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Contents

1. INTRODUCTION

PROGRAM STRUCTURE AND OBJECTIVES

The Regional Monitoring Program for Water Quality in the San Francisco Estuary (RMP) is the primary source for long-term contaminant monitoring information for the Estuary. The RMP is an innovative and collaborative effort among the scientific community, the San Francisco Bay Regional Water Quality Control Board (Water Board), and the regulated discharger/dredging community. The Program was initiated by the Water Board as a pilot study in 1989 and has been collecting water, sediment, and bivalve tissue data since 1993. The RMP's annual budget is currently approximately $3.2 million, which is primarily funded through wastewater discharge and dredging permits issued by the Water Board (refer to *Appendix* 1 for a current list of Program participants). The Status and Trends portion of the program includes long-term monitoring of the San Francisco Bay, while Special Studies change annually in response to changing management priorities and stakeholder needs.

The RMP is overseen by the Technical Review Committee (TRC), the Steering Committee (SC) and five workgroups, which consist of technical representatives from the Regional Board and discharger groups, scientists who are currently studying the Bay, invited scientists who are internationally recognized experts in their field, and federal and state regulators. The TRC oversees the activities of the workgroups and the technical content of the RMP as a whole. The SC determines the overall budget, allocation of program funds, tracks progress, and provides direction to the Program from a manager's perspective. The five workgroups, the Sources, Pathways and Loadings Workgroup, the Exposure and Effects Workgroup, the Contaminant Fate Workgroup, the Emerging Contaminants Workgroup, and the Sport Fish Workgroup directly guide planning and implementation of Special Studies and provide input on relevant aspects of the annual RMP Status and Trends monitoring. These workgroups meet typically one to two times per year to review progress and make recommendations. In 2009, strategy documents and long-term work plans were developed that articulated the priority questions to be answered and the longer-term information needs. Strategy documents have been developed for a number of topics including: small tributaries, modeling, mercury, polychlorinated biphenyls (PCBs), dioxins and nutrients. RMP workgroups have also developed long-term plans for studies of emerging contaminants and contaminant exposure and effects. These strategy documents and work plans lay the foundation for future environmental monitoring. These information needs and priorities have been summarized in the RMP Multi Year Plan which will be available April 2012.

The RMP management questions were revised in 2007 as part of the RMP's Five-year Program review process and refined and approved by the TRC and SC in 2008. The current Program uses the following management questions to guide changes in the Status and Trends monitoring elements and to prioritize which Special studies to fund:

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?
    b. What potential for impacts on humans and aquatic life exists due to contaminants in the Estuary ecosystem?
    c. What are appropriate guidelines for protection of beneficial uses?
    d. What contaminants are responsible for observed toxic responses?
2. What are the concentrations and masses of contaminants in the Estuary and its segments?
    a. Do spatial patterns and long-term trends indicate particular regions of concern?

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?
    b. What are the best opportunities for management intervention for the most important contaminant sources, pathways, and processes?
    c. What are the effects of management actions on loads from the most important sources, pathways, and processes?
4. Have the concentrations, masses, and associated impacts of contaminants in the Estuary increased or decreased?
    a. What are the effects of management actions on the concentrations and mass of contaminants in the Estuary?
    b. What are the effects of management actions on the potential for adverse impacts on humans and aquatic life due to Bay contamination?
5. What are the projected concentrations, masses, and associated impacts of contaminants in the Estuary?
    a. What patterns of exposure are forecast for major segments of the Estuary under various management scenarios?
    b. Which contaminants are predicted to increase and potentially cause impacts in the Estuary?

Status and Trends monitoring characterizes water and sediment quality and contaminants in water, sediment, and tissue in the Estuary. The Water Board uses Status and Trends data for regulatory purposes, such as evaluating the Estuary for 303(d) listing of water bodies, calculating National Pollutant Discharge Elimination System (NPDES) permit conditions, estimating Total Maximum Daily Loads (TMDL), and evaluating whether management actions are successful in reducing contaminant loads to the Estuary through modeling. For questions regarding the RMP Status and Trends contact Meg Sedlak, meg@sfei.org.

Status and Trends monitoring includes water, sediment, bivalves, sportfish, and bird eggs. In 2011, the program evaluated the data collected to date under Status and Trends, the questions that this element of the program was attempting to answer and the frequency that was needed. Based on this review, the SC and TRC recommended that the frequency of Status and Trends monitoring of water and sediment be reduced to biennial. The monitoring will be staggered so for any given year the RMP will be on the water collecting some matrix. A more detailed description of each of the elements of Status and Trends is presented below.

- Water monitoring occurs annually during the dry season for analysis of water quality, trace metals, trace organics and ancillary parameters. Water toxicity is monitored on a five-year cycle and was last conducted in 2011. For details on the 2010 water sampling event see the Water Chapter or visit the Status and Trends web page.

- Sediment monitoring occurs annually during the dry season for the analysis of trace metals, trace organics and ancillary parameters. Beginning in 2010, sediments are collected in alternate seasons starting with a wet season (winter) collection event followed by a dry season (late summer) collection event the following year. The RMP monitors for sediment toxicity annually. For details on the 2010 sediment sampling event see the Sediment Chapter or visit the Status and Trends web page.

- The RMP's bivalve bioaccumulation monitoring effort augments the long-term monitoring effort started by the State Mussel Watch Program. The current monitoring design includes

the analysis of trace organics biennially, and trace elements every 5 years. Bivalves were last analyzed for both trace element and trace organic parameters in 2008. Trace organics concentrations were measured in bivalves in 2010. Refer to the Bivalve Chapter in the 2010 bivalve chapter or visit the Status and Trends web page.

- Benthic community assessments were added to the RMP Status and Trends program in 2008 as part of the State's Sediment Quality Objectives (SQO) methodology. The SQO methodology evaluates sediment quality using a triad approach with three lines of evidence (i.e., benthos, sediment chemistry and sediment toxicity) to conduct sediment assessments. Benthos samples are collected during scheduled RMP sediment sampling events at 27 sites (20 random sites and 7 historic sites).

- The Sport Fish Contamination Study screens fish tissue for contaminants of concern to human health. This has typically been conducted on a three-year basis; however, the program is recommending that this element be conducted on a five-year rotation. Sport fish sampling includes evaluation of key fish species for long-term trend assessment, combined with follow-up sampling of additional species. The 2009 RMP sport fish sampling was part of a two-year statewide evaluation of bioaccumulation in sport fish along the entire coast of California by the State Water Board's Surface Water Ambient Monitoring Program (SWAMP). Year 1 of the program focused on the Southern California Bight and the northern California coast near San Francisco Bay. Findings are published in the report Contaminants in Sport Fish from the California Coast, 2009: Summary Report on Year One of a Two-Year Screening Survey. Year 2 focuses on the central coast and remaining locations along the northern California coast. The findings from year two will be published in the spring of 2012 in a report that will combine the findings from both years of the study. A similar sampling design to that used by the RMP for sampling the San Francisco Bay will be used for the entire State, allowing comparison of RMP data to results for similar species across California. The results from sampling popular sport fish species for mercury, PCBs, organochlorine pesticides, and PBDEs in 1994, 1997, 2000, 2003, and 2006 at several fishing locations are available via the Contaminant Data Display Download available via the RMP web site For more information refer to the technical reports Contaminant Concentrations in Fish from San Francisco Bay 2003 and Contaminant Concentrations in Sport Fish from San Francisco Bay 2006 or visit the Sport Fish Monitoring Report page.

- The United States Geologic Survey (USGS) has collaborated with the RMP since the beginning of the Program. During 2010, it continued to supplement RMP monitoring with two on-going studies that address basic hydrographic and sediment transport processes. The Hydrography and Phytoplankton study collects monthly water quality measurements in the Estuary's deep channels from the Lower South Bay to the confluence of the Sacramento and San Joaquin Rivers. Details on this study can be found on our web site. For more information refer to the *2006 Pulse of the Estuary* article What is Causing the Phytoplankton Increase in San Francisco Bay? and the *2009 Pulse of the Estuary* article Recent Trends of Phytoplankton Increases in San Francisco Bay as well as presentations from the 2011 Nutrient Workshop.

  The Sediment Dynamics in San Francisco Bay study examines the role of several physical factors controlling suspended sediment concentrations in the Estuary for a variety of

hydrologic, tidal, and wind conditions and generates time series measurements for calibration and validation of sediment transport models. Time series measurements of suspended sediment concentrations are collected at six sites using optical backscatter sensors deployed at mid-depth and near the bottom. Details on this study can be found on our web site. For more information refer to the *2003 Pulse of the Estuary* article Sediment Dynamics Drive Contaminant Dynamics and the *2009 Pulse of the Estuary* article Suspended Sediment in the Bay: Past a Tipping Point.

- Triennial bird egg monitoring (cormorant and tern) was conducted in 2009. This element of the Status and Trends Program will help us understand spatial patterns of contaminant uptake into the food web and trends in biota over time. Cormorant and tern bird egg monitoring was included as part of the Status and Trends Program in 2006/7, with triennial sampling beginning in 2009. Cormorant eggs were analyzed for mercury, selenium, PBDEs, perfluorinated compounds, PCBs, and pesticides. Tern eggs were analyzed for mercury, selenium and PBDEs. Analysis of dioxin in bird eggs is deferred until 2012.

In addition to these elements, various Special Studies are conducted annually. Special Studies are designed to investigate and develop new monitoring measures related to anthropogenic contamination or contaminant effects on biota in the Estuary. Special studies also address specific scientific issues that the TRC, SC, or Water Board identify for further study. Special Studies conducted by the RMP in 2010 are discussed later in this chapter. A summary of previous studies conducted by the RMP can be found by going to the Previous Pilot and Special Studies web page or by reading previous publications of the Annual Monitoring Results report. Specific details on the study development and selection processes can be accessed via the Selection Process web page.

The RMP synthesizes and distributes the results of our monitoring and studies through conferences, workgroups, literature reviews, technical reports, newsletters, and the *Pulse of the Estuary*. This *Annual Monitoring Results* report focuses on the Status and Trends Program. The RMP publishes separate technical reports, which are available on the web at RMP Documents and Reports. For more information on the RMP, refer to the RMP home page.

CHANGES TO THE STATUS AND TRENDS PROGRAM

There have been numerous changes over the years to the RMP in order to better address management questions and adapt to changing regulatory and scientific information needs. Table 1.1 lists changes to the program during 2010 including changes to the sampling design, sampling target parameters, availability of data, sampling stations, laboratories conducting analyses, and laboratory methods. A table of changes to the RMP since 1993 can be found in Appendix 8. Tables of reported analytes by matrix for the long-term Status and Trends monitoring of water, sediment, and bivalve tissue beginning in 1993 can be found in Appendices 5-7.

Table 1.1. Summary of Changes for the RMP Status and Trends Program, 2010

Action Codes: A= Analyte added or removed from sampling design; D= Data rejected or not available/data comparability issues; L= Change in laboratory conducting analysis or in laboratory methods; P= Change in program/sampling design; S= Station added or removed; T= Trends analysis performed.			
Action Code	**Year**	**Action**	**Detail/Rationale**
A	2010	Began reporting Sum of PCBs 208 (SFEI)	This sum provides an index of the PCBs present in Aroclor mixtures. PCB-11 is excluded from the sum because it is a by-product of dye manufacturing and is not related to Aroclors. PCB 11 does not have dioxin-like potency and has different sources than Aroclors.
A	2010	Pyrethroids Tetramethrin and piperonyl butoxide moved to a status of "Information only" by analytical lab	Compounds have a history of persisting high variability in Ongoing Precision and Recovery (OPR) and linearity data. Results are estimated to be accurate only within an order of magnitude.
D	2010	Added new PrepPreservation Code: FieldFiltered,FieldSolventPres,FieldFrozen	This code is used for Chlorophyll-a and Pheophytin samples beginning in 2010. We will not update previous years' sample records which have codes "FieldFiltered, LabAcidified" and "FieldFiltered, FieldFrozen" because it was determined that the benefit does not justify the time and effort at this time.
D	2010	Bivalve data not available for BD40 Davis Point Station because it was not sampled.	BD40 was not sampled due to terminal construction and weather issues.
D	2010	TRC cancelled scheduled analysis of archived 2006 and 2007 water samples for Diazinon and Chlorpyrifos	Initially, water samples were stored during method development for analysis once analytical issues were resolved. These issues have since been resolved. In 2010, TRC decided to cancel the analysis due to the high cost ($60,000) and the lack of a pressing need for the data.
D	2010	Whole water PBDE sample results are not available through the Web Query Tool.	In 2010, 4L whole water samples were analyzed for PBDEs as part of an intercomparison study. The Web Query Tool Does note report data from Intercomparison studies.
D	2010	YSI data collected by SFEI on water cruise are not available for 2010	Data were inadvertently deleted from YSI machine by staff working on another project before it was downloaded.
L	2010	Began adding LabPoisoned to the PrepPreservation code for organic water samples when samples tested positive for residual chlorine.	It was decided that we will not update the PrepPreservation code for samples prepped with poison from 2002-2009 because the benefit does not justify the time and effort at this time.
P	2010	Sediment samples will be collected in alternate seasons starting with a rainy season (winter) sampling event in February 2010.	There appears to be a seasonal element to sediment toxicity with winter sampling exhibiting higher toxicity. 27 samples will be collected during the dry season and 47 samples will be collected during the rainy season. February of 2010 was the first rainy season collection. The next sampling event is August 2011.

Summary of Changes to the Sampling Design for Water and Sediment

2010 was the eighth year of the probabilistic sampling design for long-term water and sediment monitoring, which employs the EPA's Generalized Random Tessellation Stratified (GRTS) sample design (Stevens, 1997; Stevens and Olsen, 1999; Stevens and Olsen, 2000). This type of design is more appropriate for addressing the RMP's overarching goals to collect data and communicate information about water quality in the San Francisco Estuary in support of management decisions. An important advantage of random station selection is that estimates of regional condition derived from a probabilistic survey will have a known level of uncertainty associated with them. Prior to 2003, a targeted sampling design was used. The targeted stations were purposefully located along the central axis of the Estuary as far from anthropogenic sources as possible to monitor 'background' concentrations of pollutants of concern. A subset of those historic water and sediment stations were retained from the original RMP monitoring design, established in 1993, to provide continuity in the long-term monitoring program.

The RMP water and sediment monitoring stations are located in six hydrographic regions of the Estuary. Random design stations are located in five of those regions: Suisun Bay, San Pablo Bay, Central Bay, South Bay, and Lower South Bay. Historic stations are also located in each of those five regions, and additionally at the confluence of the Sacramento and San Joaquin Rivers in the freshwater Rivers region of the Estuary. The sampling frames for water and sediment monitoring (the area within which stations were allocated), are the three-foot and one-foot contours of the Estuary at mean lower low water, respectively (based on NOAA's NAD-83 bathymetry coverage). About seventy-two random water and sediment stations were allocated into the hydrographic regions. Each year, a subset of the water stations are sampled in sequential order, increasing the spatial density of monitoring over time. For sediment, a station re-visit schedule was incorporated into the design to better evaluate trends over time.

The number of random design sites sampled in each region can change based on management decisions. The initial number of sites sampled in 2002 was based on a power analysis using existing, targeted site data and Water Board management priorities. A power analysis is generally used to evaluate the number of samples needed to detect a change in contaminant concentrations over time with a known level of statistical confidence. The initial random design recommended that 26 water and 40 sediment sites be monitored while maintaining a subset of 5 historic water sites and 7 historic sediment sites (a total of 31 water and 47 sediment sites). A second power analysis was conducted in 2006 using the random design data (Melwani et al. 2008). Based on those results for key contaminants of current concern and discussions with the RMP oversight committees, which include Water Board staff, the number of water sites was reduced from 31 sites to 22 sites per year beginning in 2007, while the number of sediment sites was maintained at 47 sites per year.

In 2007/2008, a new redesign review was undertaken by the TRC. After a statistical review and consultation with the RMP participants, the RMP decided to add wet weather sediment sampling back into the Status and Trends program and recommended that wet weather sediment sampling be conducted biennially. The addition of wet weather sampling (typically done in February) will provide monitoring of contaminants that have higher ambient concentrations during the winter when runoff increases. Dry season sampling continues to include eight random sites per region (n = 40). Wet season sampling will include four random sites per region (n = 20). Sampling of the historic stations will not change, and samples from these sites will continue to be collected during each sampling event (maintaining one station per region plus the two Rivers stations (n = 7)). This change was first implemented in August/September 2009 (a dry season sampling year). The change in design necessitated an update from a five-year repeat sampling cycle to a six-year repeat sampling cycle to allow for balanced alternating season sampling.

See the Memorandum on our web page for more details. Sites sampled in 2010 are listed in Appendix 3 for water, sediment and bivalve sampling.

In 2011, the TRC and SC once again reviewed the frequency of the S&T elements. At this time, the committees recommended that the RMP move to biennial sampling for both sediment and water. The sampling will be conducted sequentially so that during any given year, the RMP will be on the water sampling. Further details of this decision are presented in a memorandum (Agenda Item 6).

For more information on the Status and Trends monitoring design, refer to the following articles and technical reports: Power Analysis and Optimization of the RMP Status and Trends Program (Melwani *et al*., 2008), *Re-design Process of the San Francisco Regional Monitoring Program for Trace Substances (RMP) Status and Trends Monitoring Component for Water and Sediment* (Lowe *et al*., 2005), and the *2000 Pulse of the Estuary*.

Summary of Changes to the Sampling Design for Bivalve Bioaccumulation Monitoring

The RMP's bivalve bioaccumulation monitoring effort augments the long-term monitoring effort started by the State Mussel Watch Program. The current monitoring design includes the analysis of trace organics in bivalves biennially, and the analysis of trace metals every 5 years. In 2008 bivalves were analyzed for both trace metals and trace organic contaminants. In 2010, bivalves were only analyzed for trace organic contaminants. Bivalve sampling will next occur in 2012 for trace organic contaminants and 2013 for inorganics.

The bivalve bioaccumulation sample design remains a fixed sample design because deployment of caged bivalves requires secure moorings. Based on the findings from a series of special studies between 2000 – 2005 intended to redesign and improve technical aspects of the deployed bivalve bioaccumulation monitoring component of the RMP, several changes were made in 2003. These included:

1. Dropping three sites in the northern Estuary: Napa River (BD50) , Petaluma River (BD15) , and Horseshoe Bay (BC21) because only two to three sites were required per region to track long-term changes in contaminant concentrations.
2. Deploying only one bivalve species (*Mytilus californianus*). Because of the reduced salinity range of the study area due to the dropped sites, the program was able to deploy one, fairly salinity tolerant bivalve species, which makes comparing bioaccumulation results between regions possible.
3. Deploying bivalves in cages, rather than mesh bags, reduces the loss of organisms through predation.
4. Discontinuing the bivalve maintenance cruise. This was discontinued in 2006 after a study conducted from 2002-2005 showed no significant difference in survival of bivalves in maintained and non-maintained cages.

Changes in Parameter Reporting

During 2010, the RMP began reporting results for all 209 PCB congeners. SFEI generated Sums for 40, 208, 209 PCBs are available through the RMP web tool, Contaminant Data Display and Download (CD3). The Sum of 40 PCBs include the 40 historic target PCBs for the RMP. The Sum of 208 PCBs provides an index of the PCBs present in Aroclor mixtures. PCB 11 is excluded; it is abundant in some matrices but is derived from pigments and not Aroclors. PCB 11 does not have dioxin-like potency and has different sources than Aroclors. The Sum of 209 PCBs is provided solely for comparison to other studies that include all 209 congeners. SFEI does not recommend using this sum for comparison to any Aroclor-based thresholds (the TMDL target, OEHHA thresholds, etc.) - the Sum of 208 PCBs is better for that purpose.

RMP WORKGROUPS

Five workgroups address the major technical subject areas covered by the RMP. Workgroups consist of scientists, regulators, stakeholders and nationally recognized experts who serve to advise the workgroups. The workgroups directly guide planning and implementation of Pilot and Special Studies and provide input on relevant aspects of the annual RMP Status and Trends monitoring.

Sources Pathways and Loadings Work Group

The Sources Pathways and Loadings work group (SPLWG) was formed in 1999 to address the objective developed during the 1997 five-year program review to "describe general sources and loadings of contamination to the Estuary" (Bernstein and O'Connor, 1997). The SPLWG makes recommendations for collection, interpretation, and synthesis of data on general sources and loadings of trace contaminants to the Estuary. Their goal is to create a functional connection between the RMP and efforts to identify, eliminate, and prevent sources of pollution to the Bay. The SPLWG ensures that RMP projects and products are relevant and help to answer developing management questions in the context of Total Maximum Daily Loads (TMDLs) and attainment of water quality standards. For further information, see the SPLWG web page.

