** is also a continuing priority.

Small Tributary Loading

Note: "Small tributary" refers to the rivers, creeks, and storm drains that enter the Bay downstream from the Region 2 Water Board boundary (Mallard Island).

Relevant Management Policies and Decisions

- Refine pollutant loading estimates for future TMDLs and management decisions, including TMDL updates.
- Provisions of the Municipal Regional Permit (MRP).
- Prioritizing small tributaries for cleanup actions.
- Identifying the best management actions for small tributaries.

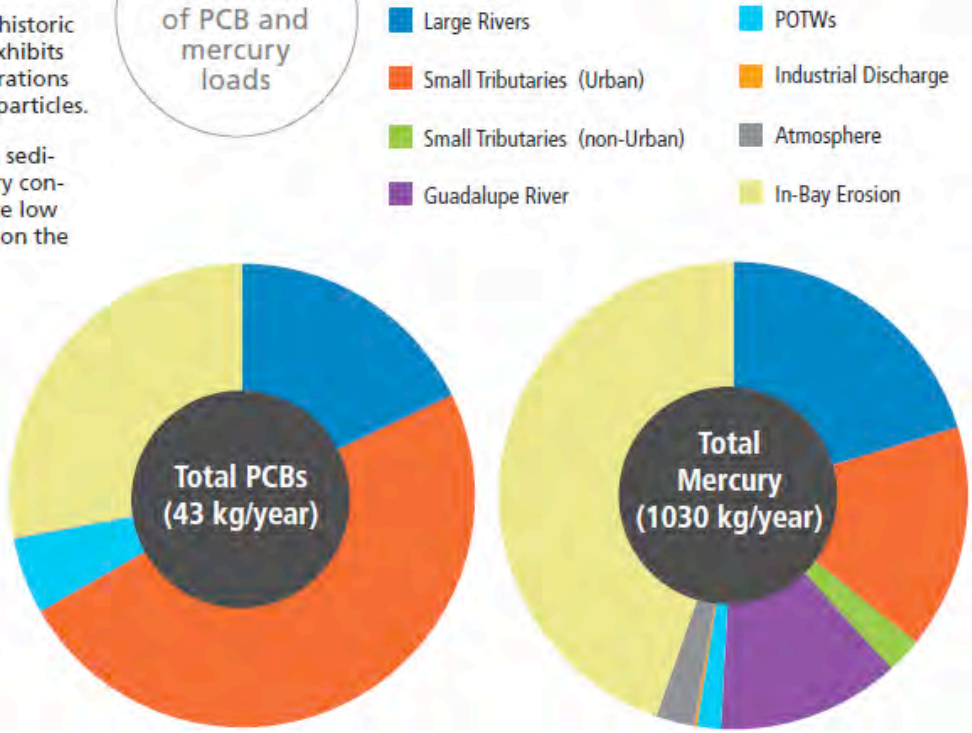
Recent Noteworthy Findings

- Small tributaries are the dominant loading pathway for suspended sediments, PCBs, and mercury.
- Mercury loads in stormwater are primarily associated with suspended sediment particles and most pollutant mass enters the Bay during the largest storms.
- Older urban systems exhibit moderate PCB concentrations in water and moderately high PCB concentrations on sediment particles.
- PCB concentrations vary more widely in stormwater and soil samples relative to mercury.
- PCBs in stormwater are commonly associated with suspended sediment particles, and in very contaminated watersheds may also occur as an emulsion.
- PCBs are associated with small areas with highly polluted soils within our watersheds – finding such areas is a challenge.
- Dioxin loads measured in two tributaries suggest a regional load estimate of 8.9 g of dioxin toxic equivalents. Concentrations appear to be highest in industrialized urban areas.
- Just six stormwater samples were used to identify Pulgas Creek and Santa Fe Channel as high leverage watersheds in relation to pollutant sources and sensitive Bay margin areas.
- The Guadalupe River with historic mercury mines upstream exhibits very high mercury concentrations in water and on sediment particles.
- Walnut Creek with its high sediment load has high mercury concentrations in water despite low concentrations of mercury on the sediment particles.

Priority Questions for the Next Five Years

1. Which are the "high-leverage" small tributaries that contribute or potentially contribute most to Bay impairment by pollutants of concern?
2. What are the loads or concentrations of pollutants of concern from small tributaries to the Bay?
3. How are loads or concentrations of pollutants of concern from small tributaries changing on a decadal scale?
4. What are the projected impacts of management actions on loads or concentrations of pollutants of concern from the high-leverage small tributaries, and where should management actions be implemented in the region to have the greatest impact?

The latest estimates of PCB and mercury loads



SMALL TRIBUTARIES LOADING STRATEGY

Monitoring loads from representative watersheds will be the major emphasis for the next several years. Monitoring of representative source characterization sites will provide data needed for model development in subsequent years. This work will be closely coordinated with and substantially augmented by MRP monitoring.

Small tributaries loading studies in the RMP from 2011 to 2016. Numbers indicate budget allocations in $1000s.

Task ID	Funder	Task Description	2011	2012	2013	2014	2015	2016
0	RMP	**Coordination and management**			20	25	40	TBD
1		**Watershed and Associated Bay Modeling**						
1A		Regional Watershed Spreadsheet Model						
1A.1	RMP	Phase I – Water, Sediment, PCBs and Mercury	20	20	25	30	35	TBD
1A.1	BASMAA	Phase I – Sediment		33		(32)		
1A. 2	RMP	Phase II – Other Pollutants of Concern						
1A.2	BASMAA	Phase II– PBDE, DDT, chlordane, dieldrin		35		(20)		
1A.3	RMP	Phase III – Periodic Updates					TBD	TBD
1B	RMP	Coordination with Bay Margins Modeling						
1C	TBD	HSPF dynamic modeling					TBD	TBD
2	RMP	**Source Area Monitoring / EMC Development**	20	80	80	80	TBD	TBD
3		**Small Tributaries Monitoring**						
3.1	BASMAA	Multi-Year Plan Development	15					
3.2	BASMAA	Standard Operating and Quality Assurance Procedures	55					
3A	RMP	Monitor Two Representative Small Tributaries	300	328	343	352	400	TBD
3AB.1	BASMAA	Monitor Two to Four Representative Small Tributaries or Sites Downstream of Management Actions	255	510	(480)	(480)	TBD	TBD
3AB.2	BASMAA	Lab Analyses, Quality Assurance, Data Management	183	316	(320)	(320)	TBD	TBD
4	RMP	**Reporting, Stakeholder Admin, Adaptive Updates**	41					
	BASMAA	**Data Analysis, Communications, Administration**	45	84	(85)	TBD	TBD	TBD
RMP Total			**381**	**428**	**468**	**487**	**TBD**	TBD
BASMAA Total		**Task 1**		**28**		**TBD**	TBD	TBD
		Tasks 2-4	**558**	**910**	**885**	**TBD**	TBD	TBD
Total			**934**	**1,366**	**1,403**	**TBD**	**TBD**	TBD

Nutrients

Relevant Management Policies and Decisions

Primary

- Nutrient numeric endpoints
- Evaluate need for revised objectives for dissolved oxygen (DO) and ammonia
- Water quality assessment – impairment status
- NPDES permits (e.g., POTW, MRP) - on-going

Secondary

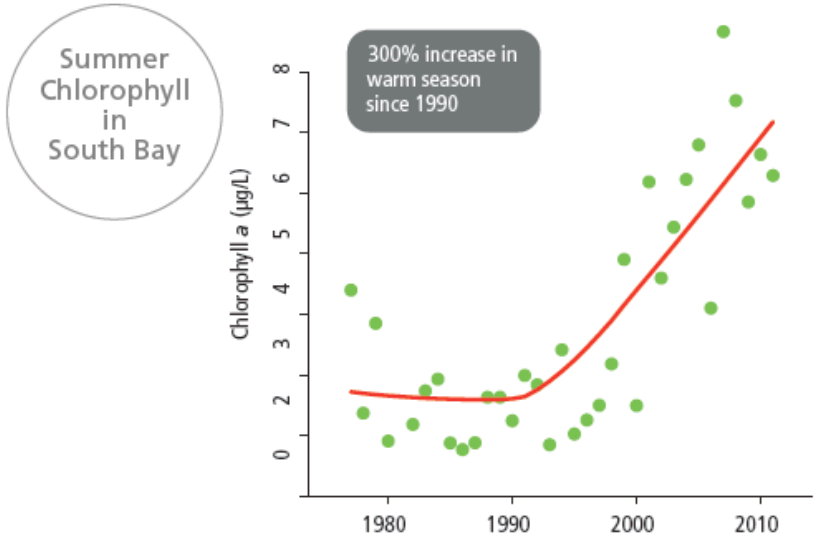
- Delta Flows
- Regional Sediment Strategy
- Watershed TMDLs
- Recycled Water Policy and POTW projects

Recent Advances in Understanding and Priority Information Needs

- There is a growing body of evidence that suggests the historic resilience of San Francisco Bay to the harmful effects of nutrient enrichment is changing.
- Since the late 1990s, regions of the Bay have experienced significant increases in phytoplankton biomass (30-105% from Suisun to South Bay) and significant declines in DO concentrations (2.0 and 4.0% in Suisun Bay and South Bay, respectively).
- USGS has found declining suspended sediment in the Bay – however, no data are available for shallow subtidal regions.
- There is a need for long-term status and trends monitoring of nutrients and eutrophication.
- At present, Bay water quality objectives related to nutrients are limited to un-ionized ammonia and dissolved oxygen.
- There are outstanding questions about the role and importance of ammonium with respect to beneficial use impairment.