Contaminant Fate Work Group

The Contaminant Fate Workgroup's (CFWG) objective is to improve our understanding of physical, chemical, and biological processes that redistribute and transform contaminants in the Estuary, ultimately leading to exposure of biota. Through improved information on Estuary processes, they aim to assist managers in directing limited resources and prioritizing actions for reducing negative impacts, both for new contaminants entering the system, as well as for legacy pollutants already in the Estuary. See the CFWG web page for further information.

Exposure and Effects Work Group

The Exposure and Effects Work Group (EEWG) developed a five-year biological effects pilot study (the Exposure and Effects Pilot Study (EEPS)) that would help address beneficial use management questions developed by the Regional Board. At the end of the study, EEWG was incorporated into the RMP as a permanent workgroup. The EEWG continues to address the biological effects portion of the Status and Trends program and Pilot and Special Studies. See the EEWG web page for more information.

Emerging Contaminants Work Group

The Emerging Contaminants Work Group (ECWG) evaluates the presence of emerging contaminants in the Estuary, defined as chemicals that are not currently regulated, but believed to potentially pose significant ecological or human health risks (e.g., pharmaceuticals, flame retardants, and perfluorinated compounds). For additional information see the ECWG web page.

Sport Fish Work Group

The Sport Fish Work Group (SFWG) guides the effort to collect and analyze select species of sport fish for target parameters of concern (e.g., mercury, PCBs and dioxins) in the San Francisco Estuary. The Sport Fish Study is a human health study and various thresholds are used to evaluate sport fish contaminant concentrations. For additional information visit the SFWG web page.

STRATEGY DEVELOPMENT

In addition to the work groups, teams from the workgroups and RMP stakeholders have been developing strategies for select issues that are of high priority to our stakeholders including dioxins, modeling , mercury , PCBs, small tributary loading and nutrients. A brief summary of strategies that have been completed are listed below. The crosswalk between the work plans and the strategies has been articulated in the Multi-year Plan for the RMP.

Dioxin Strategy

A Dioxin Strategy Team was convened in September 2008 to discuss information gaps. At that time, a dioxin strategy plan was prepared including priority questions and a five-year plan. The following questions articulate the needs and priorities for obtaining information on dioxins in the Bay:

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?

For additional information contact Susan Klosterhaus (susan@sfei.org) or Don Yee (don@sfei.org).

Mercury Strategy

The RMP Mercury Strategy was formed in 2008 to articulate key questions that scientists and managers need to answer for the best management of mercury in the Bay. The Mercury Strategy addresses five priority questions:

1) Where and when is mercury entering the food web?
2) What are the high leverage processes, sources, and pathways?
3) What are the best opportunities for management intervention?
4) What are the effects of management actions?
5) Will total mercury reductions result in reduced food web accumulation?

Based on the strategy, a request for proposals to address the first two key questions was sent out nationally to solicit studies to answer these questions. Of the number of meritorious proposals received, two were selected: a study of the use of mercury isotopes to identify potential sources, and the use of diffusive gradient in thin films (DGTs) to assess uptake of methylmercury into the foodweb. The winter 2010 Estuary Newsletter featured an article highlighting some of the findings from the mercury isotope study entitled Tracking Mercury Signatures in Bay Sediments. These studies are discussed in more detail in the Special Studies section of this chapter. Additional

information about these studies is on our web site. For more information on the RMP Mercury Strategy see this power point presentation.

Modeling Strategy

In 2009, the Modeling Strategy Team and the Contaminant Fate Workgroup identified the following priority questions:

1) What is the contribution of contaminated Bay margins to Bay impairment and what are the projected impacts of management actions to Bay recovery?
2) What patterns of exposure are forecast for major segments of the Bay under various management scenarios?
3) What are the projected impacts of management actions on loads or concentrations of pollutants of concern from high-leverage small tributaries?

For additional information, please contact Don Yee (don@sfei.org).

PCB Strategy

PCBs are a pollutant of high concern in San Francisco Bay. This strategy has been developed to ensure that the RMP is providing the information most urgently needed by managers to find remedies to the Bay's PCB problem. The following management questions have been articulated to identify the information most urgently needed as a basis for the decisions listed above.

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

For more information on this, please contact the strategy lead, Jay Davis (jay@sfei.org).

Small Tributary Loading Strategy

In 2009, the Small Tributary Loading Strategy (STLS) Team (RMP stakeholders, SFEI staff, and Water Board staff) developed a Small Tributary Loading Strategy to identify and prioritize the information that is most urgently needed by managers to reduce loads and impacts of pollutants of concern (POC) entering the Bay from small tributaries. The STLS team worked to ensure that the strategy was integrated with the requirements in the Municipal Regional Stormwater Permit (MRP). The STLS team articulated the following high priority management questions:

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?

For additional information contact Lester McKee (lester@sfei.org).

SPECIAL STUDIES

Special Studies allow for adaptive management of the RMP by allowing for short-term projects based on the changing regulatory priorities, management of the Estuary, and scientific understanding of the Estuary. Summaries of past and current Special Studies can be found on our web site.

Special Studies

Special Studies augment Status and Trends monitoring by focusing on specific topics and by providing a proactive approach to addressing management goals and needs. They help the RMP address specific gaps in data or management and scientific questions related to contaminants in the Estuary. Special Studies may eventually be incorporated into the Status and Trends Program For example, special studies identified and evaluated previously unknown organic contaminants and led to the addition of PBDEs to the RMP target analyte list to determine if they are prevalent in water, sediment, and tissue samples from the Estuary. The following special studies were conducted in 2010:

- Annual Small Fish Monitoring (2005 – 2010)
- Atmospheric Deposition Strategy
- Causes of Sediment Toxicity – Molecular Toxicity Identification Experiments
- Development of a 3-D Model of South Bay
- Development of a Conceptual Model for Bioaccumulation
- Development of Regional Suspended Sediment and Pollutant Load Estimates for San Francisco Bay Area Tributaries Based on Annual Scale Rainfall-runoff and Volume-concentration Models: Year 1 Results
- Guadalupe River Watershed Model – Year 3 (2008-2010)
- Impacts of PAH-contaminated Sediment on Early Life History Stages of Benthic Fish, Year 2
- Tributary Loading Study (on-going)
- Monitoring Tributaries for Dioxin
- PCBs in Small Fish
- Reconnaissance of Representative Watershed Sites
- Screening San Francisco Biota for Anthropogenic Pollutants – Year 1 (2010-2011)
- Sediment Quality Objectives Assessments for the San Francisco Estuary
- Understanding the Relative Sensitivity of Polybrominated Diphenyl Ether Toxicity Thresholds in Common Terns

Annual Small Fish Monitoring (2005 – 2010)

Contact: Ben Greenfield (ben@sfei.org)

Annual small fish monitoring has taken place since 2005 as part of the Exposure and Effects Pilot Study. Small fish are excellent indicators of biological uptake of contaminants, particularly mercury. Using a randomized design, the small fish program is interested in answering the following questions: (1) What factors (i.e., site characteristics) appear to be important for causing increased mercury concentrations in Bay biota? and (2) Where are the highest

mercury concentrations found in the nearshore portions of the system? The small fish study initiated in 2008 was a focused three-year intensive culminating in 2010. The goal of the project was to determine hotspots of methylmercury bioavailability by monitoring mercury concentrations in small fish and sediments. The results of the three-year study will be summarized in a report in 2011.

Atmospheric Deposition Strategy

Contact: Don Yee (don@sfei.org)

At the September 2009 Technical Review Committee meeting, it was requested that RMP staff develop a strategy for assessing atmospheric loads to the Estuary. Interest in atmospheric loads is driven by recent studies that suggest atmospheric loads of some contaminants such as mercury can be significant. Because it is difficult to accurately measure atmospheric deposition, the Committee recommended that a strategy be developed that articulates which contaminants should be included and how the loading will be measured. The report, Estimated Atmospheric Deposition Fluxes of Dioxins in the San Francisco Estuary is available on our website.

Development of a 3-D Model of South Bay

Contact: Ben Greenfield (ben@sfei.org)

A high priority for the modeling strategy and the Contaminant Fate Workgroup is the development of a numerical flexible grid model of the Estuary. The RMP had a unique opportunity to build off of the substantial efforts that were underway to model the hydrology of the South Bay as part of the South Bay Salt Ponds restoration activities. Researchers from the University of California – Berkeley and Stanford University developed a three-dimensional model of the South Bay (referred to as SUNTANS). As part of this work, Dr. Mark Stacey and his research group focused in on the South Bay. Dr. Stacey prepared bathymetry data that was later used by the USACE to populate their model. Mark Stacey of UC-Berkeley provided a summary report Test Application of a High Resolution 3-dimensional Hydrodynamic Model (SUNTANS) to San Francisco Bay; in addition, the particle tracking work undertaken by Ed Gross is also presented in the report Preliminary Simulations of Sediment Dynamics in the South San Francisco Bay.

Development of a Conceptual Model for Bioaccumulation

Contact: Aroon Melwani (aroon@sfei.org)

The Estuary is listed as impaired for many contaminants as a result of elevated concentrations observed in biota. As such, being able to model the impact of contaminants on biota is critical to successfully managing the Bay.

This project developed a conceptual model of contaminant uptake by biota. The model emphasized the roles of sediment and biota movement, drivers of spatial and temporal variation in contaminant exposure, variability in food web uptake, and attributes of local organisms (e.g., lipid and body size).

A draft report was completed in 2011; the final should be available during the first quarter of 2012.

Development of Regional Suspended Sediment and Pollutant Load Estimates for San Francisco Bay Area Tributaries Based on Annual Scale Rainfall-runoff and Volume-concentration Models: Year 1 Results

Contact: Alicia Gilbreath (Alicia@sfei.org)

A critical need for prioritizing watersheds to monitor and model is an evaluation of land use characteristics that influence stormwater loads to the Estuary.

This project will develop land use classifications (e.g., urban, open space, industrial, etc.) for the Bay Area. In addition to land use, consideration of age and condition of the development (e.g., cracked pavement, poorly maintained facilities, gravel or dirt roads, etc.) will be included in the assessment. The project will identify the highest priority land use types to be monitored in the future.

One of the priority questions for the Small Tributary Loading Strategy and the Municipal Regional Stormwater Permit is what are the loads or concentrations of pollutants of concern from small tributaries to the Bay?

This project will also begin to answer this question by using a model to estimate the mass loadings from Bay Area watersheds. A simple spreadsheet model will be developed using information on such factors as rainfall, land use, and soil type. Because the model assumes that unit area runoff values remain constant for homogenous sub-catchments, the data needs for the model are relatively easy to obtain. The model will help evaluate which watersheds are priority watersheds to monitor and to model. It is anticipated that the model will be updated annually to reflect changes in our understanding.

The final report will be available during the second quarter of 2012.

Guadalupe River Watershed Model – Year 3 (2008-2010)

Contact: Lester McKee (lester@sfei.org)

The objectives of this project are to begin the development of a numeric model to assist in estimating mass loads of mercury and PCBs, to extrapolate the data to determine long-term average loads for the period of extensive rainfall data collection (1973-present), and to determine the proportional sources in the watershed and refine the assumptions of the Guadalupe River mercury TMDL. Ultimately, the model will be used to assess the effects of best management practices and impacts of wetland restoration (e.g., effects of South Bay Salt Pond restoration).

A draft report of the model will be prepared and distributed for review in early 2012

Impacts of PAH-contaminated Sediment on Early Life History Stages of Benthic Fish, Year 2

Contact: Meg Sedlak (meg@sfei.org)

This is the second year of funding for a two-year project evaluating the effects of PAH-contaminated sediments on the development of juvenile flatfish. The impacts of pyrogenic PAHs (like those detected in San Francisco Bay) on juvenile flatfish development are largely unknown. In the first year, the effects of pyrogenic (higher molecular weight) PAHs on a model fish such as zebra fish was evaluated.

After the identification of biological endpoints with a model fish species, in the second year, the study will examine a native species, California halibut. In addition, environmental sediment samples with a PAH signature similar to San Francisco Bay will be used. This work will continue into 2012.A presentation on this research was given at the 2011 RMP Annual Meeting. A manuscript on PAH effects to the model fish is currently in preparation.

Tributary Loading Study (on-going)

Contact: Lester McKee (lester@sfei.org)

The Tributary Loading Study includes monitoring small tributary loading (annual), large tributary loading (Mallard Island, triennial), and Guadalupe River loading (triennial). These studies will help us understand the sources of

contaminants and the pathways by which they reach the Bay. During water year 2010, samples were collected at a small tributary located in an industrialized area of Hayward (referred to as Zone 4 Line A), at two locations on the Guadalupe River and at Mallard Island. A detailed look at the Tributary Loading Studies strategies and conclusions to date is available in the 2010 publication of The Pulse of the Estuary – Linking Watersheds and the Bay. For more information refer to the featured article "Advances in Understanding Pollutant Mass Loadings from Rivers and Local Tributaries" in the 2008 Pulse of the Estuary.

Monitoring Tributaries for Dioxin

Contact: Lester McKee (Lester@sfei.org)

The San Francisco Bay was listed in 1998 as an impaired water body for dioxin as a result of elevated fish dioxin concentrations. Based on the most recent sampling of sport fish in 2006, dioxin concentrations have remained unchanged. Relatively little information exists characterizing the sources, pathways and loadings of dioxin. One of the most significant areas of uncertainty is the load from the tributaries. In the Dioxin Conceptual Model/ Impairment Assessment the highest load by a factor of five is stormwater from tributaries, but this was based on monitoring of a single storm event.

2010 presented a unique opportunity to sample two major tributaries to the Estuary, the San Joaquin/Sacramento River and the Guadalupe River, for dioxin. Whole water samples were collected for dioxin analysis during four storm events. Dioxin concentrations in water samples from these studies will be used to refine the loading estimates provided in the Clean Estuary Partnership Conceptual Model/Impairment Assessment report by providing additional data on loadings from the Central Valley watershed and small tributaries that receive primarily urban runoff. A summary of the dioxin watershed loading data is available by contacting Dr. Don Yee (don@sfei.org).

PCBs in Small Fish

Contact: Rachel Allen (Rachel@sfei.org)

Small fish are an ideal indicator of short-term uptake of contaminants into the food web. Small fish integrate contaminant exposure over a one-year period and have high site fidelity.

A small number of small fish were analyzed as part of an RMP pilot study in 2007 (six composite samples) and surprisingly high concentrations of PCBs were observed in these fish (198 ng/g well above the TMDL target of 10 ng/g). These concentrations were on par with concentrations that we have observed in much higher level trophic fish.

This project will provide funding for analyzing PCBs in small fish that are collected at 42 sites as part of the small fish mercury project. A draft summary document is currently undergoing review.

Reconnaissance of Representative Watershed Sites

Contact: Alicia Gilbreath (Alicia@sfei.org)

Watersheds will be stratified in broad categories in which one or two of the watersheds could be sampled to categorize the loads from the watersheds. This list will be important to assess the watersheds to determine how logistically feasible it is to sample the tributaries (e.g., channel form, access, lighting, safety, etc.).

Screening San Francisco Biota for Anthropogenic Pollutants – Year 1 (2010-2011)

Contact: Susan Klosterhaus (susan@sfei.org)

The National Institute for Standards and Technology (NIST) will apply a similar broad scan approach, similar to that used to screen human samples, to San Francisco Estuary samples to identify previously unmonitored anthropogenic chemicals. While labor intensive, this approach has the potential to direct our monitoring efforts to chemicals that are accumulating in biota, rather than conducting extensive and expensive monitoring of biota without an indication that the contaminants are bioaccumulating.

Because different organisms have different potentials to bioaccumulate and to metabolize contaminants, we collected pooled samples of bivalves as part of the RMP 2010 bivalve monitoring effort and pooled harbor seal samples as part of our collaborations with The Marine Mammal Center and Environment Canada. In addition, because contaminants have different physical and chemical properties, they will have different affinities for lipids, blood, and tissue. As a result, all three matrices will be analyzed for in seals.

Sediment Quality Objectives Assessments for the San Francisco Estuary

Contact: Meg Sedlak (meg@sfei.org)

In 2009, the State of California adopted Sediment Quality Objectives that incorporate multiple lines of evidence to assess the health of the Estuary's sediment (i.e., sediment chemistry, sediment toxicity and benthos). At that same time, the RMP began monitoring benthos assuring that the RMP was providing all three lines of evidence to assess the sediment quality of the Estuary.

The RMP has convened a number of benthic workshops to discuss the development of benthic indices for the oligohaline (freshwater) and mesohaline (moderately saline) portions of the Estuary.

Understanding the Relative Sensitivity of Polybrominated Diphenyl Ether Toxicity Thresholds in Common Terns

Contact: Meg Sedlak (meg@sfei.org)

Some of the highest polybrominanted diphenyl ether (PBDEs) concentrations identified to date have been measured in Bay Area terns. At present, we have very little information to determine whether these concentrations are causing significant effects. This egg injection study will develop thresholds for hatching, pipping and survival for the East Coast common tern, a surrogate for the San Francisco Bay area Least, Caspian and Forster's terns.

The final report Apparent Tolerance of Common Tern (Sterna hirundo) Embryos to a Pentabrominated Diphenyl Ether Mixture (DE-71) is available on our website.

Causes of Sediment Toxicity – Molecular Toxicity Identification Experiments

Contact: Meg Sedlak (meg@sfei.org)

The final report RMP Sediment Study 2009-2010 Determining Causes of Sediment Toxicity in the San Francisco Estuary is available on our website.

Web Tools: Contaminant Data Display and Download (CD3)

The 2010 data are now available online using a dynamic mapping and graphing tool. The online Contaminant Data Display and Download (CD3)I allows water, sediment, and tissue monitoring results from 1993 to 2010 to be summarized graphically for many trace contaminants and important ancillary measures. The CD3 tool displays the data graphically on maps and in cumulative distribution function (CDF) plots (Figure 1.1).

Several software programs were used to develop the online graphics. The R statistical analysis software package *spsurvey*, which is designed specifically by EPA for GRTS sample designs was used to calculate estimates of the regional and Estuary-wide contaminant mean, variance, standard deviation, standard error, and CDFs. The R program is an implementation of the S language developed at AT&T Bell Laboratories and can be downloaded for free from the Comprehensive R Archive Network (CRAN). The spsurvey library for the analysis of probability surveys is available from USEPA's Aquatic Resources Monitoring - Monitoring Design and Analysis.

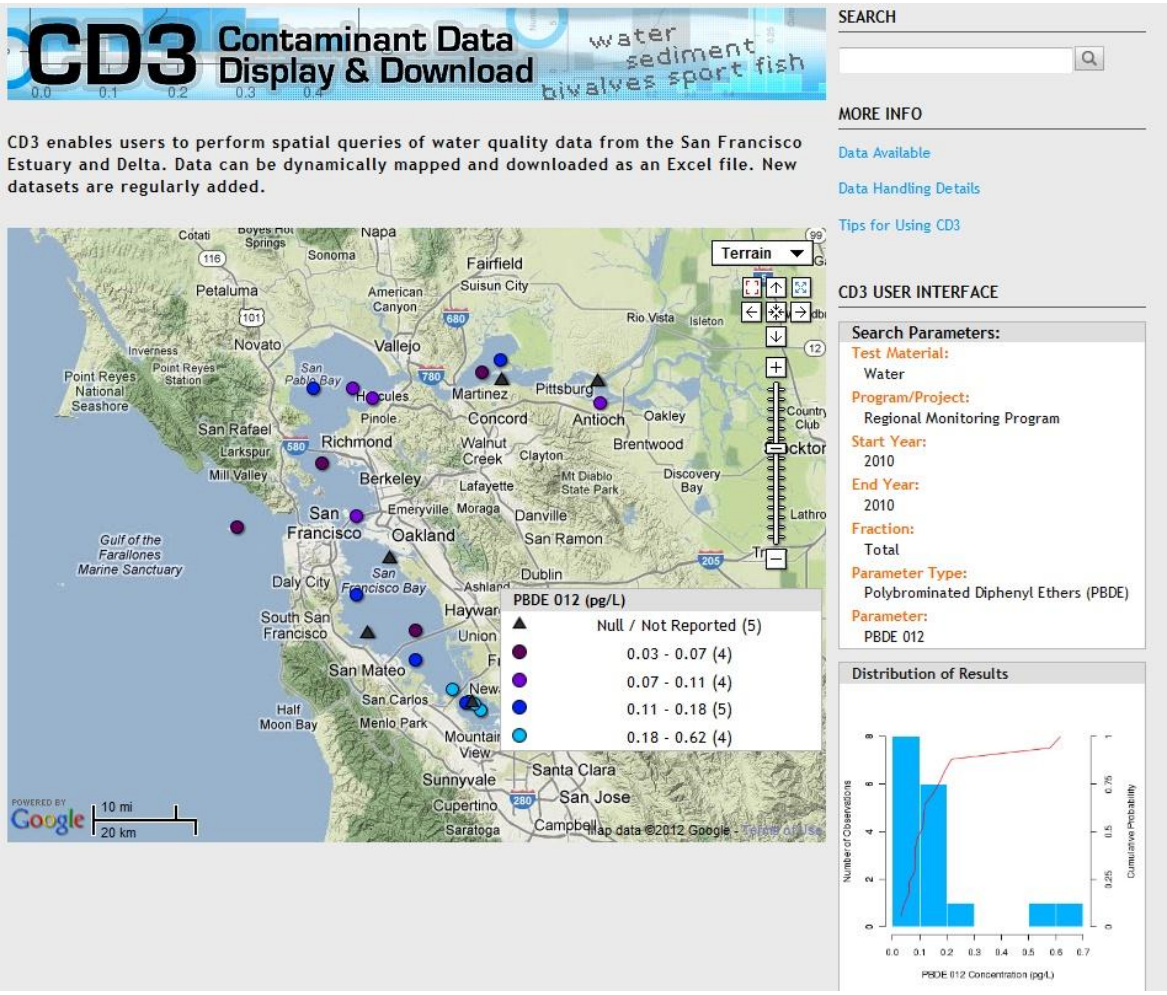

Figure 1.1 Web Map Interface Using the CD3 Tool

All RMP results, from 1993-2010, can be downloaded using the RMP CD3 web tool. The online data includes only those results that have met specific data quality objectives and have passed a rigorous QA/QC evaluation as outlined in the RMP's Quality Assurance Project Plan. Values reported below the method detection limit (MDL) are estimated to be ½ of the MDL in all calculations and graphics. Some organic compounds are summed based on the target list of RMP congeners (*Appendix 5*) for that specific compound group (e.g., PBDEs, PAHs, and PCBs). When laboratory or field replicate data are available, the average of all the replicate concentrations is provided.

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2. WATER MONITORING

BACKGROUND

Trace contaminants are introduced into the water column of the San Francisco Estuary through several major transport pathways such as runoff from rivers and creeks, atmospheric deposition, municipal and industrial wastewater effluent discharge, and remobilization of contaminants from surface sediments to the overlying water column. Contaminants of current environmental concern in the Estuary primarily originate in areas of the watershed that have been altered or disturbed by human activities through urbanization, industrial development, and agriculture. Historic mining activities have also contributed contaminants to the Estuary (e.g., mercury). The transport of contaminants from these various sources and pathways, coupled with the dynamic nature of water and sediment movement, creates complex and constantly varying conditions of contamination throughout the Estuary. For over a decade, the Regional Monitoring Program for Water Quality in the San Francisco Estuary (RMP) has monitored waters of the Estuary for trace elements, organic contaminants, and conventional water quality parameters to develop a better understanding of the cycling and distribution of contaminants in the Estuary and the management actions necessary to reduce their potential exposure to wildlife and humans. Information gained from contaminant monitoring in Estuary water assists the RMP in addressing priority management questions listed in the *Introduction*. All water samples were collected aboard the R/V *Shana Rae* between August 24 and September 2, 2010.

CHANGES IN WATER SAMPLING

The Status and Trends program for water and sediment was revised in 2002 to include a randomized sampling design. From 2002 to 2006, five historic stations and 26 randomly allocated stations in each Bay segment were monitored for contaminants in water. In 2007, the number of random sites was reduced from 26 to 17 because power analysis showed that sampling fewer sites per year could still detect trends. The five historic sites continue to be sampled.

During the first four years (1993-1996) of the Program, the RMP used a polyurethane foam plug sampler to collect water for trace organics analyses (Risebrough *et al.,* 1976; de Lappe *et al.,* 1980, 1983) and phased in a new, modified, commercially available resin (XAD-2) extraction sampler in 1996, beginning with side-by-side comparisons of both sampling systems. XAD/XAD-2 resins have been used throughout the world to measure synthetic organic contaminants in both water and air (Infante *et al.,* 1993). The sampler comparisons were continued in 1997, and results from both years were presented in the RMP 1997 Annual Report (SFEI, 1999). Since 1997, an AXYS Infiltrex system (AXYS Analytical Services Ltd., Sidney, B.C.) has been used to collect all RMP water samples for analysis of trace organic contaminants. Whole water samples are collected as ongoing tests to verify the comparability of the Infiltrex solid phase extraction method to more traditional methods of sample extraction and analysis of organic compounds in water samples. Whole water sample results are not included in the site average reported values.

As of 2008, water samples are analyzed annually for PBDEs and biennially for PCBs, PAHs, and legacy pesticides. This reduction in sampling frequency for PCBs, PAHs, and legacy pesticides was based on recommendations from the redesign process and is discussed in detail in the report Power Analysis and Optimization of the RMP Status and Trends Program. In 2008, an exception was made to analyze water for PAHs as a result of the recent Cosco Busan oil spill that occurred in November 2007. The PAH water concentrations in Central Bay (the region most impacted by the spill) in 2008 were generally within range of historical data, indicating no apparent increase due to

residual oil from the Cosco Busan spill. PAH analysis will continue to occur biennially. PAHs will be analyzed again in 2011. In 2010, only PBDEs were collected. See *Appendix* 5 for the 2010 target analyte list and *Appendix* 6 for a table of analytes reported by the RMP in water from 1993-2010.

As discussed in the introduction, the TRC and SC reviewed the frequency of water monitoring in 2011 and recommended, based on the relatively stable concentrations observed in water, that the program move to monitoring water biennially. The next water sampling will occur in 2013. In addition, the TRC and SC recommended that the frequency of organic analyses be reduced to every four years. Inorganic analyses will occur biennially.

SAMPLING SITES

For 2010, the RMP Status and Trends Program continued with implementation of the stratified, random sampling design started in 2002 and revised in 2007. Water sampling for the Status and Trends Program is currently only conducted during the dry season, specifically in late summer.

In 2010, 22 sites were sampled for water (Figure 2.1 for site map). Five of these were the historic targeted stations (BA30-Dumbarton Bridge, BC10-Yerba Buena Island, BC20-Golden Gate, BG20-Sacramento River, and BG30-San Joaquin River). The remaining 17 sites were distributed through the five segments as follows: three per region with the exception of the Lower South Bay, which had five.

Sampling of the 22 sites was successfully completed, with the following changes made to the sampling plan. The field blank scheduled to be collected at BA30 was instead collected at LSB049W. Site LSB047W was abandoned during the planning process as it was located within the identified submerged pipeline area for Hetch Hetchy pipeline. It was replaced with site LSB049W. Site SU035W was also abandoned during the planning process due to its location within the restricted area around the Ready Reserve Fleet. The first two oversample sites, SU038W and SU039W were rejected due to shallow water conditions and location within the same restricted area, respectively. Site SU035W was therefore replaced with site SU040W. The sampling location for site CB031W was shifted approximately 95 meters off of the target coordinates to place the vessel outside of the shipping channel and turning basin adjacent to the Chevron Long Wharf in Richmond. Station names, codes, location, and sampling dates for 2010 are listed in Appendix 3. A map of the station locations is shown in Figure 2.1.

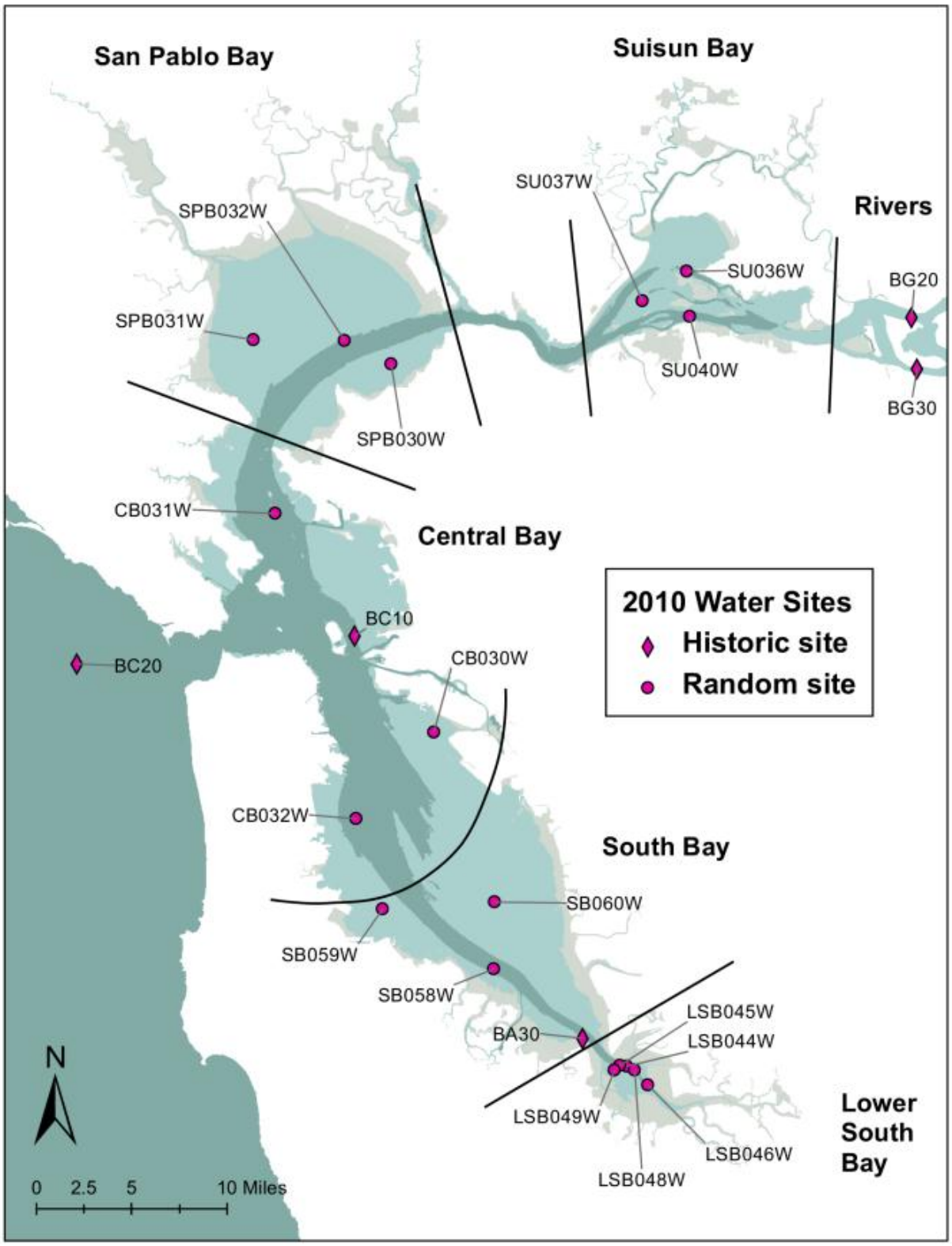

Figure 2.1 Map showing location of 2010 Water Stations

FIELD METHODS FOR WATER SAMPLING

One of the RMP objectives is to evaluate if water quality guidelines are being met in the Estuary. Therefore, the sampling and analytical methods must be able to detect and, when analytically possible, quantify substances below guideline levels. In order to attain the low detection limits used in the RMP, ultra-clean sampling methods were used in all trace metal and organic sampling procedures (Flegal and Stukas, 1987; U.S. EPA, 1995).

Water was collected for trace metal, trace organic, and select water quality analysis (Chlorophyll-a (Chla), Phaeophytin (Phaeo), dissolved organic carbon (DOC), particulate organic carbon (POC), Nitrates, Nitrites, Phosphate, Ammonia, Salinity, Hardness, Silica, and Suspended Sediments) by personnel from the San Francisco Estuary Institute (SFEI) with assistance from Applied Marine Sciences (AMS) using ultra-clean sample handling techniques. AMS collected real-time data at each station over the duration of sampling for conductivity, optical backscatter (OBS), dissolved oxygen (DO), and temperature (1 meter CTD cast for duration of sampling, followed by a full water column profile where water depth allowed). SFEI collected in situ DO, pH, salinity, conductivity, and temperature measurements at each station. Current and recent weather conditions were documented for each site.

Water samples were collected by pumping water from approximately one meter below the water surface. The sampling intake ports for both the trace organic and trace element samplers were attached to aluminum poles that were oriented up-current from the vessel and upwind from equipment and personnel. The vessel was anchored and the engines turned off before the sampling began. Total and dissolved fractions of Estuary water were collected for trace element analyses. Particulate and dissolved fractions were collected for trace organics analyses using the AXYS Infiltrex system. Whole water samples were collected at four sites to evaluate the adsorption capacity of the Infiltrex filter system.

Collection of Samples for Trace Organics

Water for analysis of trace organics was collected one meter below the surface using the AXYS Infiltrex system consisting of a constant-flow, gear-driven positive displacement pump, 3/8 inch outer diameter fluoropolymer tubing, 1 µm glass fiber cartridge particulate filter, and two parallel Teflon® columns filled with XAD-2 resin beads (size range of 300-900 µm). Amberlite XAD-2 resin is a macroreticular, styrene-divinyl benzene copolymer, nonionic bead, and each bead is an agglomeration of microspheres. The hydrophobic nature of the resin leads to excellent retention of hydrophobic contaminants.

To remove large debris that may interfere with sample collection, the sample water was first passed through a coarse screen before the fluoropolymer intake line. Particles greater than 140 µm were removed by a second inline pre-filter. The water then passed through the pump head and a pressure gauge, before it was passed through a four-inch diameter, wound-glass fiber filter (1 µm nominal pore size). Flow may be redirected to a second installed filter if the first filter becomes clogged. Material retained on the glass-fiber filter (or filters) was designated the particulate fraction. After passing through the filter, the water was split and routed through two Teflon® columns, packed with 75 mL of XAD-2 resin. Two columns were used simultaneously to permit a flow of approximately 1.5 L/min. The compounds adsorbed to the XAD-2 resin were designated as the dissolved fraction. Lastly, the water passed through a flow meter and out the exit tube, where the extracted water volume (97.5 L per sample) was verified by filling five pre-measured (19.5 L) carboys.

Collection of Field Blanks for Trace Organics

Field blanks were taken for both the resin columns and the glass fiber filters. The two column blanks were collected by opening and closing both ends of a column to simulate loading of columns into the sampler. Similarly, a glass-fiber filter blank was collected by exposing a filter to the air to mimic loading the sample filters into the cartridges. The field blanks receive the same analytical treatment in the laboratory as the field samples.

Collection of Whole Water Samples for Trace Organics

Whole water samples were collected in clean 4L amber glass bottles for select trace organic analysis using the AXYS Infiltrex System to pump the water (without filters and columns). Once the AXYS Infiltrex system was flushed, the exit tubing was pulled on board and the water samples were collected in 4L amber bottles being careful not to touch the inside of the bottle or neck of the bottle with the tubing (the outside of the tubing is considered to be contaminated – considerable care was taken not to contaminate the sample). The samples were placed on wet ice. Similar to the dissolved and particulate samples collected using the Infiltrex System, whole water samples were only collected for PBDEs this year.

Collection of Samples for Trace Metals

For trace metals, water samples were collected 1 m below the surface using a peristaltic pump system equipped with C-Flex tubing in the pump head using "clean hands, dirty hands" techniques. Sample containers, which were stored double-bagged, were filled on deck on the windward side of the ship to minimize contamination from shipboard sources (Flegal and Stukas, 1987). Unfiltered (total) water samples were pumped directly into acid-cleaned containers. Filtered (dissolved fraction) water samples were collected through an acid-cleaned polypropylene filter cartridge (Voss Technologies or Micron Separations, Inc., 0.45 µm pore size) on the outlet of the pumping system. Prior to collecting water samples, several liters of water were pumped through the system and sample bottles were rinsed three times with site water before filling, except those containing a preservative, which were filled without rinsing. The bottles were always handled by the "clean hands" collector wearing polyethylene-gloves. The sample tubing and fittings were acid-cleaned polyethylene or fluoropolymer, and the inlets and outlets were kept covered except during sampling.

For total mercury water samples, 250 to 500 mL of Estuary water was collected in mercury-clean fluorinated polyethylene (FLPE) bottles, then double-bagged in zip-lock bags. The samples were immediately placed in a cooler on ice.

For methylmercury analyses, samples were collected into 250 mL FLPE bottles, then double-bagged in zip-lock bags. Samples were preserved with 1 – 2 mL 50% sulfuric acid in the field, and immediately placed on ice in a cooler.

Collection of Field Blanks for Trace Metals

Filtered field blanks were collected prior to the collection of samples using the same acid-cleaned sampling assembly that samples were collected through. Ultra-clean deionized (DI) water was pumped through the apparatus and an acid-cleaned filter and was collected in sample bottles. The field blanks received the same handling and analyses in the laboratory as the field samples.

Collection of Data and Samples for Water Quality

Samples for conventional water quality parameters were collected using the same apparatus as for trace metals. Water samples for (dissolved) nitrate and nitrite analysis were collected into a 500 mL PE bottle at each site and were frozen on dry ice in the field. Samples for analysis of particulate organic carbon (POC) and chlorophyll/phaeophytin were field filtered on glass fiber filters (GFF) using a vacuum pump. POC samples were filtered on pre-ashed GFF. Chlorophyll/phaeophytin samples (the residue retained on the filter) were stored in 90% methanol in amber vials and were frozen on dry ice in the field. Bottles for water samples of ammonia, phosphate, and silica were filled without rinsing because the bottles contained pre-measured preservative acid (sulfuric acid for ammonia and phosphate samples and nitric acid for silica samples). The pH of these samples was checked using pH paper to assure that they were appropriately preserved (pH 2 or less).

Conductivity, temperature and depth (CTD) casts were taken at all stations to document their water column profiles. CTD casts were taken by AMS using a Sea-Bird SBE19 CTD probe to measure water quality parameters at depths throughout the water column. At each site, the CTD was lowered to approximately one meter below the water surface and allowed to equilibrate to ambient temperature for 3 minutes. Following the sampling, the CTD was then lowered to the bottom at approximately 0.15 meters per second and raised. However, only data from the down cast were kept. Data were downloaded onboard the ship and processed in the laboratory using Sea-Bird software.

The CTD probe measured temperature, conductivity, pressure, dissolved oxygen, and backscatter at a sampling rate of two scans per second. These data were compiled and averaged into 0.25 m depth bins during processing. At this time, salinity (based on conductivity measurements), and depth (based on pressure) are calculated from the indicated measures. Although the CTD data are not available for download using the Web Query Tool, SFEI maintains these data in a database. Data are available upon request (contact Cristina@sfei.org).

Collection of Aquatic Bioassay Samples

In 2002, aquatic bioassays (toxicity tests) were conducted at a subset of shallow sites in the Estuary and, since then, the frequency of sampling for aquatic toxicity testing was reduced to every five years since no aquatic toxicity had been observed in the Estuary during the summer in many years. The Technical Review Committee decided that aquatic bioassays would be conducted at five-year intervals as a screening measure to assure that any long-term change in toxicity would not be missed. Aquatic bioassay sampling occurred at 9 sites (one per segment and 4 historical sites) in 2007. No aquatic bioassay sampling occurred in 2010. The next aquatic bioassay sampling will occur in 2011.

An overview of toxicity testing in water and sediment over the past ten years of Status and Trends monitoring was summarized by Anderson, Ogle, and Lowe (2003) in the *2003 Pulse of the Estuary*.

LABORATORY METHODS FOR WATER ANALYSIS

SFEI contracts with a number of laboratories that provide high quality analytical services. Qualifications for our labs include ISO registration, NELAP accreditation and certification by the California Department of Public Health. SFEI maintains copies of SOPs for all laboratory analyses. Please contact SFEI (cristina@sfei.org) for more details.

Laboratory Methods for Water Quality Parameters

In 2010, conventional water quality parameters were measured for the RMP by Columbia Analytic Services (CAS) and by the East Bay Municipal Utility District (EBMUD, a wastewater treatment facility) laboratory.

CAS analyzed water samples for dissolved organic carbon using EPA Method 9060A. CAS determined particulate organic carbon concentration using EPA Method 9060M, using a carbonaceous analyzer.