Priority Questions for the Next Five Years

1. Is there a problem or are there signs of a problem?
   a. Are anthropogenic nutrients currently, or trending towards, adversely affecting beneficial uses of the Bay?
   b. Are beneficial uses in segments of the Bay impaired by any form of nutrients?
   c. Are trends spatially the same or different in the segments of the Bay?
2. What are appropriate guidelines for assessing the Bay's health with respect to nutrients and eutrophication?
3. Which nutrient sources, pathways, and transformation processes contribute most to concern?
   a. What is the relative contribution of each loading pathway (POTW, Delta, urban stormwater runoff, non-point sources, etc.) to the Bay overall and the Bay's key sub-systems, and how do these loads vary seasonally?
   b. What is the contribution of nutrient regeneration (benthic fluxes) from sediments and denitrification/nitrogen fixation to Bay nutrient budgets?
4. What nutrient loads can the Bay assimilate (without impairment of beneficial uses)?
5. What future impairment is predicted for nutrients in the Bay?



NUTRIENT STRATEGY

Five-Year Goals for Nutrient Strategy

1) Document our current understanding of nutrient dynamics in the Bay, highlighting what is known and the crucial questions that need to be answered
2) Implement a monitoring program that supports regular assessments of the Bay, and characterizes/quantifies key internal processes that exert important influence over the Bay's response to nutrient loading
3) Establish guidelines (water quality objectives; i.e., assessment framework) for eutrophication and other adverse effects of nutrient overenrichment, if needed
4) Quantify nutrient loads to and important processes in the Bay
5) Establish a modeling strategy to support decisions regarding nutrient management for the Bay

The Nutrient Science Strategy for the Bay is a collaborative effort with major contributions from RMP, USGS, the State and Regional Boards, BACWA, and hopefully others. Funding and oversight are provided by these multiple organizations. Multiagency collaboration is essential to address the information needs for nutrients in the Bay.

Nutrient studies in the Bay from 2011 to 2018. Numbers indicate budget allocations in $1000s.

Element	Funding Agency	Questions Addressed	2011	2012	2013	2014	2015	2016	2017	2018
Coordination and Management	RMP	1-5	20	10	20	20	20	20	20	20
	SWRCB	1-5	15	5			TBD	TBD	TBD	TBD
	BACWA	1-5	10	135	135	75+TBD	?150?	?150?	?150?	?150?
Conceptual Model	RMP	1-5		80	50		30			
Nutrient Loads and Data Gaps	RMP	3		20	30					
Synthesis: Suisun Bay, Lower South Bay, other	BACWA			100	100	100+TBD	TBD	TBD	TBD	
Science Plan Develop: V1,V2…	BACWA				15	15	TBD	TBD	TBD	TBD
	SFBRWQCB					100				
	RMP						TBD	TBD	TBD	
Assessment (NNE)	SFBRWQCB	2		60***	155***	100***	TBD	TBD	TBD	TBD
	BACWA						TBD	TBD	TBD	TBD
Monitoring: ship-based *S&T (USGS, Cloern)*	*RMP*	*1,3*	*110*	*110*	*110*	*172*	*223*	*223*	*223*	*223*
	USGS[2]	1	400	400	470	TBD	TBD	TBD	TBD	TBD
	IEP			?(>500k)	?(>500k)	?(>500k)	?(>500k)	?(>500k)	?(>500k)	?(>500k)
	BACWA						TBD	TBD	TBD	TBD
Monitoring: Moored Sensor	RMP				200	215	300	350	400	500
	BACWA				75	75+TBD	TBD	TBD	TBD	TBD
	USGS+DWR			?(>500k)	?(>500k)	?(>500k)	?(>500k)	?(>500k)	?(>500k)	?(>500k)
Monitoring Special Studies: Algal Biotoxins	RMP				65					
	other					TBD	TBD	TBD	TBD	TBD
Monitoring Special Studies: Phytoplankton composition	BACWA				60	60+TBD	?150?	TBD	TBD	
Monitoring: Suisun Bay	SFBRWQCB	1	100	110	?	TBD	TBD	TBD	TBD	TBD
Monitoring: Progr. Development, management	SWRCB	1,3		10	20	20				
includes science planning (e.g., data analysis) and institutional/financial planning, program spin-up, and management + interpretation/reporting	RMP					50	50	50	150	150
	BACWA				35	40+TBD	?200?	?200?	?150?	?150?
Management and load reduction options, cost/benefit	BACWA									
POTW and refinery effluent characterization	Dischargers, BACWA	3		200	300	200	TBD	TBD	TBD	TBD

Element	Funding Agency	Questions Addressed	2011	2012	2013	2014	2015	2016	2017	2018
Data analysis	BACWA				15	TBD	TBD	TBD	TBD	TBD
Stormwater nutrient load monitoring	RMP	3		30	40	35	TBD	TBD	TBD	TBD
Modeling*	RMP	4,5		100	100	200	100	50	50	50
	BACWA	4,5				?150?	?400?	?450?	?450?	?450?
Delta loads to Suisun	IEP	3			90	90	TBD	TBD		
Phytoplankton growth (Suisun)	IEP, SFCWA	1,3,4			100	100				
	other						TBD	TBD		
General Allocation	RMP						TBD	TBD	TBD	TBD
		RMP Nutrients	**20**	**140**	**405**	**320**	**400**	**420**	**570**	**670**
		RMP Forecasting		**100**	**100**	**200**	**100**	**50**	**50**	**50**
		RMP S&T Monitoring	**110**	**110**	**110**	**172**	**223**	**681**	**677**	**900**
		RMP Total	**130**	**350**	**505**	**520**	**TBD**	**TBD**	**TBD**	**TBD**
		SWRCB Total	**15**	**15**	**40**	**TBD**	**TBD**	**TBD**	**TBD**	**TBD**
		SFBRWQCB Total	**100**	**170**	**155**	**200**	**TBD**	**TBD**	**TBD**	**TBD**
		BACWA Total	**10**	**235**	**450**	**340 + TBD**	**TBD**	**TBD**	**TBD**	**TBD**
		IEP Total			**140+?**	**140+?**	**?>500k?**	**?>500k?**	**?>500k?**	**?>500k?**
		SFCWA Total			**50+?**	**50+?**	**TBD**	**TBD**	**TBD**	**TBD**
		Dischargers		**200**	**300**	**200**	**TBD**	**TBD**	**TBD**	**TBD**
		USGS Total	**400**	**400**	**470+?**	**TBD**	**TBD**	**TBD**	**TBD**	**TBD**
		Overall Total	**555**	**880**	**TBD**	**TBD**	**TBD**	**TBD**	**TBD**	**TBD**

***** joint with RMP Forecasting Strategy ****** $110K to USGS, $30K for stormwater loads ******* Anticipated
TBD – To be determined.
[1] Forecasted for BACWA

Forecasting (Modeling)

Relevant Management Policies and Decisions

- NPDES permits for nutrients
- The next iteration of the mercury and PCBs TMDLs
- Potential TMDLs for other contaminants
- Priorities for cleaning up local watersheds and contaminated margin sites
- Identifying best options for management actions to reduce impairment

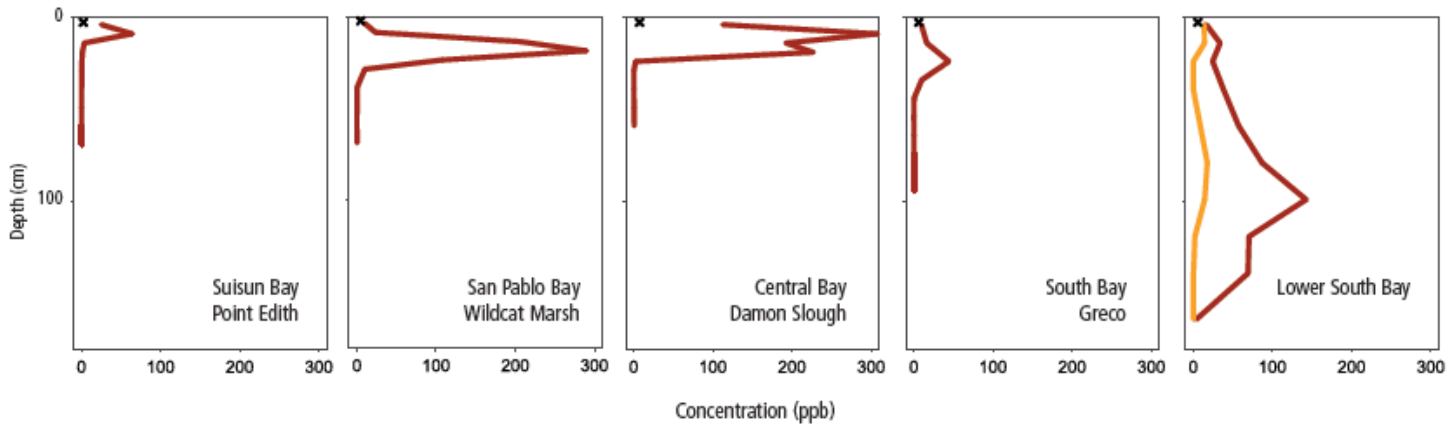
Recent Noteworthy Findings

- Sediment cores from open-water sites exhibited total mercury and PCB concentrations in deeper sediments that were generally similar to surface sediments, suggesting diminished concern for prolonged recovery due to erosion of contaminated subsurface material.
- Sediment cores from wetland sites showed wide fluctuations with peak concentrations of mercury and PCBs corresponding to approximately 1960. The wetland cores are subject to minimal mixing, and thus preserve a signal of past variation in loading and concentrations in the Bay.

Priority Questions for the Next Five Years

1. What patterns of exposure are forecast for major segments of the Bay under various management scenarios?
2. What is the contribution of contaminated Bay margins to Bay impairment?
3. What are the projected impacts of Bay margin management actions to Bay recovery?

PCBs in Wetland Cores



Sediment cores from Bay tidal marshes provide a clear picture of trends over time because of the consistent deposition and lack of vertical mixing in the marsh environment. Six wetland cores examined by RMP document drastic decreases in PCB concentrations since the 1960s. In Wildcat Marsh, for example, concentrations dropped from a maximum of 290 ppb at a depth of 19 cm to 10 ppb at a depth of 4 cm, a 97% decrease. These wetland cores document a major reduction in loads from local watersheds and in concentrations in the Bay.

FORECASTING (MODELING)

The ultimate goal of the Forecasting Strategy is to predict recovery of contaminated Bay regions and sites under different management scenarios. Efforts in the next few years will focus on modeling nutrients.

Forecasting studies in the RMP from 2010 to 2018. Numbers indicate budget allocations in $1000s.

Element	Funding Agency	Forecasting Questions Addressed	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Margins Conceptual Model	RMP	1,2,3	40									
Bioaccumulation Conceptual Model	RMP	1,2,3		40								
Bay Modeling*	RMP	1,2,3				100	100	200	100	50	50	50
	BACWA	1,2,3				TBD	TBD	TBD	TBD	TBD	TBD	TBD
RMP Total			**40**	**40**	**0**	**100**	**100**	**200**	**100**	**50**	**50**	**50**
Non-RMP Total					**0**	**0**	**0**	**TBD**	**TBD**	**TBD**	**TBD**	**TBD**
Overall Total			**40**	**40**	**0**	**100**	**100**	**TBD**	**TBD**	**TBD**	**TBD**	**TBD**

***** joint with Nutrient Strategy TBD – To be determined through synthesis efforts and workgroup discussion.

Emerging Contaminants

Relevant Management Policies and Decisions

- Development of State Water Board Policy on CECs in freshwater, coastal, and marine ecosystems
- Regional Water Board policy
- State Water Board Toxicity Policy
- Narrative water quality objectives prohibiting toxicity and water quality degradation

Recent Noteworthy Findings

- Perfluorinated chemicals in bird eggs are high relative to other locations that have been studied and in South Bay exceed a published health risk threshold.
- Triclosan was detected in sediment at seven out of ten sites with concentrations ranging from 5-10 ppb in the Central and South Bay, and a maximum of 40 ppb. Sediment toxicity thresholds are not available, but these concentrations may be of some concern.
- A screening study of alternative flame retardants generally found low concentrations. Some phosphate-based chemicals are present in sediment at levels comparable to PCBs and PBDEs; work is underway to determine if they accumulate in biota.
- A screening study of pharmaceuticals and personal care products generally found concentrations well below available acute and chronic toxicity thresholds.
- Chlorinated paraffin concentrations in the Bay also are low relative to other ecosystems.
- A small screening study (6 samples from 4 locations) in 2009 found nonylphenol concentrations in small fish ranging from 50 to 420 ppb, similar to other estuaries in California.

Priority Questions for the Next Five Years

1. What emerging contaminants have the greatest potential to adversely impact beneficial uses in the Bay?

Xx Delete "greatest"

Conceptual tiered risk and management action framework for San Francisco Bay. The rankings continually evolve as new information becomes available.

EMERGING CONTAMINANTS

Emerging contaminant studies in the RMP have been augmented substantially by coordination and pro bono work. Completion of a two-year study developing a bioanalytical screening tool is a highlight for 2013-2014.

Emerging contaminant studies and monitoring in the RMP from 2008 to 2018. Numbers indicate budget allocations in $1000s. Matching funds and source indicated in parentheses. CDFO-Canada Department of Fisheries and Oceans; MMC-Marine Mammal Center; NIST-National Institute of Standards and Technology.

Element	Questions Address-ed	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Perfluorinated Compounds	1	35	52			87		TBD	TBD	TBD	TBD	TBD
Alternative Flame Retardants	1	48						107	TBD	TBD	TBD	TBD
Chlorinated Paraffins in Biota (CDFO)	1	0 (5)										
Triclosan in Sediment (USEPA)	1	0 (5)										
White Paper on ECs in Wastewater	1		30									
Nonylphenol in Small Fish (Cal Poly)	1		0 (2)									
AXYS Brominated Dioxins in Sediments and Biota (AXYS)	1			0(18)								
Broadscan Screening of Biota for EC (NIST, SCCWRP, MMC, SDSU)	1			55 (75)	70 (75)				TBD	TBD	TBD	TBD
AXYS Mussel Study (AXYS)	1			27 (33)								
NOAA Mussel Pilot Study (NOAA, SCCWRP, SWRCB)	1			33 (50)								
EC Synthesis, Strategy Development	1				30	30	20	20	20	20	20	20
Bioanalytical Tools	1						70	56	TBD	TBD	TBD	TBD
PBDE Synthesis	1						36					
Current Use Pesticides	1						15		TBD	TBD	TBD	TBD
EC Strategy Implementation	1								TBD	TBD	TBD	TBD
Nanoparticles (Duke Univ.)	1			0 (5)					TBD	TBD	TBD	TBD
General Allocation	1								80	80	80	80
RMP Total		**83**	**82**	**115**	**100**	**117**	**141**	**246**	**TBD**	**TBD**	**TBD**	**TBD**
Non-RMP Total		**10**	**2**	**176**	**75**	**0**	**0**	**0**	**TBD**	**TBD**	**TBD**	**TBD**
Overall Total		**93**	**84**	**291**	**175**	**117**	**141**	**246**	**TBD**	**TBD**	**TBD**	**TBD**

Gray cells – further work on this topic not anticipated
Possibilities: additional work on flame retardants, broadscan followup

Exposure and Effects

Relevant Management Policies and Decisions

- Implementation of sediment quality objectives
- The next iteration of the mercury TMDL
- Permitting decisions regarding dredging projects
- Continued implementation of narrative water quality objective prohibiting toxicity

Recent Noteworthy Findings

- In every year since RMP sampling began in 1993, 26% or more of sediment samples have been determined to be toxic to one or more test species. The causes of this toxicity remain unidentified.
- Studies have indicated that mercury is impairing hatchability of Forster's tern eggs in San Francisco Bay, but that the reduction of nest success at the TMDL bird egg monitoring target of 0.5 ppm is less than 10%.
- A study examining possible endocrine responses in shiner surfperch and staghorn sculpin found hormonal imbalances that appeared to be related to PCB exposure.
- Tern embryos are less sensitive to PBDE exposure than the most sensitive species studied (American Kestrel). Effects on tern embryos at the concentrations found in the Bay do not appear likely.