EBMUD analyzed salinity by Standard Method 2520B Version 20, using electrical conductivity. Hardness as CaCO3 was measured for samples where salinity was found to be less than 5 ppt (in 2010, only the Rivers stations BG20 and BG30), using Standard Method 2340C Version 20, a titrimetric procedure using EDTA. In the past Ammonium as N has been analyzed using EPA method 350.1 by flow injection analysis. Since 2009, it has been measured using a method based on the indophenol reaction with o-phenylphenol (OPP) (Solorzano, L., 1969). Nitirite and Nitrate as N were analyzed by EBMUD using EPA method 353.2 by flow injection analysis. Phosphate as P was analyzed using EPA 365.3 by colorimetry. Pheophytin-a and Chlorophyll-a were analyzed by Standard Method H-M Version 20, using spectrophotometric determination. Suspended sediment concentration was measured using ASTM D3977. Silica as SiO2 was measured using a combination of Standard Method 4500-SiO2 C and EPA Method 370.1 and concentrations were determined spectophotometrically.

In past years, shipboard measurements for temperature, salinity, pH, and dissolved oxygen content were made using a hand-held Solomat 520 C multi-functional chemistry and water quality monitor. Beginning in 2007, shipboard measurements of temperature, salinity, conductivity, pH, and dissolved oxygen were made using a hand-held YSI (556 MPS).

Laboratory Methods for Trace Elements

Brooks Rand Labs LLC (BR) analyzed water samples for Trace Elements (Arsenic, Cadmium, Cobalt, Copper, Iron, Lead, Manganese, Nickel, Selenium, Silver, and Zinc).

Upon receipt by the lab, all samples to be prepared for analysis by reductive precipitation and analyzed using inductively coupled plasma – mass spectrometry (ICP-MS) were preserved by the addition of pre-tested concentrated HNO_3 to 0.2% (v/v).

BR determined concentrations of Ag, As, Cd, Co, Cu, Ni, Pb, and Zn by reductive precipitation, followed by filtration, and measured using inductively coupled plasma-mass spectrometry (ICP-MS) by EPA Method 1640, modified. Mn and Fe concentrations were determined by digestion with HCl and HNO3 in a sand bath and measured using ICP-MS by EPA Method 1638. Selenium analysis was also conducted by BR using preconcentrations and ICP-MS in accordance with EPA Method 1640.

The 2007 copper results suggested a discrepancy between reductive precipitation used by the commercial laboratory, BR, and the column chelating method used by the City of San Jose (CSJ) and UCSC. In 2008, 2009, and 2010 a laboratory inter-comparison exercise was conducted for analyses of copper and nickel using the two different methods by CSJ and BR. The results showed good agreement between the reductive precipitation method and the column chelating methods. Both labs followed procedures outlined in EPA Method 1640.

Total Mercury Analysis in Water Samples

In 2010, total mercury analysis of water samples was conducted by BR. Samples were collected in acid-cleaned 250 mL fluorinated polymer (FLPE) bottles with an additional 500 mL High Density Polyethylene (HDPE) bottle collected at one station for QA analysis. BR analyzed total mercury samples using a modified version of EPA Method 1631E. Samples are digested by 24 hour oxidation, reduction, Purge&Trap and detected using cold vapor atomic fluorescence spectrometry.

Methylmercury Analysis in Water Samples

In 2010, total methylmercury analysis of water samples was conducted by BR. Samples were collected in acid-cleaned 250 mL fluorinated polymer (FLPE) bottles pre-preserved at the lab with one to two mL 50% sulfuric acid.

BR analyzed methylmercury in water samples using a modification of EPA method 1630. Samples were analyzed by distillation, aqueous phase ethylation, trapping pre-collection, isothermal gas chromatography (GC) separation, and cold vapor atomic fluorescence spectrophotometer (CVAFS) detection.

Laboratory Methods for Trace Organics

In 2010, trace organic water analyses were conducted for PBDEs by AXYS Analytical Services Ltd. (AXYS). Appendix 5 contains a list of individual parameters reported by the RMP in 2009 and Appendix 6 contains a table of analytes reported by the RMP in water from 1993-2010.

A brief overview of the extraction and analytical methods used for the target trace organics are described below. The SOPs that describe the laboratory method AXYS MLA-033 Revision 6 in more detail are on file at SFEI. Please contact SFEI (cristina@sfei.org) for more details.

Two parallel XAD-2 resin columns and one or two wound glass filter(s) contained the organic compounds extracted from ~100 L of water at each site. The XAD and the filter samples were analyzed together, except at three sites the extracts were analyzed separately as dissolved and particulate fractions (three sites plus two duplicates plus one blank). Each XAD-2 column and filter sample was spiked with labeled surrogate standards. The filters were extracted by ambient temperature sonication, and XAD-2 columns with soxhlet extraction. Extract subsamples were subject to different cleanup procedures and analytical instrumentation, depending up on the target analytes.

PBDEs were analyzed using a modified version of EPA 1614. The dissolved fraction was soxhlet extracted while the particulate fraction was solvent extracted using Ambient Temperature Extraction (ATX). Extracted samples were analyzed using high-resolution gas chromatograph (HRGC) coupled to a high resolution mass spectrometer (HRMS).

Table 2.1. Target Water Analytes: A summary table of the 2010 target analytes, special field handling requirements and analytical laboratories

Analyte	Special Field Handling Requirements	Analytical Lab
Dissolved oxygen, conductivity, temperature, pH, OBS	None	Collected in field by AMS
Dissolved oxygen, conductivity, pH, , temperature, salinity	None	Collected in field by SFEI
Trace Elements (Ag, As, Cd, Co, Cu, Fe, Mn, Ni, Pb, Se, Zn)	Cooled with wet ice and refrigerated	Brooks Rand Labs LLC
Methylmercury	Preserved with sulfuric acid, cooled with wet ice and refrigerated	Brooks Rand Labs LLC
Total Mercury	Cooled with wet ice and refrigerated	Brooks Rand Labs LLC
Copper and Nickel	Cooled with wet ice and refrigerated	City and County of San Jose
Cyanide	Preserved with NaOH to a pH ≥ 12	Contra Costa County Sanity District
Trace Organics (PBDEs)	Cooled with wet ice and refrigerated	AXYS Analytical Services Ltd.
Dissolved Organic Carbon	Field filtered, preserved with 1-2 mL Sulfuric acid, cooled with wet ice and refrigerated	Columbia Analytical Services
Particulate Organic Carbon	Field filtered, field frozen on dry ice	Columbia Analytical Services
Chlorophyll/Phaeophytin	Field filtered, filter stored in 90% methanol in amber bottle, frozen on dry ice	East Bay Municipal Utility District
Salinity and Hardness	Cooled with wet ice and refrigerated	East Bay Municipal Utility District
Ammonia	Preserved with sulfuric acid, cooled with wet ice and refrigerated	East Bay Municipal Utility District
Phosphate, Nitrate and Nitrite	Frozen on dry ice	East Bay Municipal Utility District
Silica	Preserved with nitric acid, cooled with wet ice and refrigerated	East Bay Municipal Utility District
Suspended Sediment Concentration	Cooled with wet ice and refrigerated	East Bay Municipal Utility District

QUALITY ASSURANCE/ QUALITY CONTROL (QA/QC)

All samples results reported by SFEI have undergone a rigorous Quality Assurance/Quality Control (QA/QC) process by trained SFEI staff. Highlights for the 2009 water samples are summarized below.

Ancillary Parameters

QA/QC for Dissolved Organic Carbon and Particulate Organic Carbon analyzed by Columbia Analytical Services (CAS)

Analysis of DOC and POC in water samples and field collected filters respectively was performed by Columbia Analytical Services. Analytical methods used were sensitive enough to detect concentrations in all field samples. DOC or POC was not detected in any of the lab blanks reported. Precision on DOC lab-replicates was good, with an average RSD of 3.4%. within the target of <5%. POC field replicates were also good, with an average RSD of 2.5%, within the POC target of <10% variation. Recovery was evaluated in matrix spike samples, for DOC, with 8% average errors slightly above the target <5% error for DOC, and flagged but not censored. Similarly the average error for POC recovery (15.9%) was greater than the target <10%, and so POC results were flagged but not censored.

QA/QC for Cognates analyzed by East Bay Municipal Utility District Laboratory (EBMUD)

Data for 10 water sample ancillary analytes were reported by EBMUD. Detection limits were sufficient for all analytes (<50% non-detect), although around one-fourth of nitrite results were ND. Data were not blank corrected, and no analytes were detected in blanks. Lab replicates were run on field samples for phosphate, ammonium, silica, hardness, salinity, and nitrate. For chlorophyll, pheophytin, and suspended sediment concentration (SSC), field replicates were evaluated for precision. Replicates from matrix spike samples were used for nitrite. Average precision was within target for most analytes: less than 10% RSD for all chlorophyll, pheophytin, and SSC, and <15% for ammonium, nitrate, and nitrite. Salinity, hardness, and silica had RSDs less than the target of 5%, but phosphate was just outside that target with 5.1% RSD and flagged but not censored. Matrix spikes were used to assess accuracy, except for Chlorophyll a, Pheophytin, salinity, and SSC, which had no recovery checks. Recovery was generally good, with average recovery errors less than the 15% target for nitrogenous nutrients, except for ammonium (16% error). Recoveries were within the target <5% for hardness and silica, but phosphate recovery errors (14%) were above the target <10%. Ammonium and Phosphate were flagged as “VIU”, but not censored. Concentrations were in a similar range as previous years.

QA/QC for Trace Metals by Brooks Rand Labs LLC (BR)

Trace elements were analyzed in water samples by Brooks Rand. Detection limits were sufficient for most analytes; dissolved MeHg and Ag were non-detect in ~25% of samples, but otherwise method sensitivity was generally good with <10% NDs. Results were all blank corrected, and variation in the blanks was <MDL. Precision on lab replicates was good, with average RSDs <25% for all analytes. Recoveries on certified reference materials (CRMs) all averaged <25% error, so no flags were needed. There were a few samples for a few analytes where initially dissolved concentrations exceeded total concentrations by greater than the amount of combined analytical variability (>35%); on reanalysis, all of those results except one, which was flagged as rejected, were similar but reversed, suggesting mislabeling of the original subsamples analyzed by the lab. Average concentrations for 2010

were generally similar to the previous 5 years (2005-2009). Only dissolved Fe was much higher, about 3x the historical average, similar to the difference seen in 2009, and likely due to a change in the dissolved Fe analysis method starting 2009. An intercomparison study with the City of San Jose Environmental Services lab continues due to interest in the South Bay site specific copper objective. Results between the two labs generally correlated well, aside from the possibly mislabeled samples mentioned previously.

Organic Parameters

QA/QC for Trace Organics by AXYS Analytical Services Ltd. (AXYS)

The only organic compounds reported in water samples for 2010 were PBDEs, analyzed by AXYS Analytical. Detection limits reported were similar to those in 2009; of 49 congeners reported, about 20% (varying slightly between dissolved, particulate and total fractions) were not detected in over half the samples. Some analytes were measurable in blank samples from all fractions. For 8 of the analytes, blanks constituted a large portion (>1/3) of the reported field sample results in over half of the samples. PBDE Blank contamination is an ongoing challenge in analyses of low concentration samples like water given their ubiquity in modern urban environments. Analytical precision from field-replicate results was within the target <35% average RSD for most analytes, except three particulate fraction PBDEs (197, 207,and 208) and one dissolved fraction PBDE (203), flagged but not censored for RSDs between 35-70%. Recoveries of blank-spike samples (spiked with 8 analytes at ~50x the MDL) were good, with average error of 8% (ranging 0 to 14% for individual congeners), well within the target <35% error. Most of the PBDEs were found at similar concentrations as reported previously by RMP.

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3. SEDIMENT MONITORING

BACKGROUND

Since 1993, the Regional Monitoring Program for Water Quality in the San Francisco Estuary (RMP) has routinely monitored contaminants in surface sediments (top 5 cm) collected at stations throughout the San Francisco Estuary. The RMP underwent a programmatic change in 2002 and the sediment sampling component was changed from 26 targeted sites sampled annually to a randomized sampling design with 47 sites sampled annually, 40 random sites and 7 historic sites retained from the original sampling design. As discussed in the introduction in 2011, the Technical Review Committee (TRC) and Steering Committee (SC) recommended that sediment be sampled biennially. Sediments are monitored because they are a fundamental component of the Bay ecosystem and they play a key role in the fate and transport of contaminants. Sediments serve as contaminant sources and sinks, and most contaminants are usually found in concentrations orders of magnitude higher in the upper few centimeters of sediments than in the water column. Sediment contamination information is used in making decisions related to many important management concerns: the identification of sediment "toxic hot spots" and reference areas; the clean-up of numerous sites in the region that require information about background contaminant levels; and the continued dredging throughout the Estuary that requires testing and comparisons to a reference concentration. Information about sediments addresses several of the RMP questions listed in the *Introduction*. Beginning in 2011, sediment sampling will alternate biennially between wet season and dry season collections, with wet season collections limited to 27 sampling sites at which the full sediment quality triad will be analyzed. All sediment samples were collected aboard the R/V *Questuary* operated by Romburg Tiburon Center (RTC) during February 1 – February 12, 2010.

SITES

In 2010, RMP Status and Trends Program continued with implementation of the stratified, random sampling design started in 2002 (see Chapter 1, *Introduction*). Since 2002 sediment contaminant monitoring has been conducted each year during the dry season (September) at 47 stations, including seven targeted historical sites (Figure 3.1). Sediments are collected from 20 of the random sites and all seven historic sites for toxicity screening (Figure 3.2). In addition, benthos samples were collected at the same 27 sites. Station names, codes, coordinates, and sampling dates for the 2010 sediment monitoring effort are listed in *Appendix 4*. A map with the sampling sites is presented in Figure 3.1.

In order to allow for analysis of long-term temporal trends, repeat sampling of a subset of random sites and continued (yearly) monitoring of historic sites in each of the six regions is conducted. The Rivers Region has two historic sites, the Sacramento River (BG20) and the San Joaquin River (BG30). All other regions have one historic site each: Suisun Bay (Grizzly Bay - BF21), San Pablo Bay (Pinole Point - BD31), Central Bay (Yerba Buena Island - BC11), South Bay (Redwood Creek - BA41) and Lower South Bay (Coyote Creek - BA10). These seven historic sites were selected because they have long-term synoptic chemistry and toxicity measures associated with them (SFEI, 2005). Sites ending with 001S or 002S were randomly allocated during the initial restructuring of the sampling scheme in 2002 and are sampled annually while those ending in 003S and 004S are sampled every 5 years.

Every attempt is made to procure acceptable sediments from the target coordinates. Acceptable sediment consists of at least 60% fines and is determined by qualitative analysis. In the event that acceptable sediment is not able to be collected, the vessel is repositioned within a 100 m radius of the given coordinates. If sediment collection is still

unsuccessful, the sampling operations will proceed to the next scheduled site and the failed site will be replaced with the next site on the list of available alternative sites, referred to as an oversample site.

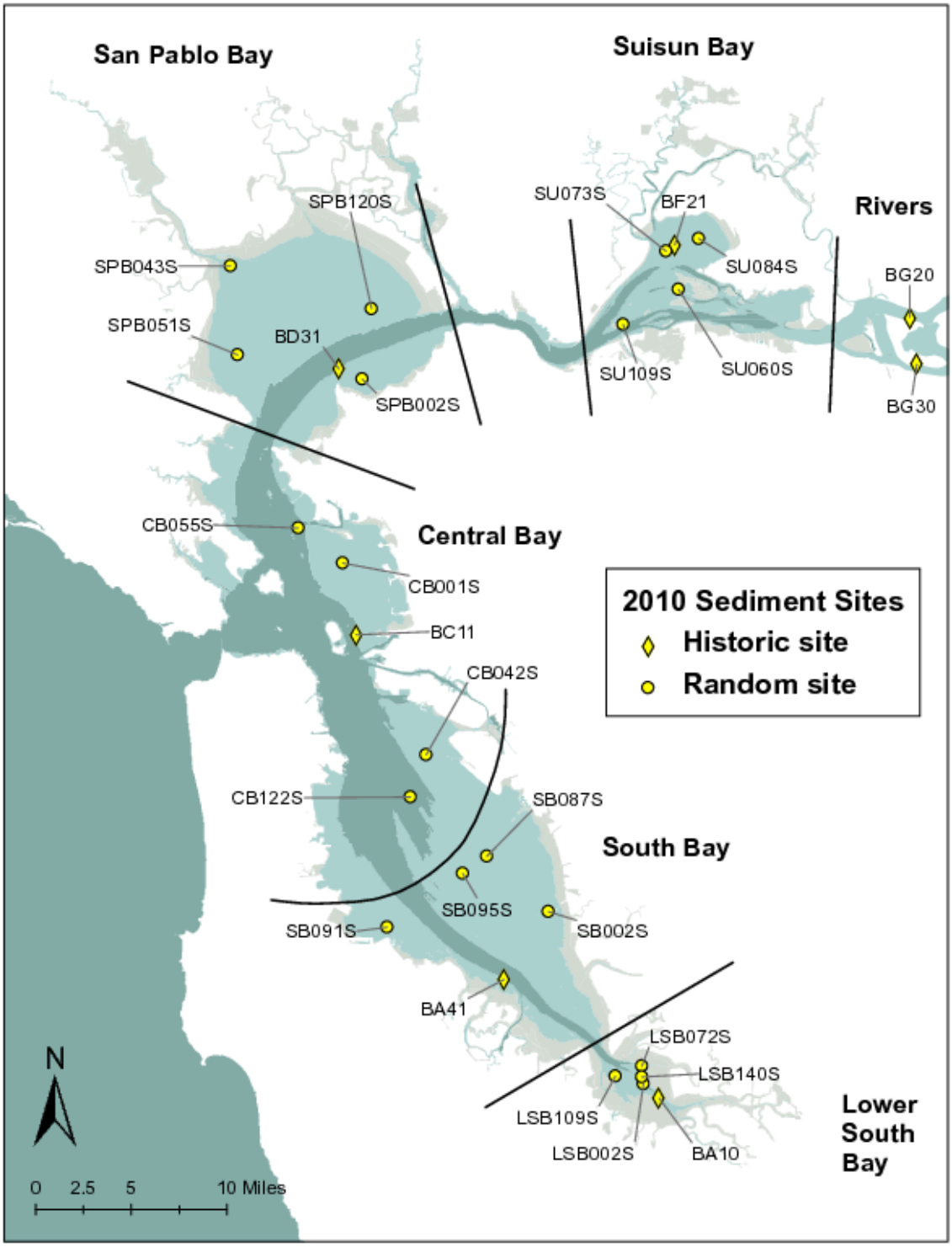

Figure 3.1 Map showing location of 2010 Sediment Stations

In 2008, one of the annual sites, SU001S, located in Suisun Bay, was permanently replaced with oversample site SU073S. Historically, SU001S was a sandy site which resulted in repeatedly failed attempts at obtaining acceptable grabs. The area was then subject to active dredging which changed the bottom profile significantly.

The cruise conducted in 2010 marked the first year of a new sampling scheme incorporating alternating wet and dry season sampling events, with a total of seven historical and twenty random sites samples in wet season years.

FIELD METHODS

Shipboard Measurements

Conductivity, Temperature, and Depth (CTD) measurements were taken by Applied Marine Sciences (AMS-CA) at each site. A Sea-Bird SBE19 CTD probe was used to measure water quality parameters at depths throughout the water column. At each site, the CTD probe was lowered to approximately one meter below the water surface and allowed to equilibrate to ambient temperature for 3 minutes. Following the sampling, the probe was then lowered to the bottom at approximately 0.15 meters per second and raised. However, only data from the down cast were kept. Data were downloaded onboard the ship and processed in the laboratory using Sea-Bird software.

The CTD probe measured temperature, conductivity, pressure, dissolved oxygen, and backscatter at a sampling rate of two scans per second. These data were compiled and averaged into 0.25 m depth bins during processing. At this time, salinity (based on conductivity measurements), and depth (based on pressure) were calculated from the recorded measurements. Although the CTD data are not available via the online Contaminant Data Display and Download tool (CD3), the RMP maintains these data in a database, and they are available upon request.

Oxidation-Reduction Potential (ORP) and pH shipboard measurements were taken by SFEI staff at each site. Two measurements of *in situ* pH were recorded onboard the sampling vessel by submerging a Hach™ pH probe directly into the sediment sample to approximately 1" in depth after the Van Veen grab was brought on deck. A total of four measurements (two from each grab) were recorded at each station. Measurement of sediment ORP was resumed in 2003, measured in a cored sub-sample of the Van Veen by probe inserted (WTW Sentix ORP, KCl electrolyte) to depths of 1 cm and 6 cm from the sediment surface, and 1 cm from the core bottom. The probe was equilibrated for 10 minutes before recording each measurement.