Priority Questions for the Next Five Years

Effects on Benthos

1. What are the spatial and temporal patterns of impacts of sediment contamination?
2. Which pollutants are responsible for observed impacts?
3. Are the toxicity tests, benthic community assessment approaches, and the overall SQO assessment framework reliable indicators of impacts?

Effects on Fish

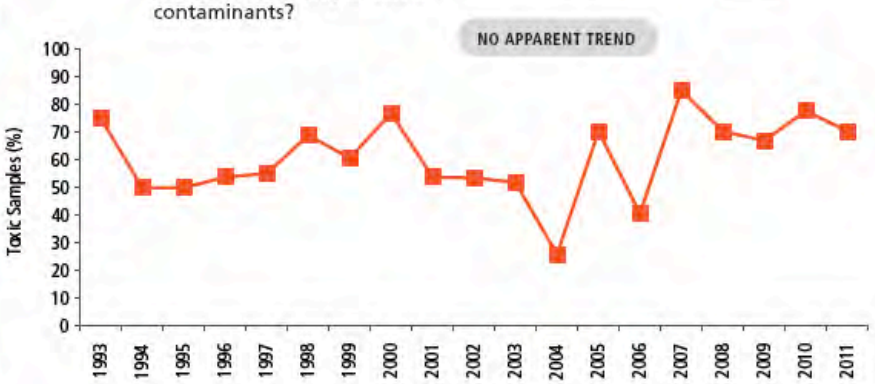
4. Are pollutants, individually or in combination, reducing the reproductive ability, growth, and health of sensitive fish populations?
5. What are appropriate thresholds of concern for contaminant concentrations for Bay species?
6. What are cost-effective indicators for monitoring effects of contaminants?

Effects on Birds

7. Is there clear evidence of pollutant effects on survival, reproduction, or growth of individual birds?
8. Are pollutants in the Bay adversely affecting bird populations?
9. What are appropriate guidelines for protecting bird populations that are at risk?
10. Do spatial patterns in accumulation indicate particular regions of concern?

Sorting benthos.
Photograph by Ellen Willis-Norton

Percent Toxic Sediment Samples



EXPOSURE AND EFFECTS

Studies to address information needs relating to dredged material testing are a priority for 2014.

Exposure and effects studies and monitoring in the RMP from 2008 to 2014. Numbers indicate budget allocations in $1000s.

	Element	Questions Addressed	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Benthos	Benthic Assessment Tools	3	20	25	30		50	76				
	Causes of Sediment Toxicity: TIEs and LC50 Work	2	10	80								
	Causes of Sediment Toxicity: Molecular TIEs	2			60							
	Causes of Sediment Toxicity: Moderate Toxicity Strategy	2,3					50		30	TBD	TBD	TBD
	USEPA Water Quality Synthesis (National Coastal Condition Assessment) (USEPA)	1,3				(100)	(50)					
	Hotspot Followup Study	1,2,3				60	30			50	TBD	TBD
	Reference Site, Benthos Recovery After Dredging	1							50			
Fish	Endocrine Disruption in Fish	4,6	35									
	Effects of PAHs on Flatfish (NOAA)	4,5,6	40	50								
	Effects of Copper on Salmon (NOAA)	4,5				37		(38)				
Birds	Mercury and Selenium Effects on Terns (USGS)	7,8,9,10	75	54								
	PBDEs: Sensitivity in Terns	8			48							
RMP Total			**179**	**209**	**138**	**97**	**130**	**76**	**80**	**TBD**	**TBD**	**TBD**
Non-RMP Total			**0**	**0**	**0**	**100**	**50**	**38**	**TBD**	**TBD**	**TBD**	**TBD**
Overall Total			**179**	**209**	**138**	**197**	**180**	**114**	**TBD**	**TBD**	**TBD**	**TBD**

Gray cells – further work on this topic not anticipated

Mercury

Relevant Management Policies and Decisions

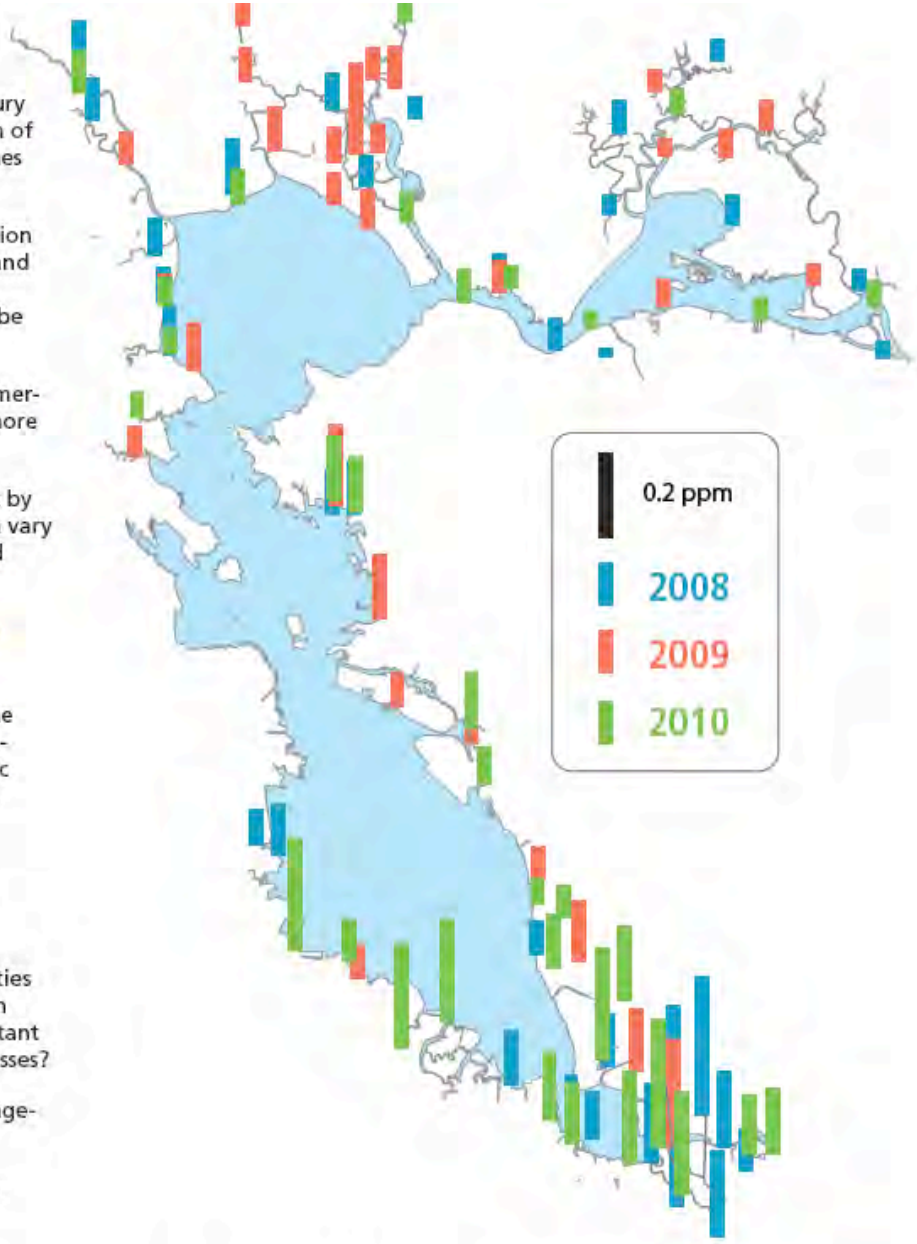
- Review new information and prepare plan to update the current mercury TMDL and implementation plan
- The next iteration of the mercury TMDL
- Identifying best options for management actions to reduce mercury impairment

Recent Noteworthy Findings

- The median mercury concentration in striped bass in 2009 was 0.44 ppm, higher than the TMDL target of 0.20 ppm. Concentrations have shown no decline since 1970.
- Monitoring of mercury in small fish indicates that a high proportion (85% in 2008-2010) of samples was above the 0.03 ppm TMDL target for wildlife prey.
- The small fish monitoring also indicates that concentrations are relatively high in the Lower South Bay region.
- Based on mercury concentrations in blood, nearly 60% of all breeding Forster's Terns sampled in the Bay are at high risk of toxic effects.
- Sediment cores suggest extensive transport and mixing of past loads and diminished concern for erosion of contaminated subsurface material.
- A mass budget for methylmercury indicates that in-Bay production of methylmercury is about 100 times greater than external loading.
- Source control (principally erosion of mining waste, stormwater, and wastewater) is being pursued but will take many decades to be effective.
- Control of internal net methylmercury production may achieve more rapid reductions.
- Opportunities for reducing risk by controlling internal production vary by habitat (open Bay, managed pond, tidal marsh).