Sediment Sampling Field Methods

Multiple (two to three) sediment grabs were taken at each site, with sediment sub-samples collected for ancillary, chemical and toxicity analyses. Sediment samples were collected using a Young-modified Van Veen grab with a surface area of 0.1 m^2. The grab is made of stainless steel, and the jaws and doors are coated with Dykon® (formerly known as Kynar®) to make them chemically inert. All scoops, buckets, and stirrers used to collect and homogenize sediments are constructed of Teflon® or stainless steel coated with Dykon®. Sediment sampling equipment was thoroughly cleaned (sequentially with detergent, acid, methanol, and rinsed with ultrapure water) at each sampling location prior to each sampling event. In order to further minimize sample contamination, personnel handling samples wore gloves and employed clean hands techniques.

To ensure the quality of the sediment samples, each grab must satisfy several criteria in order to be accepted: complete closure, no evidence of sediment washout through the doors, even distribution of sediment in the grab, minimum disturbance of the sediment surface, and minimum overall sediment depth appropriate for the sediment type. Overlying water was drained off an accepted grab. At 27 of the stations, Surface Water Interface Core (SWIC)

samples were collected for toxicity testing using estuarine species. At 7 of these sites, the rivers sites and Suisun Bay sites, additional SWICs were collected for toxicity testing using freshwater crustaceans (*Ceriodaphnia dubia)*. Due to the area requirements associated with the collection of SWICs, no sediment for chemical analysis is able to be collected from these grabs. The top 5 cm of sediment was collected from each of the grabs (avoiding portions cored or probed) and placed in a compositing bucket to provide a single composite sample for each site. Between sample grabs, the compositing bucket was covered with aluminum foil to prevent airborne contamination. After all sediment grabs (or at least two if complications prevent collection of sufficient material within 20 minutes) were placed into the compositing bucket, the bucket was taken into the ship's cabin and thoroughly mixed to obtain a uniform, homogeneous mixture. Aliquots were subsequently split into appropriate containers for analysis of sediment quality, trace metals, trace organics, and toxicity analyses. Samples were also collected for trace metals archive and trace organics archive. Cruise Reports documenting RMP sampling events are available on our website.

Collection of Ancillary Parameters

The RMP analyzed sediments collected at 27 sites within the San Francisco Estuary for grainsize, percent solids, total organic carbon (TOC), and total nitrogen (TN). Moss Landing Marine Laboratories (MLM) conducted the grainsize analysis. Sediments for grainsize analysis were collected in Whirl-pak bags and were stored without refrigeration. Sediment samples collected for TOC, % solids and TN were analyzed by Columbia Analytical Services (CAS). Sediments for these analyses were collected in 60 ml glass jars and frozen at the end of the day.

Collection of Trace Element Parameters

Sediment was collected at 27 sites within the San Francisco Estuary for analysis of the trace elements aluminum (Al), cadmium (Cd), copper (Cu), iron (Fe), Manganese (Mn), nickel (Ni), lead (Pb), silver (Ag), zinc (Zn), and % solids by the City and County of San Francisco laboratory (CCSF). CCSF supplied factory cleaned I-Chem 200 series (or equivalent) 250 ml HDPE containers. After collection, samples were placed on dry ice and kept frozen until delivered to CCSF.

Analysis of additional trace elements arsenic (As), mercury (Hg), methylmercury (MeHg), selenium (Se), and % solids was conducted by Brooks Rand Ltd. (BR). BR provided I-Chem 300 series factory cleaned 250 ml HDPE containers. Due to special handling requirements, samples collected for methylmercury analysis were placed on dry ice within 20 minutes of collection. All other samples were placed on dry ice as soon as possible. All samples were kept frozen until analyses.

Sediment was collected at 27 sites for trace metal archive. After homogenization, sediment was put into 250 ml HDPE containers and stored on dry ice until they were placed into long term storage at -18°C.

Collection of Trace Organic Parameters

Sediment was collected at 27 sites for the analysis of the trace organics parameters polycyclic aromatic hydrocarbons (PAHs), polybrominated diphenyl ethers (PBDEs), polychlorinated biphenyls (PCBs), and pesticides by East Bay Municipal Utility District (EBMUD). EBMUD provided factory cleaned I-Chem 200 series (or equivalent) 250 ml glass containers. Samples were placed on dry ice immediately after collection and kept frozen until delivered to EBMUD.

Sediment was collected at 27 sites for analysis of pyrethroids at the California Department of Fish and Game Water Pollution Control Laboratory (CDFG-WPCL). Samples were collected in factory cleaned I-Chem 200 series (or equivalent) 250 ml glass containers and stored on dry ice after homogenization. Samples were kept frozen until analysis.

Sediment was collected for the analysis of dioxins at 27 sites by AXYS Analytical (AXYS). All samples were placed into factory cleaned 250 ml amber glass containers and kept frozen on dry ice until analysis.

Sediment was collected at 27 sites for trace organics and dioxins archive. After homogenization, sediment was put into 250 ml glass containers and stored on dry ice until they were placed into long term storage at -18°C.

Collection of Sediment for Toxicity Testing

Two types of samples were taken for analysis of sediment toxicity by the UC Davis Marine Pollution Studies Laboratory at Granite Canyon (UCD-GC). Whole sediments samples were taken from 27 stations for analysis of toxicity to *Eohaustorius estuarius*. Samples from 7 of the sites in the north east part of the estuary were additionally tested for toxicity using two freshwater species, *Hyalella azteca* and *Chironomus dilutus*. In 2008, the RMP reinstated collection of surface water interface cores (SWICs). This year, SWICs were collected at 27 stations for development tests using the bivalve *Mytilus galloprovincialis*. Additional SWICs were collected at 7 of the north east estuary stations for tests using freshwater species *Ceriodaphnia dubia*.

One liter plastic containers were provided by UCD-GC for the collection of homogenized sediment for the amphipod toxicity tests. Eight-inch cores were used to collect intact cores (~1.5 inches deep) for the SWIC toxicity tests. Each core was capped with a lid that contained air holes and sealed around the edges using parafilm. The cores were kept upright and stored in a refrigerator or on wet ice until analysis by UCD-GC.

All sampling containers were pre-cleaned by the lab using the following procedures: containers were scrubbed with dilute micro solution, rinsed with deionized water (DI), rinsed with hexane, and rinsed with DI again. The containers were then soaked for 24 hours in an acid bath, rinsed with DI and then soaked for 24 hours in a DI bath. Containers were rinsed again with DI water and placed in a drying oven overnight.

Collection of Sediment Benthos

The RMP collected benthos samples at the same 27 sites where sediment toxicity was tested. Samples were screened through 0.5 and 1.0 mm nested sieves while onboard ship. The material retained on the screen was placed in sample jars, and a solution of relaxant was added to the jar. After approximately 15 minutes, 10% sodium borate buffered formalin was added to fix each sample. Samples were rinsed and transferred from formalin to 70% ethanol 3-14 days after collection. Taxonomic identification of benthic organisms will be led by City and County of San Francisco – Oceanside Biology Laboratory (CCSF-OBL) with additional assistance from James Oakden (Moss Landing Marine Lab), and Susan McCormick.

Laboratory Methods for Sediment Analysis

SFEI contracts with a number of laboratories that provide high quality analytical services. Qualifications for our labs include ISO registration, NELAP accreditation and certification by the California Department of Public Health. A brief overview of the laboratory methods used for RMP target analytes are described below. SFEI maintains SOPs

for all laboratory analyses. Please contact Donald Yee donald@sfei.org or Cristina Grosso cristina@sfei.org for more details.

Percent Solids

Percent solids are the percent content by weight of solid material in a sediment sample. Brooks Rand LLC (BR) measured percent solids in sediment using Method SM 2540G. For this method, a solid sample was homogenized, then portioned, dried, measured, and the percent of dried solid material calculated.

City and County of San Francisco (CCSF) analyzed percent solids as part of their analysis of trace metals using a modification of EPA method 6020A. When analyzing for trace metals in sediment a separate homogeneous aliquot of the sample must be dried to determine total percent solids.

California Department of Fish and Game Water Pollution Control Laboratory (CDFG-WPCL) analyzed percent solids by a modification of EPA Method 8081B, as part of their analysis of pyrethroids. Sediment was weighed and allowed to dry in an oven at 70° C for 24 hours to determine moisture content. This result was later converted into percent solids.

AXYS Analytical analyzed percent solids using proprietary method MLA-017 in combination with the analysis of dioxins and furans. EBMUD analyzed percent solids using EPA Method 160.3 as part of the analysis of trace organics and CAS analyzed percent solids using EPA Method 1684 on combination with TOC and TN.

Grainsize

Grainsize analysis prior to 2008 was conducted by the University of California Santa Cruz – Department of Environmental Toxicology (USCS-DET). In 2008 grainsize determination changed to an optical method and was analyzed by Moss Landing Marine Lab - Geological Oceanography (MLML-GeoOc) using a Beckman-Coulter laser particle size analyzer after digestion with hydrogen peroxide according to Aiello and Kellett (2006). In addition to silt (0.0039 to <0.0625 mm) and sand (0.0625 to <2.0 mm), granule and pebble (2.0 to <64 mm) and clay particles (<0.0039 mm) were also analyzed with the LS 13 320 laser particle sizer in 2010.

Total Organic Carbon (TOC) and Total Nitrogen (TN)

Analysis of TOC and TN was performed by Columbia Analytical Services (CAS) using EPA 440. The samples were prepared for analysis by air drying followed by grinding in a mini ball mill. All samples were then analyzed for TOC and TN on HCL acidified samples using combustion at 950°C with thermoconductivity detection.

Trace Metals

Trace metals in sediment were analyzed by the City and County of San Francisco (CCSF) and Brooks Rand Ltd. (BR).

Total trace metals analyzed by CCSF consisted of aluminum (Al), cadmium (Cd), copper (Cu), iron (Fe), lead (Pb), manganese (Mn), nickel (Ni), silver (Ag) and zinc (Zn). These metals were measured using a modification of the EPA digest method 3050B, and modified EPA analysis method 6020A. For the digestion of samples, a representative 1 – 2 gram (wet weight) or 1 gram (dry weight) sample was digested with repeated additions of nitric acid (HNO_3) and hydrogen peroxide (H_2O_2). Samples were analyzed using Inductively Coupled Plasma-Mass Spectrometry (ICP-MS).

Sediments were analyzed for mercury by BR using a modified version of EPA Method 1631. Samples were digested in HNO_3 and H_2SO_4, and then further oxidized with bromine monochloride (BrCl). Samples were analyzed with stannous chloride ($SnCl_2$) reduction, single gold amalgamation and cold vapor atomic fluorescence spectroscopy (CVAFS) detection using a BR Model III CVAFS Mercury Analyzer. All sample results for low-level mercury analysis were blank corrected.

Arsenic and selenium concentrations were measured in sediments using proprietary method BR-0020 Rev 007 by BR. Samples were first oxidized by heating with specific reagents. For the analysis of arsenic, sample concentrations were determined by hydride generation – cryogenic trapping – atomic absorption spectrometry (HG-CT-AAS). For the determination of selenium, samples were reduced in HCl with addition of hydroxylamine hydrochloride (NH_2OH HCl) and heating, converting all selenium to Se(IV). After that HG-CT-AAS was performed.

Methylmercury in the sediment samples was analyzed by BR using a modified EPA Method 1630. The sediment samples were prepared by acid bromide/methylene chloride extraction. The samples were analyzed by aqueous phase ethylation, Tenax trap collection, gas chromatography separation, isothermal decomposition, and cold vapor atomic fluorescence spectroscopy (CVAFS).

Trace Organics

In 2008, pyrethroids were added to the suite of organic contaminants monitored in sediments by the RMP in order to investigate the potential toxicity of pyrethroids in the bay. In 2009 analysis was again conducted by California Department of Fish and Game Water Pollution Control Laboratory (CDFG-WPCL). Samples were prepared using an automated extraction system and analyzed using a modified version of EPA 8081B by dual column gas chromatography with dual electron capture detectors (GC-ECD) and/or gas chromatography with triple quadruple mass spectrometry (GC-MSMS).

Sediment organics were analyzed by EBMUD. Samples are generally analyzed based on the methods followed by the National Oceanic and Atmospheric Administration's (NOAA's) National Status and Trends Program. PAHs were analyzed using gas chromatography/mass spectrometry (GC/MS), and PCBs, PBDEs, and organochlorine (OC) pesticides were analyzed using high resolution gas chromatography – mass spectrometry (HRGC-MS).

EBMUD used the following extraction and concentration procedure for all sediment trace organic compounds of interest. Samples were homogenized and then extracted using a Dionex Accelerated Solvent Extraction (ASE; EPA Method 3545). The sample extracts were dried with anhydrous granular Na_2SO_4. Extracts were cleaned up with an alumina/copper column and concentrated to 1 ml in dichloromethane (DCM).

Just prior to analysis of PAHs the sample extracts were spiked with deuterated internal standards (fluorine-d10 and benzo[a]pyrene-d12). PAHs were then analyzed using U.S. EPA Method 8270, which was slightly modified to provide sufficient sensitivity for PAHs in sediments.

Samples were analyzed for OC pesticides using a modification of EPA method 1668A. Just prior to analyses, injection internal standards were added to the sample extracts, and then an aliquot of the extract was injected into the gas chromatograph. The analytes were separated by the gas chromatograph and detected by a high resolution (>8,000) mass spectrometer (HRMS). Two exact mass-to-charge ratios (m/z's) were monitored throughout a predetermined detention time.

Samples were analyzed for PCBs using EPA Method 1668A. A cleanup standard was spiked into the extract prior to analyses. The extract was then put through a drying column and concentrated. After drying and concentrating, the samples were cleaned up using gel permeation and activated alumina column chromatography. After cleanup, the solvent was exchanged to hexane. Injection internal standards were added to each extract before injection into the gas chromatograph. The analytes were separated by gas chromatography and detected by a high-resolution (>10,000) mass spectrometer (HRMS). Similar to the oc-pesticide analyses, two exact m/z's were monitored throughout a predetermined detention time.

Sediments were analyzed for PBDEs using a modification of EPA method 1614. A cleanup standard was spiked into the extract, which was then dried and concentrated. The samples were then purified using an activated alumina column, and the solvent in the samples was exchanged to hexane. Just prior to the analysis, injection internal standards were added to each extract and an aliquot was injected into the gas chromatograph. Similar to OC pesticides and PCB analyses, the PBDE congeners were separated by the gas chromatograph and detected by a high-resolution (>5,000) mass spectrometer (HRMS) with two exact m/z's monitored for each compound.

Starting in 2008, sediment samples were also analyzed for polychlorinated dibenzodioxins and furans. The analysis was conducted by AXYS Analytical Laboratory using AXYS MLA-017 Rev 16. Extraction and analysis procedures were in general in accordance with USEPA Method 1613, Revision B using isotope dilution and a high-resolution mass spectrometer (HRMS) coupled with a high-resolution gas chromatograph (HRGC) equipped with a DB-5 capillary chromatography column. A second column was used for confirmation of specific congener identification.

Table 3.1 Target Sediment Analytes: A summary table of the 2010 target analytes, analytical laboratories, reporting units, and method codes.

Parameter	Lab(s)	Reporting Unit	Method Code(s)
Depth	AMS-CA	m	NA
pH (porewater, interstitial sediment)	AMS-CA	pH	NA
Dioxins/Furans	AXYS	Pg/g	EPA 1613B Mod.
Arsenic (As)	BR/CCSF	mg/Kg	EPA 1638 Mod./ EPA 6020A Mod.
Mercury (Hg)	BR/CCSF	mg/Kg	EPA 1631/ EPA 6020A Mod.
% solids	BR/CCSF/CDFG/MLML	%	Various
Selenium (Se)	BRL/CCSF	mg/Kg	EPA 1638 Mod/ EPA 6020A Mod.
Mercury, Methyl (MeHg)	Brooks Rand Laboratory	µg/Kg	EPA 1630 Mod.
Total Organic Carbon	CAS	%	EPA 440
Total Nitrogen	CAS	%	EPA 440
Aluminum (Al)	CCSF	mg/Kg	EPA 6020A Mod.
Cadmium (Cd)	CCSF	mg/Kg	EPA 6020A Mod.
Cobalt (Co)	CCSF	mg/Kg	EPA 6020A Mod.
Copper (Cu)	CCSF	mg/Kg	EPA 6020A Mod.
Iron (Fe)	CCSF	mg/Kg	EPA 6020A Mod.
Lead (Pb)	CCSF	mg/Kg	EPA 6020A Mod
Manganese (Mn)	CCSF	mg/Kg	EPA 6020A Mod.
Nickel (Ni)	CCSF	mg/Kg	EPA 6020A Mod.
Silver (Ag)	CCSF	mg/Kg	EPA 6020A Mod.

Parameter	Lab(s)	Reporting Unit	Method Code(s)
Zinc (Zn)	CCSF	mg/Kg	EPA 6020A Mod.
Pyrethroids	CDFG-WPCL	µg/Kg	EPA 8081B Mod.
PAHs (Low and High Molecular Weight, Alkylated)	EBMUD	µg/Kg	EPA 8270
Cyclopentadienes	EBMUD	µg/Kg	EPA 1668A Mod.
Chlordanes	EBMUD	µg/Kg	EPA 1668A Mod.
DDTs	EBMUD	µg/Kg	EPA 1668A Mod.
HCHs	EBMUD	µg/Kg	EPA 1668A Mod.
Other Synthetic Biocides (Hexachlorobenzene, Mirex)	EBMUD	µg/Kg	EPA 1668A Mod.
PCBs	EBMUD	µg/Kg	EPA 1668A
PBDEs	EBMUD	µg/Kg	EPA 1614 Mod.
Grainsize	MLML-GeoOc	%	Beckman-Coulter Laser Particle Size Analyzer
Sediment Toxicity – (Amphipod) Mean % Survival	UCD-GC	%	EPA 600/R-94-025
Sediment Toxicity – (Bivalve) Mean % Normal Alive	UCD-GC	%	EPA 600/R-95-136M
Sediment Toxicity – Fresh Water *H. azteca*	UCD-GC	%	EPA 600/R-99-064
Sediment Toxicity – Fresh Water *C. dubia*	UCD-GC	%	EPA 821/R-02-012M
Sediment Toxicity – Fresh Water *C. dilutus*	UCD-GC	%	EPA 600/R-99-064

Quality Assurance/ Quality Control (QA/QC)Ancillary Parameters

QA/QC of Percent Solids

Percent solids were measured individually along with analyzed samples by all chemical analytical labs in order to determine chemical concentrations on a dry weight basis. Variations of a few percent among subsamples between labs (and within labs for replicates) frequently result due to slight heterogeneity within samples.

QA/QC of Grain Size by Moss Landing Marine laboratory

Starting in 2008, grainsize for particles <2mm was determined by an optical (laser scattering) method, which measures particle size distribution as a percentage of volume (rather than mass from sieving and weighing methods in prior years). Currently, the larger than sand fraction >2mm (typically bivalve shells and shell fragments) was determined as a percentage of bulk sediment mass, with the size distribution of the remaining (<2mm) fraction determined by the optical method. Comparisons of optical versus sieving/weighing particle size distribution determinations in the literature have shown good agreement for deep marine sediments, although RMP split samples measured by weighing have shown mixed agreement between methods (% fines within 10% for most samples, but up to 30% difference in some cases). The laboratory has switched to a wet sieving method for comparison of weighed split samples to the optical method, which shows fewer artifacts of aggregation than drying before sieving. For the optical method, reproducibility with splits from a single sample were generally good, averaging ~5% difference among replicate measurements of subsamples from collected sediments. The lab has also implemented a procedure of performing the optical analyses in replicate for all samples. Although most

samples are fairly homogeneous, the replicate measurements will help identify the most heterogeneous samples as well as providing a better measurement of their average characteristics.

QA/QC of Total Organic carbon and Total Nitrogen by Columbia Analytical Services (CAS)

Measurements of sediment total organic carbon (TOC) and total nitrogen (TN) showed no major issues. All TOC results were above the method detection limit of 0.01% (similar to previous years). Detection limits for TN were 0.01% as in 2009, with around 10% of samples not detected. Neither TOC nor TN was measured in blanks. Accuracy and precision of QC sample measurements were within the average recovery error and RSD (relative standard deviation) targets of 15% for TN and 5% for TOC. Several different laboratories have analyzed sediment ancillary measures for RMP in the past several years, but results were generally within similar concentration ranges as previous years, so any analytical bias of changing labs is likely fairly small.

QA/QC of Trace Metals

Sediment sample trace elements other than As, Hg, and Se were measured at the City and County of San Francisco (Southeast Wastewater Treatment Plant Laboratory). Concentrations were above detection limits in sediment samples for all target elements. Target analytes detected in blank samples included Ag, Cr, and Ni, but at concentrations only slightly higher than detection limits, so no results were censored. Precision on replicates was good, with RSDs <25% for all target analytes. Recoveries on reference material samples were good for most analytes, with a Cr average error at 38% outside the range (25%) but not censored, but Al greatly outside (>50%) and censored (not reported). Since the RMP is focused on biological toxicity rather than geological composition of sediments, the laboratory uses a near total rather than true "total" metals (HF acid) digestion, so resistant mineral phase elements such as Al are often not fully recovered. Average concentrations of target elements were around 80-100% of previous years' RMP averages.

Brooks Rand measured As, Hg, MeHg, and Se in sediment samples, with generally good data quality. There was only one sample with Se not detected. Field sample results were reported blank corrected; no target analytes were detected in blanks above the detection limit. Precision on lab replicates of field samples was good, with RSDs on lab replicates averaging <10% for all analytes. Precision on other sample types analyzed in replicate (certified reference materials (CRM), matrix spikes (MS), and blank spikes) was not as good, but still within target values (<35%). Average error on CRM recovery (<15%) was within target (<35%), and for MS results only Se was out of range at 37%. However, because recoveries on the CRM, a preferred measure of recovery given external validation, were good for Se, no flags were added. Average concentrations of data in 2010 were somewhat similar past years. For Hg and Se, the average concentration in 2010 fell close to the interannual (2005-2009) average±1 sd (standard deviation). Arsenic was a bit above that range (1.5 sd), and methyl mercury almost 2 sd lower. Sampling wet season in 2010 may have contributed to lower MeHg concentrations, but MeHg was within the 95% confidence interval of the annual means, which could just represent inter-annual variation rather than a seasonal bias.

QA/QC of Trace Organics

PAHs, PBDEs, PCBs, and pesticides were reported by the East Bay Municipal Utility District laboratory. Detection limits were sufficient for most analytes, with about a dozen each of the less prevalent alkylated PAHs, PCBs, and

PBDEs (about 10% of the analytes) not detected in over half the samples. About one-third of the analytes reported were measured in one or more blanks, but their concentrations were generally small compared to those in field samples. Only 4 analytes had more than 50% of field samples censored for blank contamination contributing a significant portion (>1/3) of the field sample concentration: PCBs 104, 186, 192, and PBDE 010. Average precision from lab replicate analyses was generally good (<35% RSD), except for a few PCBs (94, 152, 155, 184) and fipronil sulfone flagged for being moderately outside the target (35-70% RSD), and only PBDE 010 and PCB 145 were censored for poor precision (RSD >70%). In general recovery was good (average error <35%), with only p,p'-DDT and trans-nonachlor flagged for recoveries moderately out of their certified values (35-70% error) in CRMs, and fipronil sulfone and PBDEs 196 and 209 flagged but not censored for moderate errors in matrix spike recovery. Only fipronil was censored for poor recovery (>70% average error) in the matrix spikes. Although measured concentrations of other analytes differed from reference values in CRMs, as those values were not certain (certified), they were not used in flagging or censoring of analytes. Most of abundant analytes were in the same general concentration range as previous years (within ~50% of the previous 5 years' average).

A change in reporting (but not in analytical) methods for 2010 resulted in the inclusion of a Sum of 208 PCBs. This change was made due to the identification and specific quantitation of PCB 11, a by-product of organic dye production. PCB 11 is not highly toxic, and differs from Aroclor mixture (intentionally synthesized) PCBs, in that it is not produced with notable amounts of the coplanar (dioxin-like) PCB congeners, which are the cause of nearly all the risk associated with PCBs. The sum of 208 PCBs (that is, excluding PCB 11) is expected to show better correlation and thus be a better surrogate measurement of the presence of the toxic dioxin-like PCBs.

The California Department of Fish and Game lab at Rancho Cordova measured sediment concentrations of 14 pyrethroid analytes (some co-eluting compounds that could not be resolved). Detection limits and frequencies of detection were similar to 2009, with slightly over half the analytes not detected in all samples. No blank contamination was observed. Average precision values (RSDs) from lab replicate analyses were good (<35% RSD) for the analytes that were detected at quantitative (at least 3xMDL) levels. No sediment reference materials are available for pyrethroids, so matrix spikes were used to evaluate recovery, with mostly good results (average error <35%), and only Resmethrin being flagged but not censored for recovery moderately outside the target (35-70% error). Most of the analytes were in the same general concentration range as the 2009 results, although bifenthrin, one of the most abundantly found pyrethroids in 2009, was not measurable in any of the 2010 wet season samples.

QA/QC for Sediment Toxicity

Whole sediment and sediment-water interface toxicity tests were performed the University of California Davis Marine Pollution Studies Lab. Samples in one of the two batches of samples used for sediment toxicity tests exceeded the lab recommended holding time limit of 14 days (flagged in the results), but the lab did not believe the longer hold times had a significant impact on the toxicity testing results. Some water quality measures were outside the recommended organism tolerance range as outlined by the test protocol and were qualified; the criterion that failed most often was conductivity/salinity, with one exceedance of the pH lower limit. However, the lab stated that these deviations alone were not sufficient to alter test results by causing observed responses (mortality, etc.)

SEDIMENT TOXICITY

Two types of sediment bioassays were conducted at 27 of the RMP stations in 2010 (Figure 3.2). Homogenized whole-sediment was tested for toxicity using the amphipod *Eohaustorius estuarius* in the 10-day amphipod survival test (EPA 600/R-94-025). Sediment was re-homogenized in the sample jars by placing them on a rolling apparatus and manually stirring with a polypropylene spoon. Samples were then distributed to replicate test beakers. Overlying water was added to the test containers, and sediment was allowed to equilibrate overnight before the amphipods were added. Randomly selected amphipods were placed into replicate containers and allowed to burrow into the test sediments. Amphipods were exposed to whole sediment for ten days with percent survival as the endpoint. The negative control for the *E. estuarius* solid-phase test consisted of home sediment, which was clean, well-sorted fine-grained sand collected at the same place and time as the test amphipods.

Surface-water interface (SWI) cores were tested using the bivalve *Mytilus galloprovincialis* in a 48-hour static embryo-larval development toxicity tests (EPA 600/R-95-136M). SWI cores were prepared for analysis by adding overlying water and allowing the cores to equilibrate overnight. Bivalve embryos were added by placing a 25 µm screen tube into each core. At the end of each test the larvae were isolated from the cores by removing the screen tubes and rinsing the larvae into20 ml scintillation vials. The contents were preserved with formalin. The mussel larvae were counted to determine the percentage of embryos that developed into live normal larvae. The negative controls for the *M. galloprovincialis* tests consisted of SWI cores filled with clean home sediment as described above.

A sample was considered toxic if:

1. There was a significant difference between the laboratory control and test replicates using a separate variance t-test (alpha = 0.01), and

2. % survival for amphipods or % normal alive for bivalves was less than the evaluation threshold of effect (the Control minus the MSD). The difference between the mean endpoint value in the control and the mean endpoint value in the test sample was greater than the 90th percentile minimum significant difference (MSD).

A sample must meet both criteria to be considered toxic, because a t-test can often detect small differences between samples when there is low variance among laboratory replicates. One way to ensure that statistical significance is determined based on large differences between means, rather than on a small variation among replicates, is to use the MSD. MSD is a statistic that indicates the difference between the two means (the mean of the sample and control replicates) that will be considered statistically significant given the observed level of among-replicate variation and the alpha level chosen for the comparison. MSD values generated from RMP *E. estuarius* and *M. galloprovincialis* tests were used by UCD-GC to establish a 90th percentile MSD threshold. This analysis indicates that the *E. estuarius* test is capable of identifying statistically significant differences in 90% of cases, where the difference between the treatment and the control is 18.8%. The threshold is calculated by subtracting 18.8% from the control response. The bivalve larvae 90th percentile MSD is 15.2% (Phillips *et al*., 2001). The control responses for the amphipod test were 93% and 96%, and the toxicity thresholds were 74.2% and 77.2%. Control responses for the bivalve larvae test were 83.6% and 89.3%, and the toxicity thresholds were 68.4% and 74.1%.

Sediments were not toxic to amphipods, *Eohaustorius estuaries*, or mussel, *Mytilus galloprovincialis*, larvae at 6 out of 27 stations (Figure 3.2). Amphipod toxicity was observed at 19 stations: Suisun Bay (Grizzly Bay (BF21), SU060S, SU073S, and SU084S), San Pablo Bay (Pinole Point (BD31), SPB002S, and SPB043S), Central Bay (Yerba

Buena Is. (BC11), CB001S, CB042S, CB055S, and CB122S), South Bay (Redwood Creek (BA41), SB002S, SB087S, SB091S, and SB095S), and Lower South Bay (Coyote Creek (BA10) and LSB109S). Sediment samples from six stations were toxic to larval mussels: Sacramento River (BG20), San Joaquin River (BG30), Suisun Bay (Grizzly Bay (BF21) and SU060S), Central Bay (CB001S), and South Bay (SB091S). A toxic sample indicates the potential for biological effects to estuarine organisms. However, since sediments contain numerous contaminants, it is difficult to determine which contaminant(s) may have caused the observed toxicity. Further laboratory tests, Toxicity Identification Evaluations (TIEs), are required to investigate the potential causes of an observed toxic hit.

The RMP only performs TIEs on sediments that have less than 50% survival (or normal-development). The RMP program managers authorize these additional studies on a case-by-case basis based on the annual bioassay results. No sediment TIEs were performed in 2010. The Exposure and Effects Work Group (EEWG) recommended that work to address the causes of the observed toxicity be continued over the next five years, and recommended a workgroup process to develop and oversee new studies. Please see the report RMP Sediment TIE Study 2007-2008 for a more detailed account of the initial study, and the EEWG website for an update on new RMP special studies addressing current issues related to the causes of toxicity.

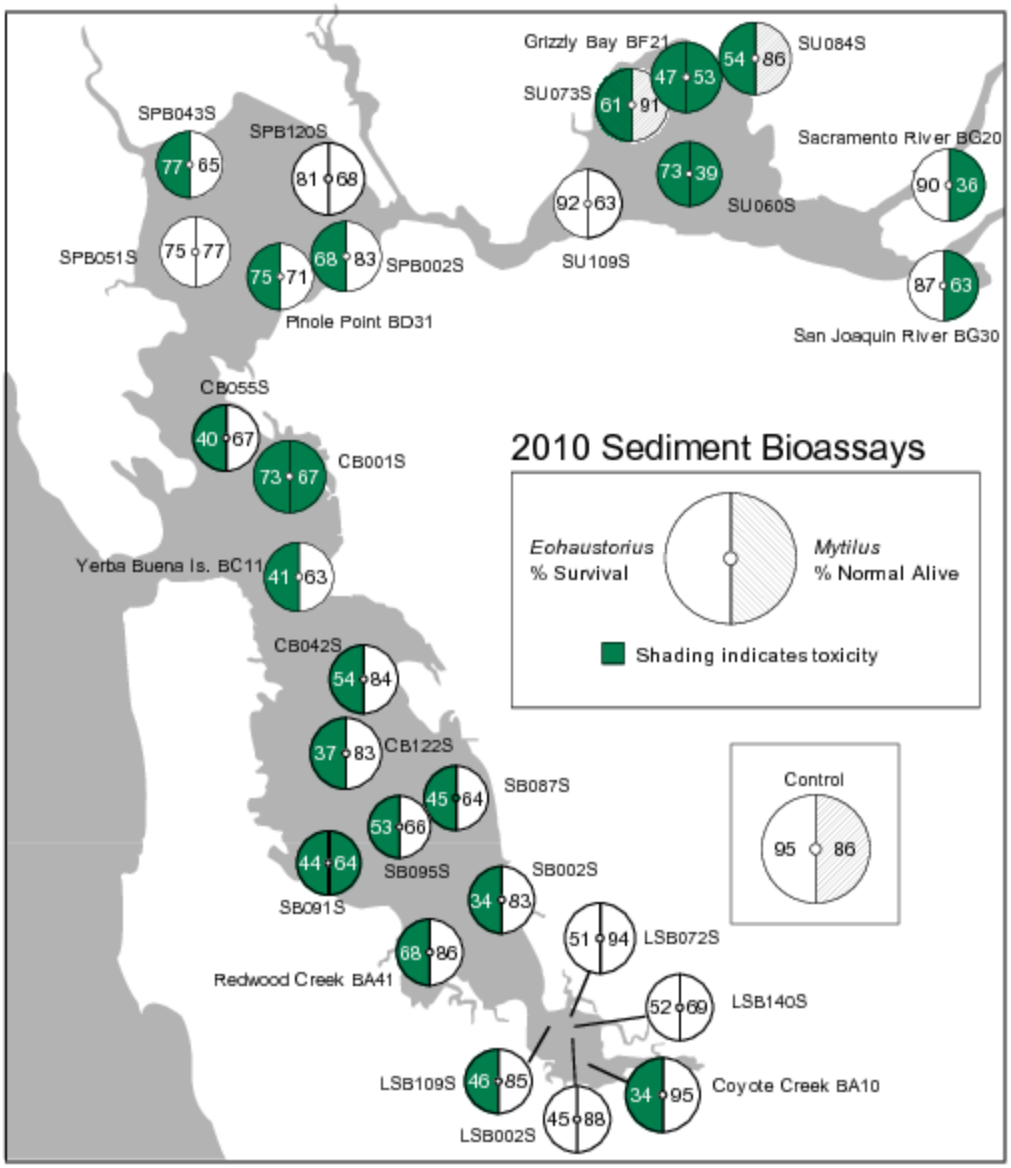

Figure 3.2 Sediment bioassay results for 2010.

ASSESSMENT OF SEDIMENT QUALITY

Estuary sediments are evaluated through comparisons to several sets of sediment quality guidelines (Table 3.2). Although these guidelines hold no regulatory status, they provide concentration guidelines that are useful in assessing the potential for toxic and benthic effects.

Table 3.2 Sediment Quality Guidelines (dry weight basis)

Effects Range-Low (ERL) and Effects Range-Median (ERM) values from Long *et al.* (1995, 1998).
Effects Range-Low; values between this and the ERM are in the possible effects range.
Effects Range-Median; values above this are in the probable effects range.

San Francisco Bay Ambient Sediment Concentrations (ASC) from Gandesbery *et al*. (1999).
Ambient sediment levels from background sediments in the Estuary allow one to assess whether a site has elevated levels or is "degraded".

Background sediment concentrations for selected trace elements in the San Francisco Bay, from Hornberger *et al*. (1999)
Chromium and nickel concentrations observed throughout the core. All trace elements, except Ag, measured by Inductively Coupled Argon Plasma Emission Spectroscopy (ICAPES). Ag measured by Graphite Furnace Atomic Absorption Spectrometry (GFAAS).
Near total metals are extracted with a weak acid for a minimun of one month, therefore, concentrations approximate the bioavailability of these metals to Estuary biota.

Parameter	unit	ERL	ERM	ASC-sandy <40% fines	ASC-muddy >40% fines	Background Concentrations (Bay wide ranges)	
						Total	Near Total
Arsenic	mg/Kg	8.2	70 †	13.5	15.3		
Cadmium	mg/Kg	1.2	9.6 †	0.25	0.33		
Chromium	mg/Kg	81	370 †	91.4	112	110 - 170	70 - 120
Copper	mg/Kg	34	270 †	31.7	68.1	20 - 55	20 - 41
Mercury	mg/Kg	0.15	0.71 †	0.25	0.43		0.05 - 0.07
Nickel	mg/Kg	20.9	51.6	92.9	112	70 - 100	50 - 100
Lead	mg/Kg	46.7	218 †	20.3	43.2	20 - 40	10 - 20
Selenium	mg/Kg			0.59	0.64		
Silver	mg/Kg	1	3.7 †	0.31	0.58	0.7 - 0.11	0.7 - 0.11
Zinc	mg/Kg	150	410 †	97.8	158	60 - 70	50 - 100
Sum of HPAHs (SFEI)	µg/Kg	1700	9600	256	3060		
Fluoranthene	µg/Kg	600	5100 †	78.7	514		
Perylene	µg/Kg			24	145		
Pyrene	µg/Kg	665	2600 †	64.6	665		
Benz[*a*]anthracene	µg/Kg	261	1600 †	15.9	244		
Chrysene	µg/Kg	384	2800 †	19.4	289		
Benzo[*b*]fluoranthene	µg/Kg			32.1	371		
Benzo[*k*]fluoranthene	µg/Kg			29.2	258		
Benzo[*a*]pyrene	µg/Kg	430	1600 †	18.1	412		
Benzo[*e*]pyrene	µg/Kg			17.3	294		
Dibenz[*a,h*]anthracene	µg/Kg	63.4	260 †	3	32.7		
Benzo[*g,h,i*]perylene	µg/Kg			22.9	310		
Indeno[1,2,3-*c,d*]pyrene	µg/Kg			19	382		
Sum of LPAHs (SFEI)	µg/Kg	552	3160	37.9	434		
1-Methylnaphthalene	µg/Kg			6.8	12.1		
1-Methylphenanthrene	µg/Kg			4.5	31.7		
2,3,5-Trimethylnaphthalene	µg/Kg			3.3	9.8		
2,6-Dimethylnaphthalene	µg/Kg			5	12.1		
2-Methylnaphthalene	µg/Kg	70	670 †	9.4	19.4		
Naphthalene	µg/Kg	160	2100 †	8.8	55.8		
Acenaphthylene	µg/Kg	44	640 †	2.2	31.7		
Acenaphthene	µg/Kg	16	500 †	11.3	26.6		
Fluorene	µg/Kg	19	540 †	4	25.3		
Phenanthrene	µg/Kg	240	1500 †	17.8	237		
Anthracene	µg/Kg	85.3	1100 †	9.3	88		
Sum of PAHs (SFEI)	µg/Kg	4022	44792	211	3390		
p,p'-DDE	µg/Kg	2.2	27 †				
Sum of DDTs (SFEI)	µg/Kg	1.58	46.1 †	1.58	46.1		
Total Chlordanes (SFEI)	µg/Kg	0.5	6	0.42	1.1		
Dieldrin	µg/Kg	0.02	8	0.18	0.44		
TOTAL PCBs (NIST 18)	µg/Kg			5.9	14.8		
Sum of 40 PCBs (SFEI)	µg/Kg	22.7	180 †	8.6	21.6		

† Values used to calculate mean ERM quotients (Hyland *et al*. 1999).

Sediment contamination and toxicity results were used to evaluate the quality of the 2010 Regional Monitoring Program samples (Table 3.3). Sediment contamination was estimated for each site by considering the number of contaminants in a sample that exceeded the San Francisco Estuary Ambient Sediment Concentration (ASC: Gandesbery *et al.*, 1999), Effects-Range guidelines (ERL and ERM: Long *et al.*, 1995), and the ERM quotients (Long *et al*., 1998). The number of sediment contaminants above the ERL or ERM guidelines has been used previously to predict potential biological effects (Long *et al*., 1998). Long *et al*. (1998) found that samples with more than four ERM exceedances showed toxicity in 68% of amphipod tests, while 51% of samples were toxic to amphipods when more than nine ERLs were above the guidelines. Based on these results the 2010 RMP sediment samples were considered potentially toxic if either four or more ERMs, or nine or more ERLs were exceeded. Samples that did not have values for at least 80% of the parameters (24 of 30 for ERL and ERM) were not included in the calculations. The number of contaminant concentrations above ASC guidelines could not be determined as the 2010 sediment grain size analysis results were not available.

ERM values were used to calculate a mean ERM quotient (mERMq) for each sample. The mERMq has been used in previous RMP reports and San Francisco Estuary publications as an index of cumulative sediment contaminant concentrations (Thompson *et al.*, 1999; Hunt *et al*., 2001a,b; Fairey *et al*., 2001; Thompson and Lowe, 2004). The primary reason for using the mERMq is that it provides a measure of potential additive contaminant effects. For example, amphipod survival has been found to be significantly and inversely correlated to mERMq (Thompson *et al.*, 1999), suggesting that contaminants individually present in relatively low concentrations in sediments may act together to adversely influence amphipod survival. In past reports and publications, however, the mERMq has been calculated in several different ways. However, if comparisons to other U.S. estuaries are to be accomplished, a standard method of calculation is necessary. Therefore, the calculation of mERMq was changed in order to make the RMP ERM quotients comparable to other studies from around the U.S. (Hyland *et al.*, 1999; Long *et al*., 2002; Hyland *et al.*, 2003). The 2010 mERMqs were calculated using 24 parameters as indicated in Table 3.2 per the Hyland method (Hyland *et al.*, 1999). Samples that did not have at least 19 of the 24 parameters were not included in the calculations. Twenty-three analytes were reported for all 2010 sediment samples.