Priority Questions for the Next Five Years

1. Where is mercury entering the food web? – we may have answered this sufficiently – topic for Strategy Team discussion.
2. Which processes, sources, and pathways contribute disproportionately to food web accumulation?
3. What are the best opportunities for management intervention for the most important pollutant sources, pathways, and processes?
4. What are the effects of management actions?
5. Will total mercury reductions result in reduced food web accumulation?



Mercury concentrations (ppm) in silverside from 2008-2010.

MERCURY

The Mercury Strategy began with a multi-year suite of studies in 2008. The synthesis completed in 2012 led to a focus on reducing methylmercury production in tidal marsh restoration projects and salt ponds.

Mercury and methylmercury studies and monitoring in the RMP from 2008 to 2017. Numbers indicate budget allocations in $1000s.

General Area	Element	Mercury Questions Addressed	2008	2009	2010	2011	2012	2013	2014	2015	2016	20
Mercury Strategy	Methylmercury Synthesis	1,2,3,4,5				75						
	Food Web Uptake (Small Fish) (Status and Trends)	1,4	150	150	150	20				TBD	TBD	TE
	High Leverage Pathways (DGTs)	2	58	58								
	High Leverage Pathways (Isotopes)	2,5	40	40								
	Methylmercury Fate Model	3,4		25								
	Methylmercury in Marshes and Salt Ponds	1,3,4					25					
RMP Total			248	273	150	95	25	0	0	TBD	TBD	TE
Non-RMP Total			0	0	0	0	0	0	0	TBD	TBD	TE
Overall Total			248	273	150	95	25	0	0	TBD	TBD	TE

PCBs

Relevant Management Policies and Decisions

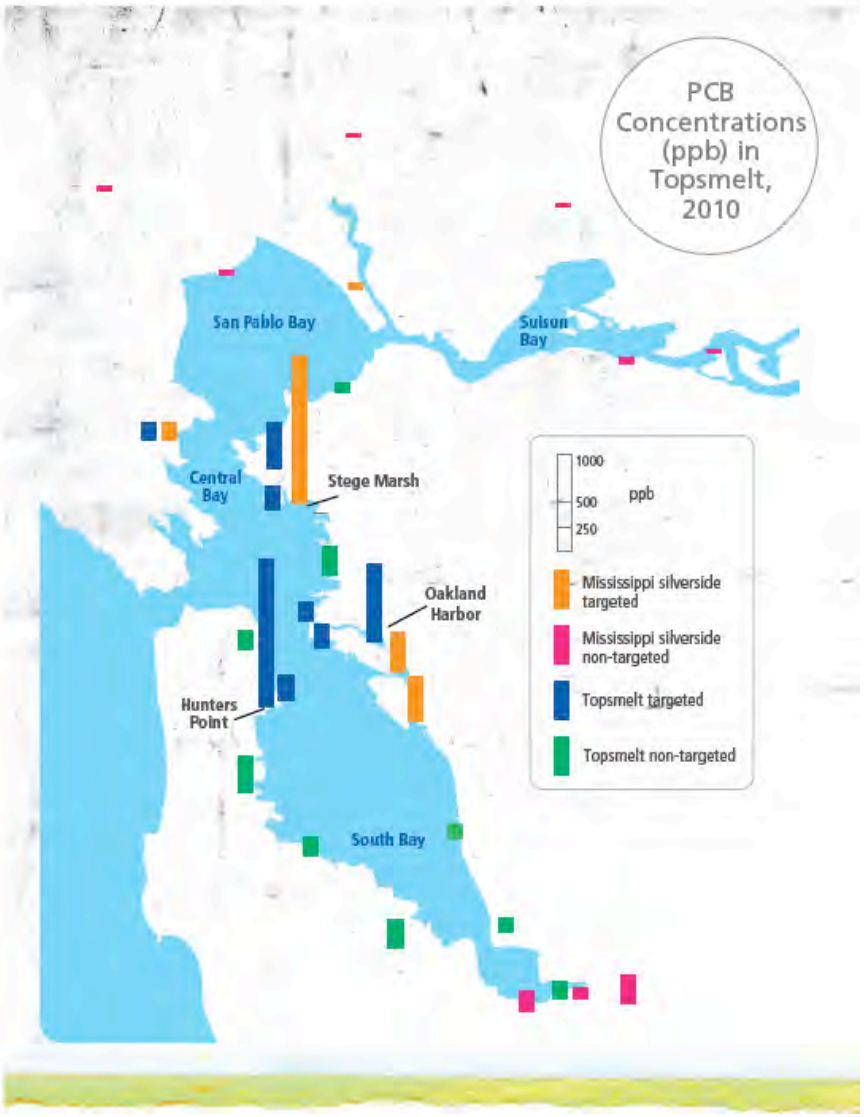
- Review new information and prepare plan to update the current TMDL
- The next iteration of the PCBs TMDL
- What management actions are the best options for reducing PCB impairment?

Recent Noteworthy Findings

- Sport fish were lower on a wet weight basis in the most recent sampling (2009), though on a lipid weight basis concentrations were comparable to past sampling rounds.
- Risks to fish-eating birds persist. In 2000-2003, 17% of 149 tern eggs were above an effects threshold.
- Small fish accumulate high concentrations of PCBs that correlate with concentrations in sediment.
- Bivalve monitoring continues to indicate declines, with half-lives ranging among stations from 7 to 14 years, and longer half-lives in the South Bay.
- Bay sediment appears to be cleaner than in the 1990s. The Bay-wide average was 7.0 ppb in 2004-2009 compared to 31 ppb in the 1990s. A different sampling design and different methods probably contribute to this apparent decrease.
- Average concentrations in Suisun Bay sediments are lower than in the other Bay segments.
- Bay cores show some areas with higher concentrations at depth, but this is less of a concern than previously thought.
- A new PCB has been identified in effluents and the environment across the U.S. PCB 11 and several other PCBs are inadvertent by-products in the manufacturing of commonly used pigments. These pigment PCBs are distinct from the Aroclor-derived PCBs that are the subject of the PCBs TMDL.

Priority Questions for the Next Five Years

1. What potential for impacts on humans and aquatic life exists due to PCBs?
2. What are appropriate guidelines for protection of beneficial uses?
3. What is the total maximum daily load of PCBs that can be discharged without impairment of beneficial uses?
4. What are the rates of recovery of the Bay, its segments, and in-Bay contaminated sites from PCB contamination?
5. What are the present loads and long-term trends in loading from each of the major pathways?
6. What role do in-Bay contaminated sites play in segment-scale recovery rates?
7. Which small tributaries and contaminated margin sites are the highest priorities for cleanup?
8. What management actions have the greatest potential for accelerating recovery or reducing exposure?
9. What is the most appropriate index for sums of PCBs?



PCBs

Studies under the PCB Strategy began in 2010. A synthesis completed in 2014 will set the stage for a multi-year study plan for 2015 and beyond.

PCB studies and monitoring in the RMP from 2010 to 2017. Numbers indicate budget allocations in $1000s.

Element	PCB Questions Addressed	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Food Web Uptake (Small Fish)	1,7	50					TBD	TBD	TBD	TBD	TBD
PCB Conceptual Model Update	1,2,3,4,5,6,7,8,9		53								
Priority Margin Site Conceptual Models							40	60			
Priority Margin Site Monitoring							40	100	100	100	100

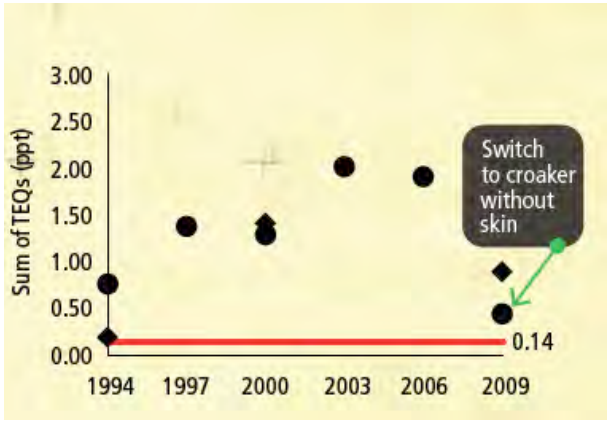
DIOXINS

Relevant Management Policies and Decisions

- Reissue permit requirements in 2013-2014
- Review 303(d) listings
- Establish TMDL development plan in 2013-2014