Long *et al*. (1998) showed that 49% of sediment samples were toxic to amphipods when mERMq values were greater than 0.5, and 71% of samples were toxic when mERMq values were greater than 1.0. Mean ERM quotients, calculated with 24 contaminants, were used in a previous study of the San Francisco Estuary in which values greater than 0.15 were associated with increased risks of benthic impact (Thompson and Lowe, 2004). These values were used to evaluate the 2010 RMP sediment samples for potential adverse ecological effects.

In 2010, four stations were considered potentially toxic by the RMP (CB001S, CB122S, LSB002S, and SB091S) because nine or more contaminant concentrations were above the ERL guidelines. No stations sampled in 2010 had four or more contaminant concentrations above the ERM guidelines (Table 3.3). Only one station had a mERMq value greater than 0.15 (SB091S) and at least 9 results above the ERL guidelines (Table 3.3).

Sediment evaluations are useful tools that incorporate sediment contamination and toxicity into a weight of evidence assessment of the condition of sediments in the Estuary. Each component is analyzed independently and weighted equally, but although they should be related the results do not always agree. The complexity of sediment evaluations demonstrate the need to consider as much data as possible in assessing the condition of Estuary sediments and the importance of performing future studies to reconcile and understand the observed contradictions.

Table.3.3 Summary of sediment quality for the RMP in 2010

na = 2010 Grain Size data not available

Code	Site Name	Date	% Fines	mERMq	No. of ASC above Guidelines	No. of ERL above Guidelines	No. of ERM above Guidelines	Toxic to Amphipods?	Toxic to Bivalves?
BG20	Rivers	2/10/10	na	0.0244	na	2	1	no	yes
BG30	Rivers	2/10/10	na	0.0535	na	4	1	no	yes
BF21	Suisun Bay	2/9/10	na	0.0723	na	7	1	yes	yes
SU060S	Suisun Bay	2/9/10	na	0.0555	na	6	1	yes	yes
SU073S	Suisun Bay	2/9/10	na	0.0715	na	6	1	yes	no
SU084S	Suisun Bay	2/9/10	na	0.0671	na	7	1	yes	no
SU109S	Suisun Bay	2/9/10	na	0.0203	na	1	1	no	no
BD31	San Pablo Bay	2/8/10	na	0.0745	na	7	1	yes	no
SPB002S	San Pablo Bay	2/8/10	na	0.0696	na	6	1	yes	no
SPB043S	San Pablo Bay	2/8/10	na	0.0724	na	6	1	yes	no
SPB051S	San Pablo Bay	2/8/10	na	0.0619	na	6	1	no	no
SPB120S	San Pablo Bay	2/8/10	na	0.0707	na	6	1	no	no
BC11	Central Bay	2/4/10	na	0.0896	na	7	1	yes	no
CB001S	Central Bay	2/4/10	na	0.1241	na	13	1	yes	yes
CB042S	Central Bay	2/4/10	na	0.0679	na	5	0	yes	no
CB055S	Central Bay	2/4/10	na	0.1076	na	6	1	yes	no
CB122S	Central Bay	2/4/10	na	0.1076	na	10	1	yes	no
BA41	South Bay	2/3/10	na	0.0958	na	8	1	yes	no
SB002S	South Bay	2/3/10	na	0.0813	na	5	1	yes	no
SB087S	South Bay	2/3/10	na	0.0600	na	3	0	yes	no
SB091S	South Bay	2/3/10	na	0.1964	na	20	1	yes	yes
SB095S	South Bay	2/3/10	na	0.0565	na	4	0	yes	no
BA10	Lower South Bay	2/2/10	na	0.0261	na	2	1	yes	no
LSB002S	Lower South Bay	2/2/10	na	0.1007	na	9	1	no	no
LSB072S	Lower South Bay	2/2/10	na	0.0998	na	7	1	no	no
LSB109S	Lower South Bay	2/2/10	na	0.0964	na	6	1	yes	no
LSB140S	Lower South Bay	2/2/10	na	0.0969	na	8	1	no	no

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4. BIVALVE MONITORING

BACKGROUND

The RMP has been analyzing bivalve tissue samples for trace contaminants since 1993. Bivalves bioaccumulate chemical contaminants through their food by ingesting sediment and assimilating contaminants that are sorbed to particles and by filtering dissolved contaminants directly from the water column. Bivalves act as transfer vectors of contaminants to higher trophic levels of the aquatic and sediment food webs. Contaminant concentrations in living organisms can accumulate to levels much greater than those found in ambient water and sediment due to an organism's inability to metabolize certain contaminants (Vinogradov, 1959) and a high affinity of some contaminants for lipid-rich tissue in bivalves (Stout and Beezhold, 1981). Biomonitoring using bivalves has been widely applied by the California State Mussel Watch Program (Phillips, 1988; Rasmussen, 1994) and other studies (Young *et al.,* 1976; Wu and Levings, 1980; Hummel *et al*., 1990; Martincic *et al.,* 1992, Gunther *et al.,* 1999; O'Connor, 2002). Bivalves are excellent organisms for biomonitoring of contaminants since they accumulate contaminants from the ambient environment, have limited mobility and are fairly resistant to contaminant effects (O'Connor, 2002). The RMP is continuing the long-term monitoring of the State Mussel Watch Program, which monitored sites throughout the Estuary beginning in 1976.

The objectives of the RMP Bioaccumulation Monitoring Program are to:

1. Describe the distribution and trends of pollutant concentrations in the Estuary.
2. Measure pollution exposure and effects on selected parts of the Estuary ecosystem.
3. Compare monitoring information to relevant benchmarks, such as TMDL targets, tissue screening levels, water quality objectives, and sediment quality objectives.

These general goals implicitly address the RMP objective (see Chapter 1 *Introduction*) of determining long-term trends in contaminant levels. This program component also complements the water and sediment sampling. Unlike the water quality sampling, which gives an indication of water quality at one particular point in time, contaminant concentrations measured in transplanted bivalves serve to integrate water quality over the period of deployment (typically 90 to 100 days). Also, while measurement of contaminant concentrations in water and sediment are useful for trend monitoring over time, they do not reveal the extent to which various contaminants are able to transfer into the food web and pose risks to consumers.

In 2001, trace metals measurements in bivalves were reduced from every year to every fifth year as a cost reduction measure for metals not on the 303(d) List or the Water Board's "pollutants of concern" for San Francisco Bay list. Trace metals were last measured in bivalve tissue in 2008. Trace organics are measured biennially.

In 2006, the RMP Status and Trends program was re-evaluated to determine whether current sampling size and frequency are appropriate for meeting the needs of RMP stakeholders (Melwani et al., 2008). Based on this evaluation, bivalve sampling was modified from an annual to a biennial frequency. Accordingly, bivalve sampling was not performed in 2007 or 2009. Bivalve sampling occurred in 2010, and is proposed to next occur in 2012.

FIELD METHODS

Bivalve Monitoring Field Methods

The RMP Bivalve Bioaccumulation Monitoring Program was initiated in 1993 as a transplant study in which bivalves were collected from "clean" locations (i.e., those with relatively low concentrations of specific pollutants) and transplanted to targeted sites within the Estuary. Bivalves were deployed for 90 to 100-day periods with deployment beginning in February and June. These deployment periods were chosen to encompass the range of hydrographic conditions in the Estuary and to allow comparisons of within-season variation in addition to long-term trend monitoring. At the conclusion of deployments, bivalves are retrieved, processed using clean techniques, and aliquoted for eventual analysis. Generally, 30–40 bivalves are composited from each site for each type of analysis, although high bivalve mortality sometimes reduces the number of organisms in a composite sample. The current RMP sampling plan stipulates that we deploy biennially during the dry season, usually in June and retrieve the samples after approximately 100 days.

Starting with the 1999 dry season (summer) deployments, CTD profiles were collected at each bivalve site during both deployment and retrieval cruises to help determine how ambient environmental factors affect the transplanted bivalves. Salinity, dissolved oxygen, temperature, and total suspended solids impact bivalve health and could affect contaminant bioaccumulation rates.

Source of Bivalves

Bioaccumulation was evaluated by collecting mussels (*Mytilus californianus*) from Bodega Head, an uncontaminated "background" site of known chemistry. These mussels (*Mytilus californianus*) stored in running seawater at the Bodega Marine Laboratory until deployment.

Prior to 2003, several different species were used in the transplant study. Beginning in 2003, the program was modified to deploy one species, *Mytilus californianus,* in order to ensure higher comparability between sites. *Mytilus californianus* is a salt tolerant species that can also handle salinities as low as fifteen ppt (Bayne, 1976). Trace element and trace organic tissue concentrations are more comparable throughout the San Francisco Estuary when they are accumulated by the same species because metabolism rates would be similar in all deployed organisms.

Resident clams (*Corbicula fluminea*) were also collected from one site on the Sacramento River and one site on the San Joaquin River. Resident clams were collected using a clam dredge approximately two feet wide by three feet long and 50 pounds in weight. The dredge was deployed from a boat and was dragged along the bottom. When brought to the surface, the clams were placed into a clean plastic container and packaged for organics analysis.

Deployment of Transplanted Bivalves

At each site, two to three hundred mussels were randomly allocated and placed into predator resistant cages for deployment. The number of individuals was increased from 160 to 300 in 2008 to accommodate additional analysis for PBDEs in tissue, although in 2010 three hundred mussels were deployed only at Coyote Creek and Yerba Buena Island, with all other sites receiving two hundred mussels. Mussels of approximately the same shell length were used (49-81 mm). The same number was also used for the reference (time zero) sample, which was used to provide a baseline on "pre-deployment" tissue condition before deployment.

The cages were constructed out of rigid plastic mesh and PVC pipe. The mesh overlapped around itself to keep predators from slipping through any gaps between the edges. After the cages were built, they were soaked in water for at least a day to remove any potential signal associated with the adhesives used for the construction.

At each site, a line ran from the bottom of the fixed structure out to the bivalve mooring, which consisted of a large screw (earth anchor) that was threaded into the bottom and was associated with pilings or other permanent structures. A large subsurface buoy was attached to the earth anchor by a one to two meter line. The bivalve cages were attached to the buoy line, which kept the bivalves off the bottom to prevent smothering. Since the beginning of the program, loss of a mooring has occurred on only two occasions, probably due to being ripped out by a vessel anchor. Mooring installation, bivalve deployment, and retrieval were all accomplished by SCUBA divers.

A mooring was unable to be securely and safely installed for site BD40 (Davis Point) during the deployment cruise and was not deployed.

Retrieval of Transplanted Bivalves

Upon retrieval, the bivalve cages were cut off the buoy line and taken to the surface. On the vessel, the number of dead organisms was recorded. Bivalves were allocated for various analyses and studies as determined by SFEI staff and is outlined in detail in the 2010 Bivalve Retrieval Report. Bivalves allocated for trace organic analyses were not rinsed, wrapped in two layers of aluminum foil, placed in 2-gallon zip-top bags and placed on dry ice. Bivalves allocated for Growth analysis were rinsed in the field to remove overlying mud, placed in 2-gallon zip-top bags and placed on dry ice.

SITES

Bivalves were initially deployed at eleven sites throughout the Estuary to represent both the spine and margins of the Estuary. In 1994, four deployment sites were added, for a total of 15. Specific site locations were heavily influenced by the availability of a fixed structure to easily relocate the subsurface moorings.

Based on a new biogeographical delineation of the Estuary, it was apparent that the newly defined segments were not represented equally by the 15-station bivalve deployment design. Consequently, an analysis was undertaken to determine the optimum number and distribution of bivalve deployment sites needed to track trends in bioavailable contaminants in the Estuary. Based on this analysis, several sites were removed from the project and, in 2003, the design of the Program study sites was modified to its current configuration of 11 sites, consisting of three transplant sites within the Lower South Bay-South Bay, Central Bay and San Pablo Bay Estuary segments, respectively, and collection of resident bivalves at two sites within the Rivers segment.

In 2010, bivalves were successfully deployed at 8 of the 9 scheduled sites. A mooring was unable to be securely and safely installed for site BD40 (Davis Point) during the deployment cruise and was not deployed. Resident bivalves were successfully collected from the two sites within the Rivers segment.

Station names, codes, location, and sampling dates for the 2010 monitoring effort are listed in Appendix 3 and shown in Figure 4.1.

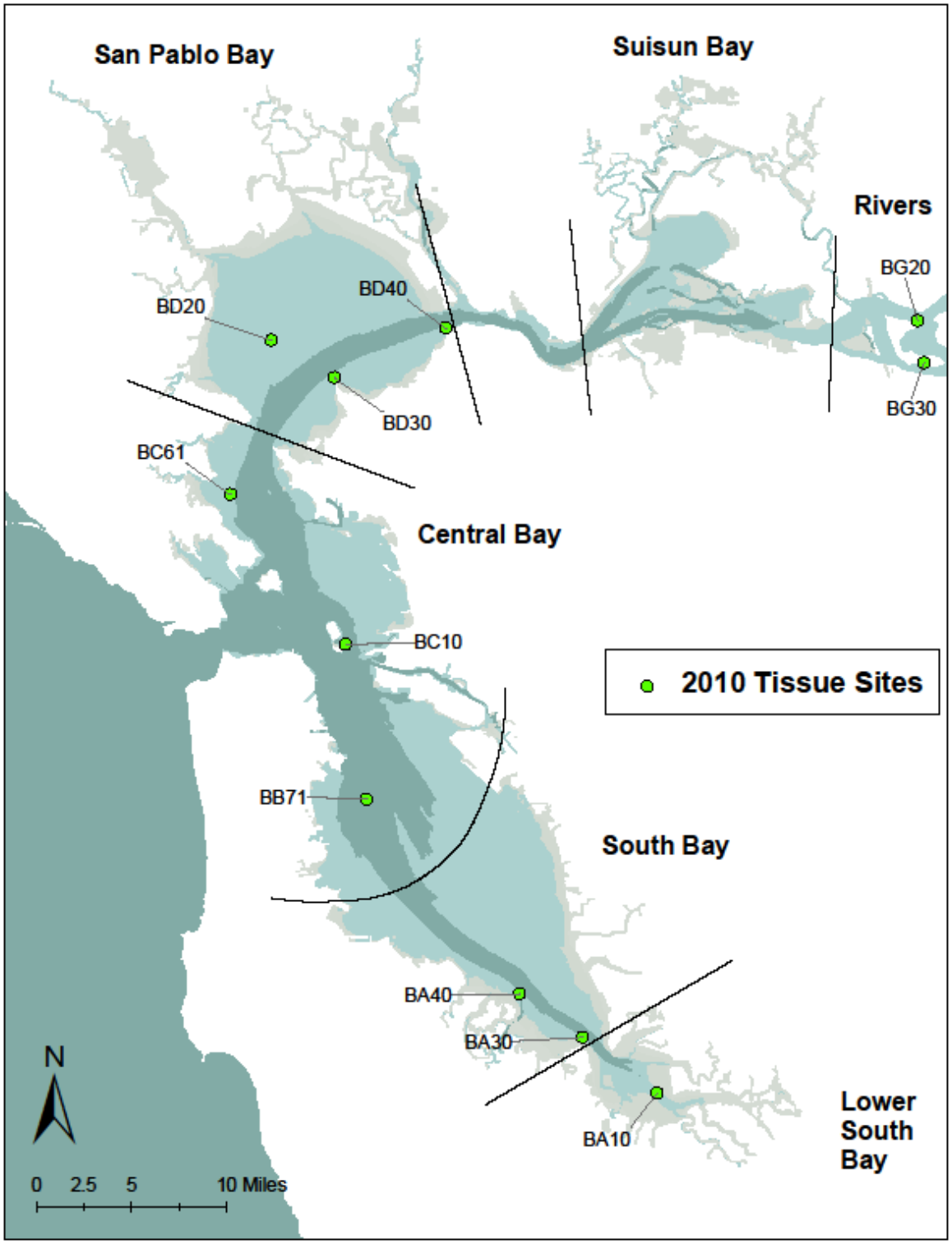

San Pablo Bay
Suisun Bay
Rivers
BG20
BD40
BD20
BG30
BD30
BC61
Central Bay
BC10
2010 Tissue Sites
BB71
South Bay
BA40
BA30
N
BA10
Lower South Bay
0 2.5 5 10 Miles

Figure 4.1 Map of 2010 Bivalve Monitoring Stations

ANALYSIS

Target Analytes

Bivalves are analyzed for trace metals aluminum, cadmium, copper, lead, nickel, selenium, silver and zinc every five years. Trace metals were last measured in bivalve tissue in 2008.

Bivalves are analyzed biennially for trace organics and ancillary parameters. Trace organics include PAHs, PBDEs, PCBs , Chlordanes, Cyclopentadienes, DDTs, HCHs, Hexachlorobenzene, and Mirex.

A summary table of target analytes is presented below. Refer to Appendix 4 for a more detailed listing of target analytes.

Table 4.1 Target Bivalve Analytes: A summary table of the 2010 target analytes, field preparation code, analytical laboratories and reporting units

Analyte	Field Prep Code	Analysis Lab	Reporting Unit
Trace organics	Not rinsed, placed on dry ice	AXYS Analytical Laboratories	ng/g (ppb)
Trace elements	Not rinsed, placed on dry ice	CCSF	µg/g (ppm)
Selenium	Not rinsed, placed on dry ice	Brooks Rand Laboratories	µg/g (ppm)
Brominated flame retardants (BFRs)	Not rinsed, placed on dry ice	AXYS Analytical Laboratories	ng/g (ppb)
Growth	Rinsed in field, placed on dry ice	Applied Marine Sciences	g
Archive	Not rinsed, placed on dry ice	N/A	N/A

Data are available for downloading via the RMP website using the *Web Query Tool* at http://www.sfei.org/rmp/wqt.

Laboratory Methods for Bivalve Analysis

SFEI maintains SOPs for all laboratory analyses. Please contact SFEI (amy@sfei.org) for more details.

Currently, trace organics analyses of bivalve tissue samples are performed by AXYS Analytical Laboratories. In the past, trace organics analyses of bivalve tissue samples were conducted by the California Department of Fish and Game Water Pollution Control Laboratory (CDFG-WPCL). A brief overview of the extraction and analyses used for the target trace organics are described below. Extract cleanup and partitioning methods are modifications of the multi-residue methods for fatty and non-fatty foods described in the U.S. Food and Drug Administration Pesticide Analytical Manual (US FDA, 1994). The laboratory SOPs that describe the methods in more detail are on file at SFEI.

Tissue Extraction

Samples were removed from the freezer and allowed to thaw. Prior to extraction, bivalve tissue samples were homogenized using a Büchi B-400 homogenizer. A 10 g sample was mixed with approximately 7 g of pre-extracted Hydromatrix® until the mixture was free flowing. The mixture was then extracted using U.S. EPA Method 3545 (Pressurized Fluid Extraction) with a 50/50 mixture of acetone/dichloromethane. The samples were extracted a second time using the same conditions. The extracts were dried and filtered through a 0.45 µm syringe filter into J2 Scientific AccuPrep 170 (GPC) autosampler tubes. Two milliliters each of the filtered extracts were removed and placed in a pre-weighed aluminum planchet for percent lipid determination.

All sample extracts were cleaned-up using a J2 Scientific GPC (Autoinject 110, AccuPrep 170, DFW-20 Fixed Wavelength Detector, 1" i.d. glass column with 70 g Bio-Beads SX-3 in 100% DCM). For pesticides, PCBs, and PBDEs the GPC purified extracts were then fractionated into 4 separate fractions on a Florisil column using petroleum ether (F1), 6% diethyl ether/petroleum ether (F2), 15% diethyl ether/petroleum ether (F3), and 50% diethyl ether/petroleum ether (F4) elution. For PAHs, the GPC purified extracts were further cleaned-up with silica/alumina column chromatography using DCM:pentane (1:1) as the solvent.

Organochlorine Pesticide, PCB, and PBDE Analyses in Tissue

Cleaned-up extracts were evaporated and fractionated. The fractions were concentrated to an appropriate volume using K-D/micro K-D apparatus prior to analysis by dual column high resolution gas chromatography with electron capture detection. A mixture of synthetic organic standards was eluted through the Florisil 7 column to determine the recovery and separation characteristics of the column.

Analysis of Extractable PAH Compounds in Tissue

Extraction methods for homogenized tissue samples were identical to those for PCBs, PBDEs, and organochlorine pesticides. All samples were then cleaned up using a large (1 inch i.d.) GPC column. The extracts were evaporated using a K-D apparatus to 5 mL. The extracts were then fractionated. The fractions were concentrated to 1 mL using K-D/nitrogen blow down apparatus prior to analysis by gas chromatography/mass spectrometry.

Bivalve Growth and Survival

Applied Marine Sciences (AMS) conducted the bivalve health measure evaluations as in previous years.