Recent Noteworthy Findings

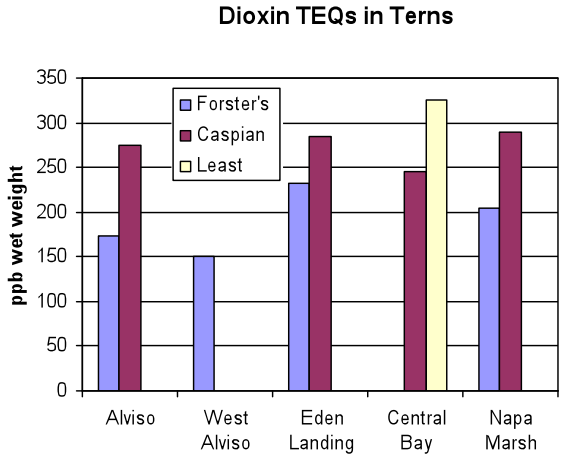
- The key sport fish indicator species (shiner surfperch and white croaker) have been higher than the Water Board screening value of 0.14 ppt and show no sign of decline, but there is a great deal of uncertainty regarding the human health risk associated with dioxins in sport fish.
- Dioxin-toxic equivalents in Least Tern, Caspian Tern, and Forster's Tern eggs are at or above estimated thresholds for adverse effects; risks especially significant in combination with dioxin-like PCBs.
- Few data on dioxins are available on other priority questions – the Dioxin Strategy was developed to address this need.
- Recent wetland cores suggest rapidly declining inputs from local watersheds during recent decades, though additional coring data are needed to support this hypothesis



Dioxin and furan TEQ concentrations (ppt) in white croaker (circles) and shiner surfperch (diamonds). Baywide averages.

Priority Questions for the Next Five Years

1. Are the beneficial uses of San Francisco Bay impaired by dioxins?
2. What is the spatial pattern of dioxin impairment?
3. What is the dioxin reservoir in Bay sediments and water?
4. Have dioxin loadings/concentrations changed over time?
5. What is the relative contribution of each loading pathway as a source of dioxin impairment in the Bay?
6. What future impairment is predicted for dioxins in the Bay?



Mean concentrations of dioxin and furan TEQs in three tern species, 2000-2003. Mean concentrations for the California Least Tern fall within the effects threshold range. Concentrations within the effects threshold range were observed in some eggs of all species. From Adelsbach and Maurer (2007).

DIOXINS

Dioxin studies and monitoring in the RMP from 2008 to 2017. Numbers indicate budget allocations in $1000s. Unlike the other contaminants, dioxin costs have generally been itemized explicitly as add-ons to RMP studies.

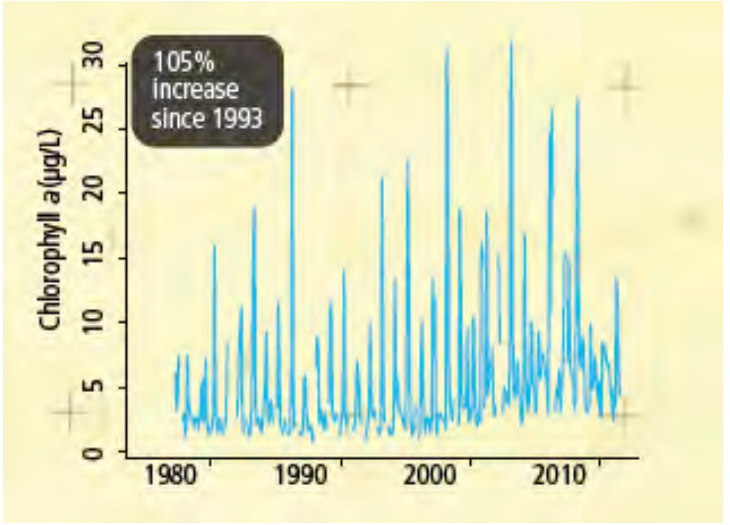
Dioxin Strategy studies began in 2008, with a multi-year plan extending through 2013. Synthesis activities are planned for 2015 after the data from the earlier studies are available.

General Area	Element	Dioxin Questions Addressed	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Dioxin Strategy	Quality Assurance	1,2,3,4,5,6		14						TBD	TBD	TBD
Status and Trends	Sport Fish	1,2,4		22					24	TBD	TBD	TBD
	Avian Eggs	1,2,4					13			TBD	TBD	TBD
	Surface Sediments	2,3		58	58					TBD	TBD	TBD
	Water	2,3		26		26				TBD	TBD	TBD
Loads	Small Tributary Loading	4,5,6			65		52			TBD	TBD	TBD
	River Loading (THg)	4,5,6			34					TBD	TBD	TBD
Forecast	Sediment Cores	3,4,6			57					TBD	TBD	TBD
	Synthesis: One-Box Model	3,4,5,6								20	TBD	TBD
	Synthesis: Food Web Model	5,6								20	TBD	TBD
Loads	Atmospheric Deposition	5,6			20					TBD	TBD	TBD
RMP Total			0	120	234	26	65	0	TBD	TBD	TBD	TBD
Non-RMP Total			0	0	0	0	0	0	TBD	TBD	TBD	TBD
Overall Total			0	120	234	26	65	0	TBD	TBD	TBD	TBD

STATUS AND TRENDS

Relevant Management Decisions

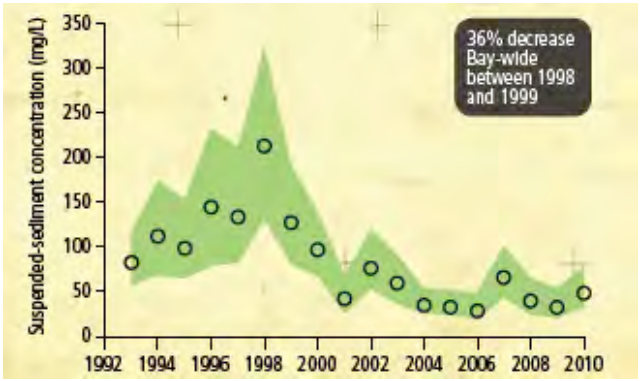
- Revision of Mercury and PCB TMDLs in 2016-2020
- Development of Se TMDL in 2013-2014 (North Bay) and 2015 beyond (South Bay)
- De-listing of legacy pesticides (2012-2013)
- Evaluation of sediment and water quality objectives
    - Copper site-specific objective and cyanide anti-degradation policy
    - 303 (d) listings
    - Reasonable potential analysis
- Dredged material management
    - Defining ambient conditions in Bay (PCBs, Hg, PAHs, etc.)
- Identification of causes of sediment toxicity in the Bay
- Development of and assessment with nutrient numeric endpoints; management of ammonium
- Providing fundamental science to evaluate the health of the Bay and to model the fate and transport of contaminants.



Chorophyll trend in the South Bay.

Recent Advances in Understanding

- Annual sampling of water and sediment chemistry has documented a general lack of trend in persistent pollutants and spatial patterns that vary by pollutant but are consistent from year to year.
- A sudden decrease in suspended sediment concentrations occurred in 1999.
- Increasing chlorophyll concentrations have been observed in the Bay and are attributed to a variety of possible drivers (e.g., decrease in SSC concentrations and an increase in bivalve predators).
- PBDEs appear to be leveling off (BDE 47) or declining (BDE 209)
- Concentrations of mercury in sediment correlate poorly with methylmercury in sediment (MeHg represents 1% of total Hg).



Suspended sediment trend at a representative station.

Priority Questions for the Next Five Years

1. Are chemicals at levels of concern?
2. What are the concentrations and masses of priority contaminants?
3. Have concentrations and masses increased or decreased?

STATUS AND TRENDS

Status and trends monitoring budget allocations in the RMP from 2012 to 2018. Allocations are spread evenly over the years, even though the expenditures (see next page) occur intermittently.

	2013	2014	2015	2016	2017	2018
% increase subcontractors	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%
STATUS AND TRENDS TOTAL	**$1,057,400**	**$1,033,663**	**$1,191,072**	**$1,203,524**	**$1,217,444**	**$1,231,711**
Water Chemistry (biennial 22 sites)	$81,667	$83,708	$85,801	$61,250	$62,781	$64,351
Aquatic Toxicity (every five years)	$2,333	$2,392	$2,451	$1,000	$1,025	$1,051
Bivalves (biennial 11 sites)	$22,500	$23,063	$23,639	$24,230	$24,836	$25,457
Sediment Chemistry (biennial 47 sites dry/47 wet)	$92,500	$92,500	$94,813	$97,183	$99,612	$102,103
Sediment Toxicity (biennial, margins only, dry and wet, 27 sites)	$25,750	$0	$0	$27,054	$27,730	$28,423
Sediment Benthos (quadrennial, margins only, dry 27 sites)	$30,900	$0	$15,836	$16,232	$16,638	$17,054
Fieldwork and Logistics and Vessel	$218,000	$184,000	$215,250	$220,631	$226,147	$231,801
Suspended Sediment in SF Bay	$250,000	$250,000	$250,000	$250,000	$250,000	$250,000
Hydrography and Phytoplankton	$110,000	$173,000	$223,000	$223,000	$223,000	$223,000
Fish Contamination Study (quintennial)	$0	$0	$54,000	$55,350	$56,734	$58,152
Cormorant Eggs (triennial)	$25,000	$25,625	$26,266	$26,922	$27,595	$28,285
Forster's Tern Eggs (triennial)	$25,000	$25,625	$26,266	$26,922	$27,595	$28,285
Archiving	$8,750	$8,750	$8,750	$8,750	$8,750	$8,750
Data Management	$165,000	$165,000	$165,000	$165,000	$165,000	$165,000

Status and Trends sampling was scaled back significantly in 2012, with a change from annual to biennial sampling of water and sediment. The amount of information gained from annual sampling was diminishing, while needs for special studies to generate information on other topics were increasing. The reduction of Status and Trends effort freed up approximately $400,000 per year for studies on other topics.

STATUS AND TRENDS

Actual (2012-2013) and anticipated (2014-2019) status and trends monitoring expenditures in the RMP from 2012 to 2019, indicating the years in which sampling is planned to actually occur. Projections are in 2012 dollars.

	2012	2013	2014	2015	2016	2017	2018	2019
Water Chemistry (biennial 22 sites)	$0	$55,000	$0	$190,000	$0	$55,000	$0	$190,000
Aquatic Toxicity (every five years)	$0	$0	$0	$7,000	$0	$0	$0	$0
Bivalves (biennial 11 sites)	$45,000	$0	$45,000	$0	$45,000	$0	$45,000	$0
Sediment Chemistry (biennial 47 sites dry/27 wet)	$110,000	$0	$185,000	$0	$110,000	$0	$185,000	$0
Sediment Toxicity (biennial 27 sites dry/27 wet)	$51,500	$0	$0	$0	$51,500	$0	$51,500	$0
Sediment Benthos (biennial 27 sites dry/27 wet)	$61,800	$0	$0	$0	$61,800	$0	$0	$0
Fieldwork and Logistics	$214,000	$192,000	$230,000	$192,000	$230,000	$192,000	$230,000	$192,000
Fish Contamination Study (quintennial)	$0	$0	$270,000	$0	$0	$0	$0	$270,000
Cormorant Eggs (triennial)	$75,000	$0	$0	$75,000	$0	$0	$75,000	$0
Forster's Tern Eggs (triennial)	$75,000	$0	$0	$75,000	$0	$0	$75,000	$0

PROGRAM MANAGEMENT

- Includes four general categories of activities
  - Program Management ($266,000)
    - Internal coordination (staff management), coordination with Program participants, external coordination with related groups, Program planning
  - Contract and Financial Management ($179,000)
  - Workgroup and Peer Review Coordination ($221,000 - includes honoraria and travel)

Program Review
Periodically, the RMP conducts an overall peer review of the Program as a whole. Two Program Reviews have been conducted to date, in 1997 and in 2003. The timing and scope of Program Reviews are determined by the Steering Committee.

- The RMP has evolved considerably since the 2003 Review, with greatly enhanced planning processes that have made the Program much more forward-looking and thoroughly peer-reviewed.
  - Workgroups have been permanently established to address the major topical areas of the Program.
  - Strategy Teams consisting of stakeholders and local scientists have been formed to identify the highest priority management questions on important topics and to formulate long-term workplans to answer them.
  - The Steering Committee has also taken a more forward-thinking approach, capturing all of the workgroup and strategy team plans in a RMP Master Plan, and in holding an annual planning workshop (beginning in 2010) to provide direction to all of the subcommittees.
  - With carefully considered guidance from stakeholders and peer reviewers, the RMP has prioritized and addressed the topics recommended in the 2003 review, and is continually sharpening its focus on using the resources that are available in an efficient manner to provide the information that is most needed to support TMDLs and other management initiatives.
- The Steering Committee does not consider a Program Review appropriate in 2013 because ongoing review of critical elements is well established. A Review will be conducted after the Master Planning process has become established and when a clear need for an overarching review becomes apparent.

Peer Review
Extensive peer review is a key to the cost-effective production of reliable information in the RMP. This peer review is accomplished through the following mechanisms.

- Workgroups. The RMP Workgroups include leading scientists that work with stakeholders to develop workplans. Peer review occurs at all stages of a project: planning, implementation, and reporting.
- Technical Review Committee. Provides general technical oversight of the Program.
- Peer-reviewed Publications. Another layer of peer review occurs when journal publications are prepared. This occurs for most significant RMP studies.

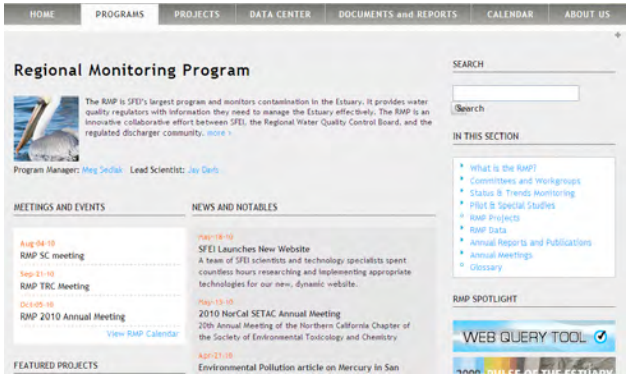
COMMUNICATIONS

- Averages $275,000 per year (8% of the total budget).
- Includes the Pulse of the Estuary, Annual Meeting, Multi-Year Plan, State of the Estuary report card, RMP web site, Annual Monitoring Results, technical reports, journal publications, newsletter, oral presentations and posters, media outreach.
- These platforms are used to make information from the RMP available to the following target audiences.
    - Primary Audience
        - RMP Participants. Need information to encourage support for the RMP and water quality programs in the Bay. The Pulse, Annual Meeting, Multi-Year Plan, State of the Estuary report card, RMP web site, newsletter, fact sheets, oral presentations, media outreach.

- Secondary Audiences
    - Other regional managers. Need information to inform their decisions and evaluate effectiveness of their actions. A target audience for all communication products.
    - Regional law and policy makers. Need information to encourage support for water quality programs in the Bay. The Pulse, State of the Estuary report card, media outreach.
    - Regional Scientists. Need to share information to increase understanding of water quality and maintain technical quality of the science. A target audience for all communication products.
    - Media, public outreach specialists, educators. Need information to encourage support for the RMP and water quality programs in the Bay, and to protect their health. The Pulse, Master Plan, State of the Estuary report card, RMP web site, newsletter, fact sheets, media outreach.
    - Managers and scientists from other regions.

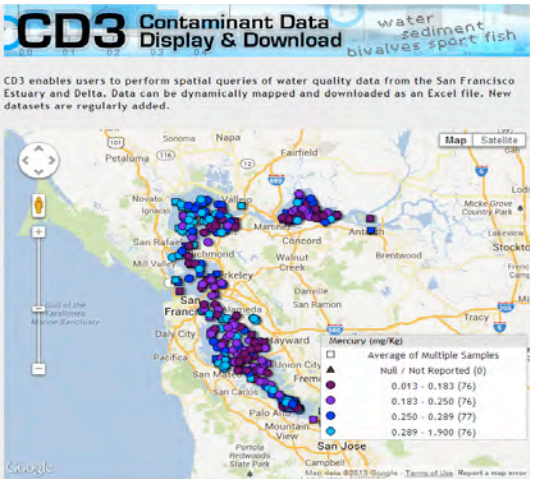
Highlights for the Next Five Years

- Next Pulse: 2015
- Closer partnership with SFEP to reach broader audience
- Annual Meeting joint with State of the Estuary in 2015
- Continued web site improvement



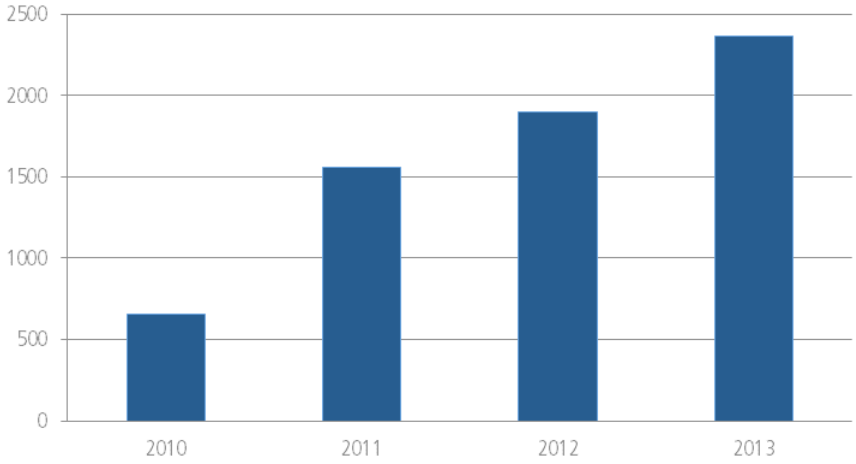
Home page for the RMP web site.

DATA MANAGEMENT AND QUALITY ASSURANCE



A data display by the RMP CD3 Tool.

- **Data Management** ($289,000 per year)
  - The RMP database contains approximately xx records generated since the Program began in 1993.
  - Includes formatting, uploading, and reporting each year's data; managing, maintaining, and improving the RMP database to enable easy access to RMP data through the RMP website; coordination with statewide data management initiatives (i.e., SWAMP and CEDEN); support for quality assurance evaluation, data analysis, and RMP report production.
  - Web-based data access tools include user-defined queries, data download and printing functionality, maps of sampling locations, and visualization tools. Through the user-defined query tool, results can be downloaded into Excel in both a cross-tabulated and flat-file format. Dynamic mapping of concentrations allows users to view spatial distributions across the Estuary, and statistical functions, such as cumulative distribution function plots, provide aggregated summaries.
  - These platforms are used to make information from the RMP available to water quality managers, stakeholders, scientists, and the public.



2400 users used the Contaminant Data Display and Download Tool in 2013.

- **Quality Assurance** ($30,000 per year)
  - Includes QA review of the data that are submitted by the laboratories. Development and application of the QAPP. Review in comparison to data quality objectives and prior results. Review of congener ratios.
  - Troubleshooting problems with chemical analyses.
  - Occasional special studies to assess sampling methods, analytical methods, or lab performance.

New Initiatives for the Next Five Years

- Efficiencies in Data Uploading and Formatting
- Enhancement of Visualization Tools
- Coordination with the Estuary Portal
- Coordination with SFEI EDIT Program

RMP AND NON-RMP STUDIES RELATED TO WATER QUALITY IMPACTS OF DREDGING AND DREDGED MATERIAL DISPOSAL

Notable Activities

- In 2011 the RMP created a web page to provide the latest information on thresholds for bioaccumulation testing and in-Bay disposal (http://www.sfei.org/content/dmmo-ambient-sediment-conditions). These thresholds are based on RMP Status & Trends data.

Dredging related studies. Dollar amounts in thousands.

	Study	2009	2010	2011	2012	2013	2014	2015	2016	2017
RMP Status & Trends	S&T Sediment Triad	260	250	250	250		250		250	
RMP Status & Trends	USGS Suspended Sediment Studies	250	250	250	250	250	250	250	250	250
RMP Exposure and Effects	Benthic Assessment Tools		30		50	76				
RMP Exposure and Effects	Causes of Sediment Toxicity: TIES	76								
RMP Exposure and Effects	Causes of Sediment Toxicity: Molecular TIES		60							
RMP Exposure and Effects	Causes of Sediment Toxicity: Moderate Toxicity Strategy				50		30			
RMP Exposure and Effects	Impact of Dredging on Benthos						50			
RMP Exposure and Effects	Effects of PAHs on Flatfish	50								
RMP Exposure and Effects	Hotspot Followup			60	30			50		
LTMS	Eeelgrass Buffer Zone Study(2) - proposed									

1 identifying a reference site for toxicity testing rather than referring to disposal sites
2 evaluating the appropriateness of the 250 foot buffer zone in effect to protect eelgrass from dredging

RMP STUDIES SATISFYING SPECIFIC PERMIT CONDITIONS

Industrial Wastewater Treatment Plants

Policy	Provision	Study
Mercury Watershed Permit	Better understand mercury fate, transport, the conditions under which methylation occurs, and biological uptake	Mercury Strategy Studies: Food Web Uptake (small fish), DGTs, Isotopes
Copper Action Plan	Investigate possible copper sediment toxicity	S&T Sediment Toxicity
Copper Action Plan	Investigate sublethal effects on salmonids	Effects of Copper on Salmon (NOAA)

RMP STUDIES SATISFYING SPECIFIC PERMIT CONDITIONS

Municipal Wastewater Treatment Plants

Policy	Provision	Study
Mercury Watershed Permit	Better understand mercury fate, transport, the conditions under which methylation occurs, and biological uptake	Mercury Strategy Studies: Food Web Uptake (small fish), DGTs, Isotopes
Copper Action Plan	Investigate possible copper sediment toxicity	S&T Sediment Toxicity
Copper Action Plan	Investigate sublethal effects on salmonids	Effects of Copper on Salmon (NOAA)

RMP STUDIES SATISFYING SPECIFIC PERMIT CONDITIONS

Urban Stormwater

Policy	Provision	Study
Municipal Regional Stormwater Permit (MRP)	C.8.e Pollutants of Concern and Long-Term Trends Monitoring	Small Tributary Loading Strategy (STLS) Studies
MRP	C.11.b. Monitor Methylmercury	STLS
MRP	C.11.g. Monitor Stormwater Mercury Pollutant Loads and Loads Reduced	STLS
MRP	C.11.h. Fate and Transport Study of Mercury in Urban Runoff	Mercury Strategy Studies (Small Fish, DGTs, Isotopes); Modeling Strategy Studies
MRP	C.12.g. Monitor Stormwater PCB Pollutant Loads and Loads Reduced	STLS
MRP	C.12.h. Fate and Transport Study of PCBs in Urban Runoff	PCBs in small fish, Modeling Strategy Studies, Priority Margin Site Studies
MRP	C.13.e. Studies to Reduce Copper Pollutant Impact Uncertainties	S&T Sediment Toxicity, Effects of Copper on Salmon (NOAA)
MRP	C.14.a. Control Program for PBDEs, Legacy Pesticides, and Selenium.	STLS

Item 8

RMP Multi-Year Planning Workshop

October xx, 2014
San Francisco Estuary Institute
First Floor Conference Room
4911 Central Avenue, Richmond, CA
9AM - 12 PM
Lunch will be provided

DRAFT AGENDA

1.	**Goals, ground rules** The goals **are** to: ▪ Achieve the desired outcomes listed for each agenda item. ▪ Provide overarching guidance to the TRC and Workgroups for selection of special studies for 2016. ▪ Begin to establish a general framework for planning in 2017 and beyond. Ground rules: ▪ No wordsmithing or bean counting ▪ Work together to keep the meeting on time and in focus to meet the goals ▪ Be succinct – time is limited	9:00 Tom Mumley (Chair)
2.	**Action: Anticipated management decisions and policies, and related information needs** (Attachment: Updated version of page 6 in Draft January 2015 Multi-Year Plan) **Desired outcome:** Provide input to ensure the summary of current and anticipated water quality management decisions, policies, and actions (page 6 of the Multi-Year Plan) is up to date and complete.	9:15 Tom Mumley, Group
3.	**Information: Overview of existing plans and budgets, possible future directions, updated Multi-Year Plan** (Attachment: Draft January 2015 Multi-Year Plan) Overview of big picture items. **Desired outcome:** Inform the group on big picture of existing plans and budget allocations.	9:25 Jay Davis

4.	**Specific program priorities for 2016 and general priorities for 2017-2020**
	A brief overview of each item will be presented by Jay or Meg as each is discussed.
	Elements to be discussed:
	• Status and trends – quick recap
	  o Suspended sediment (Schoellhamer)
	  o Basic water quality (Cloern)
	• Special study topics
	  o Small tributary loads
	  o Nutrients
	  o Emerging Contaminants
	  o PCBs
	  o Selenium
	  o Exposure and effects
	  o Dioxins
	  o Other?
	• Program management
	• Data management
	• Communications
	Desired outcome: Agreement on content of table on MYP page 11 (general priorities expressed as rough dollar allocations for special study areas over the next five years) and of the more detailed special study table (Excel spreadsheet) for 2016.
		9:35
		Tom Mumley, Group

5.	**Summary, Action Items, Adjourn Planning Session**	11:55
	Lunch	12:00