Analysis of contaminant concentrations was conducted on a subset of the transplanted bivalves (composites contain 40-60 individual bivalves from each site) prior to deployment in Estuary locations (T-0) and after the 100-day deployment period. The differences between pre- and post-deployment concentrations allow determination of contaminant uptake during the period of deployment. A new batch of bivalves were also collected from the original T-0 transplanted bivalve collection sites at the end of the deployment period to obtain information on uptake variables that may have affected wild populations during the deployment period.

In 2001, AMS began calculating the growth mean in addition to the condition index (CI) for the RMP as an indicator of bivalve health. The CI interpretation of bivalve health can be confounding when ambient conditions (i.e., salinity) are more uniform such as during the summer deployment period. In 2002, the RMP discontinued the condition index measure in favor of the growth mean as the only health indicator. Because the CI is the ratio of dry tissue weight to shell cavity volume, it could be affected by changes in either tissue weight or shell size. For example, either a decrease in tissue weight with stable shell size or an increase in shell size with stable tissue weight could be interpreted as a decrease in CI. Consequently, the interpretation of CI as an indicator of health can be problematic. The growth mean is a measure of growth of the composite of bivalves at a particular site in comparison to the T-0. The growth mean was determined by taking the dry weight of each individual and subtracting the mean dry weight of the T-0 for that species. This calculation was done for each individual bivalve. The mean of the difference of all the individuals at a particular site was then calculated to give the growth mean.

Quality Assurance/ Quality Control (QA/QC)Ancillary Parameters

QA/QC Growth and Survival

Caged transplanted bivalves were maintained and monitored by Applied Marine Sciences, and resident bivalves were collected from river stations not suitable for the transplants. Bivalve weights and growth (for transplants) were in line with previous results for their respective species. Survival was generally ~70% or higher, which provided enough material for chemical analyses with some left to archive.

QA/QC Trace Organics

Trace organic compounds in bivalves were analyzed by AXYS Analytical. Detection limits for most PAHs were sufficient, with five (11%) of the PAH analytes with non-detects over half the samples. In comparison 22 out of 49 PBDEs (45%), 37 out of 209 PCB congeners (18%), and 11 of 22 pesticides (50%) reported as non-detects in most (>50% of) samples.

Many of the analytes were found in blanks; 25 of 58 PAHs and alkylated-PAHs, 2 of 49 PBDEs, 6 of 209 PCB congeners, and no pesticides were found in one or more blanks. Impacts of contamination differed among analyte groups, with analytes in some samples censored for blank concentrations constituting a large (>1/3) portion of their field concentrations; over half the results were censored for 13 (mostly alkylated) PAHs, and 1 PBDE (PBDE 99). Average precision (RSDs) from lab replicate analyses were generally within the target (<35% RSD) for samples in a quantitative range (>3xMDL), except for 2 of the 58 (PAHs and alkylated-PAHs) censored for poor (>70% RSD) precision, and one PAH and one PBDE flagged but not censored (35-70% RSD). Precision on PCB and pesticide replicates were all within target (<35% RSD). Blank spike results were used to assess accuracy as no CRMs or matrix spikes were reported by the lab. As there were no blank spikes for alkylated PAHs, their recoveries could not be evaluated and results were qualified to indicate limited QC. Recovery was generally good for most of the remaining analytes, with average error within the <35% target, except for two PAHs flagged but not censored (35-70% average error). Most of the analytes were in the same general concentration range as previous years; with some decreases in sums (e.g. Sum of 209 PCBs) possible due to revised handling on advice of the analytical laboratory for handling of samples with reported interferences; “estimated” maximum concentrations previously handled as semi-quantitative estimates were revised to be handled as non-detects under elevated reporting limits; RMP convention of handling non-detects as 0 concentrations would therefore result in lower sums for samples where such interferences occurred.

BIVALVE TRENDS

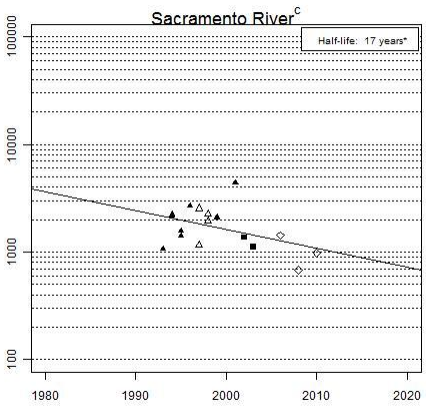
The RMP currently monitors contaminant accumulation in bivalve tissue at nine sites distributed throughout the Bay (Figure 4.1). Many of these sites have been monitored since 1980 by the State Mussel Watch (SMW) program and, consequently, by the RMP. Additionally, the NOAA National Mussel Watch (NMW) program has monitored resident mussel contamination levels at several sites in San Francisco Bay since 1986. Two of the NMW sites are located near RMP bivalve sampling sites. The data from these co-located sites have been included to corroborate trends seen in SMW and RMP bivalve data.

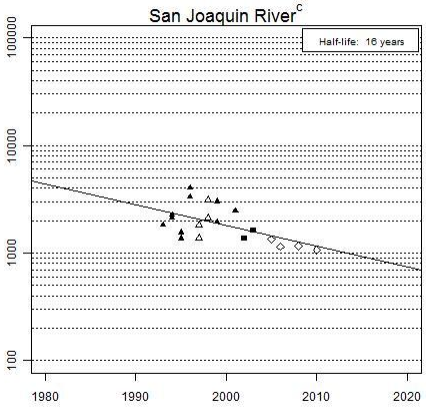
To look at trends of trace organics concentrations in bivalves, linear regressions of log-transformed tissue concentrations over time were generated for the nine sites. The contaminants analyzed were Sum of PCBs, Sum of DDTs, Sum of PAHs, and Sum of PBDEs. Bivalve tissue concentration data from the RMP and the SMW were plotted normalized to lipid weight, while the NMW data were plotted as dry weight (due to high variability in their lipid measurements over the years, making them unreliable). The different data point markers represent different monitoring programs and analysis labs, as shown in the legends. For each linear regression, the slope, significance level and estimated half-life are shown in the tables below. The estimated half-life (if applicable) is also shown on each graph, but is marked with an asterisk when derived from a regression that is not significant at the 0.05 level.

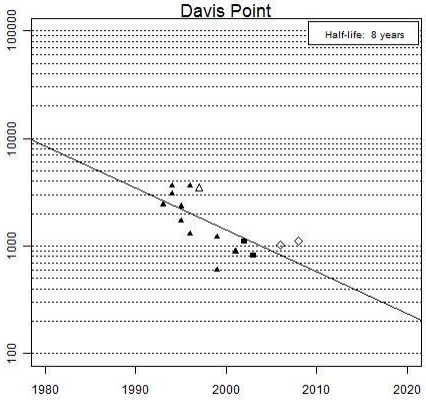
Polychlorinated Biphenyls (PCBs) in Bivalves

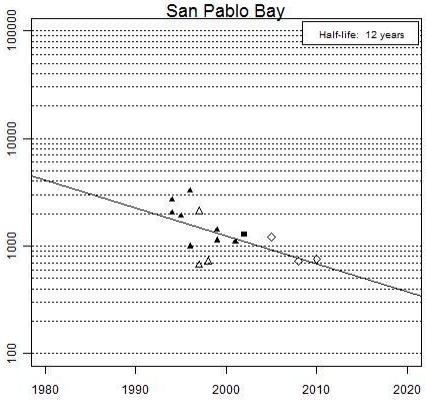
The PCB data from the State Mussel Watch Program are sum of Aroclors and the RMP PCB data are sum of congeners. Both datasets were normalized to bivalve lipid content. The PCBs data from the National Mussel Watch Program are sum of congeners in dry weight due to unexplained variation in lipid data obtained from different labs over the years.

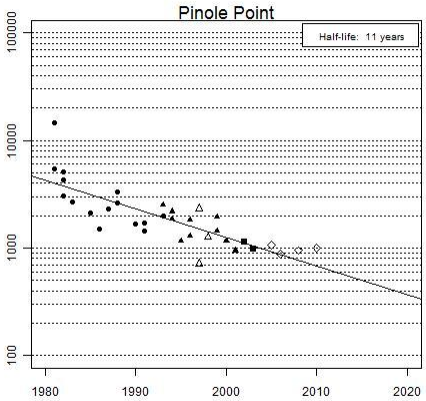
RMP and SMW – Sum of PCBs data (ng/lipid g)

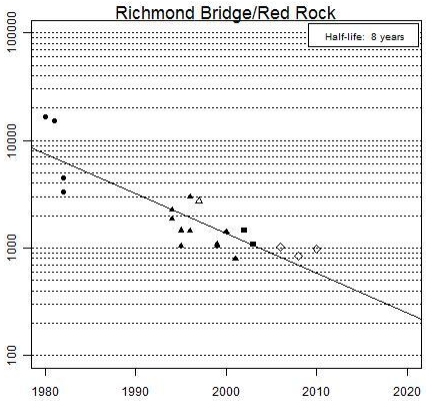












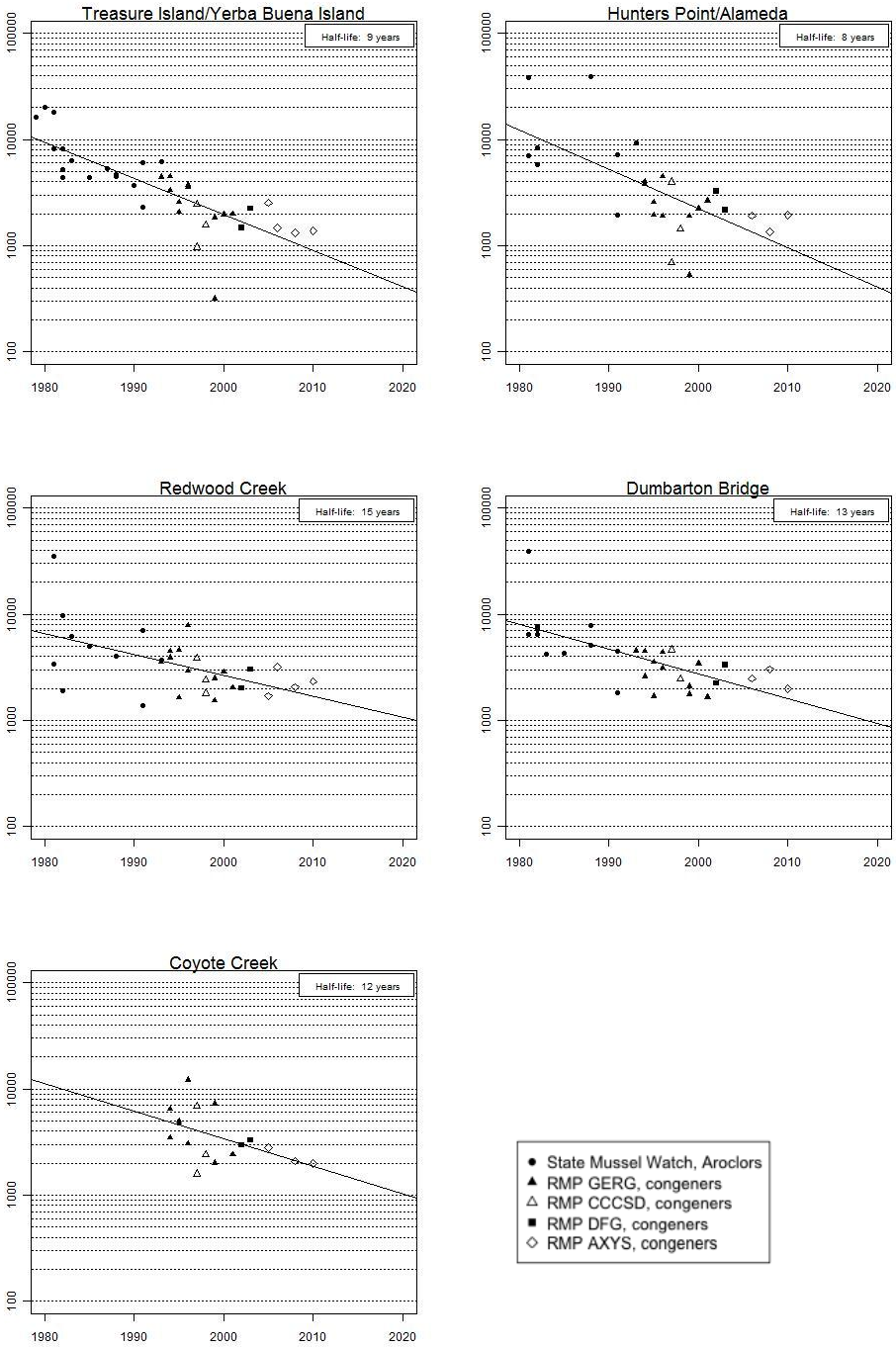


Figure 4.2 PCB concentrations (ng/g lipid) in transplanted mussels (RMP and SMW data), 1979-2010 c) Trends calculated on resident clams, Corbicula fluminea, rather than transplanted mussels

Table 4.2 Linear regression statistics for PCB concentrations over time (RMP and SMW data). Trends are calculated on resident clams, *Corbicula fluminea,* rather than transplanted mussels

Code	Site Name	N	Years	Trend	Half-life (years)	Slope	p-value	R^2
BG20	Sacramento River[c]	18	1993-2010	?	17	-0.02	0.067	0.19
BG30	San Joaquin River[c]	20	1993-2010	▼	**16**	**-0.02**	**0.009**	**0.32**
BD40	Davis Point	15	1993-2008	▼	**8**	**-0.04**	**0.005**	**0.47**
BD20	San Pablo Bay	15	1994-2010	▼	**12**	**-0.03**	**0.021**	**0.34**
BD30	Pinole Point	34	1981-2010	▼	**11**	**-0.03**	**< 0.001**	**0.65**
BC61	Richmond Bridge/ Red Rock	20	1980-2010	▼	**8**	**-0.04**	**< 0.001**	**0.74**
BC10	Treasure Island/ Yerba Buena Island	36	1979-2010	▼	**9**	**-0.03**	**< 0.001**	**0.64**
BB71	Hunters Point/Alameda	26	1981-2010	▼	**8**	**-0.04**	**< 0.001**	**0.45**
BA40	Redwood Creek	30	1981-2010	▼	**15**	**-0.02**	**0.002**	**0.3**
BA30	Dumbarton Bridge	29	1981-2010	▼	**13**	**-0.02**	**< 0.001**	**0.48**
BA10	Coyote Creek	17	1994-2010	▼	**12**	**-0.03**	**0.036**	**0.26**

All nine RMP-monitored sites with transplanted mussels show statistically significant declines in PCB concentrations in bivalve tissue, while only one of the resident clam sites shows a significant decline. The estimated half-lives for bivalve PCB concentrations range from 8 to 17 years by site.

NMW – Sum of PCBs data (ng/dry g)

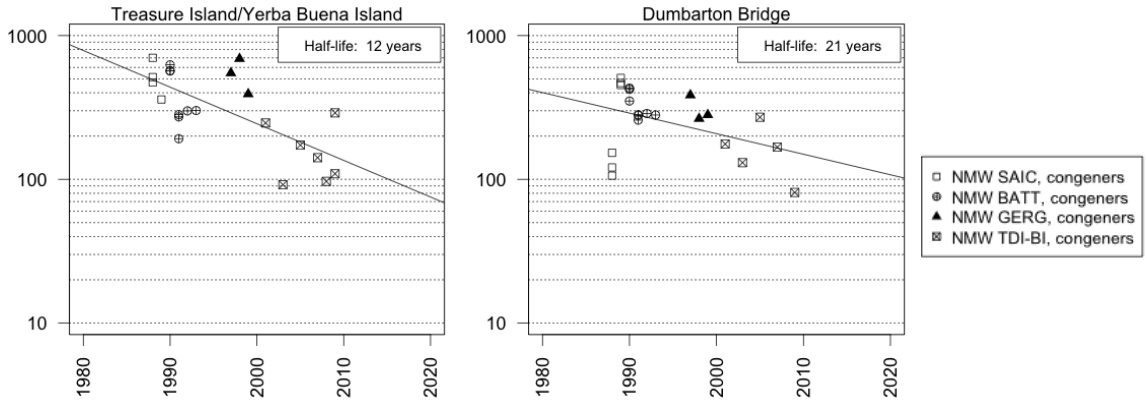


Figure 4.3 PCB concentrations (ng/g dry wt.) in transplanted mussels (NMW data), 1988-2009

Table 4.3 Linear regression statistics for PCB concentrations over time (NMW data)

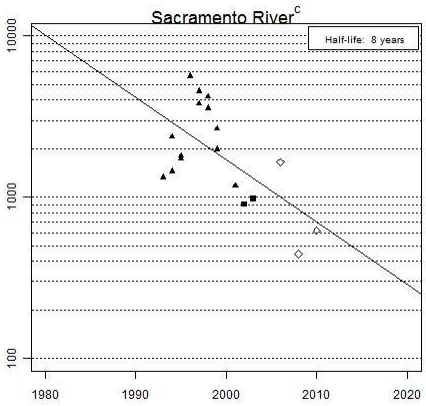
Code	Site Name	N	Years	Trend	Half-life (years)	Slope	p-value	R^2
BC10	Treasure Island/ Yerba Buena Island	22	1988-2009	▼	**12**	**-0.03**	**< 0.001**	**0.49**
BA30	Dumbarton Bridge	22	1988-2009	▼	**21**	**-0.01**	**0.048**	**0.18**

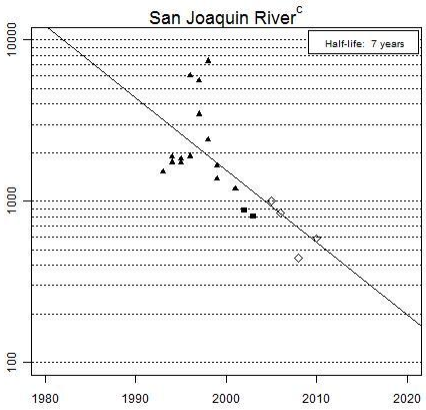
Both National Mussel Watch sites show statistically significant declines in PCBs concentrations in bivalve tissue. However, the NMW data suggest slower rates of decline than the SMW and RMP data. For the Treasure Island site, the NMW data gives an estimated 12 years for bivalve PCBs concentrations to decrease by half versus the 9-year half-life estimated by the combined SMW and RMP data. Similarly, for the Dumbarton Bridge site, the NMW data gives an estimated 21-year half-life versus the 12-year half-life estimated by the SMW and RMP data.

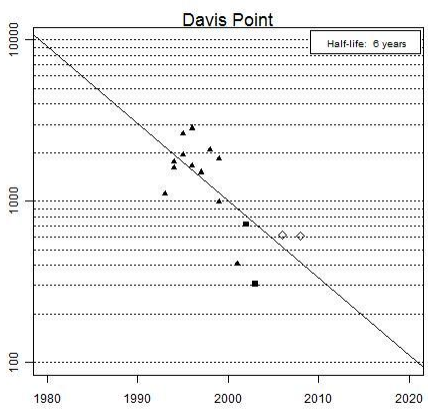
DDTs Trends in Bivalves

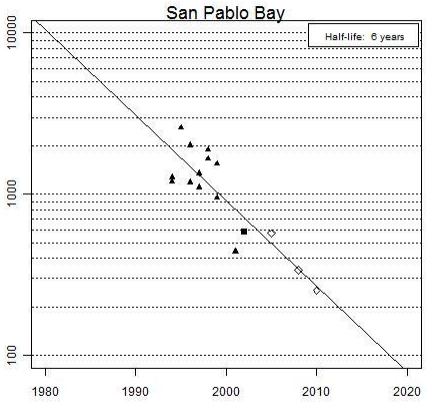
The DDTs data from the RMP, the SMW and the NMW are the sum of six DDTs [o,p'-DDD; o,p'-DDE; o,p'-DDT; p,p'-DDD; p,p'-DDE; p,p'-DDT]. The RMP and the SMW DDTs data sets were normalized to bivalve lipid content, while the NMW DDTs data are presented as portion of dry tissue weight.

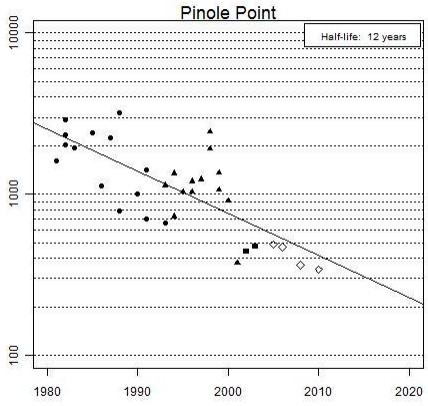
RMP and SMW – Sum of DDTs data (ng/g lipid)











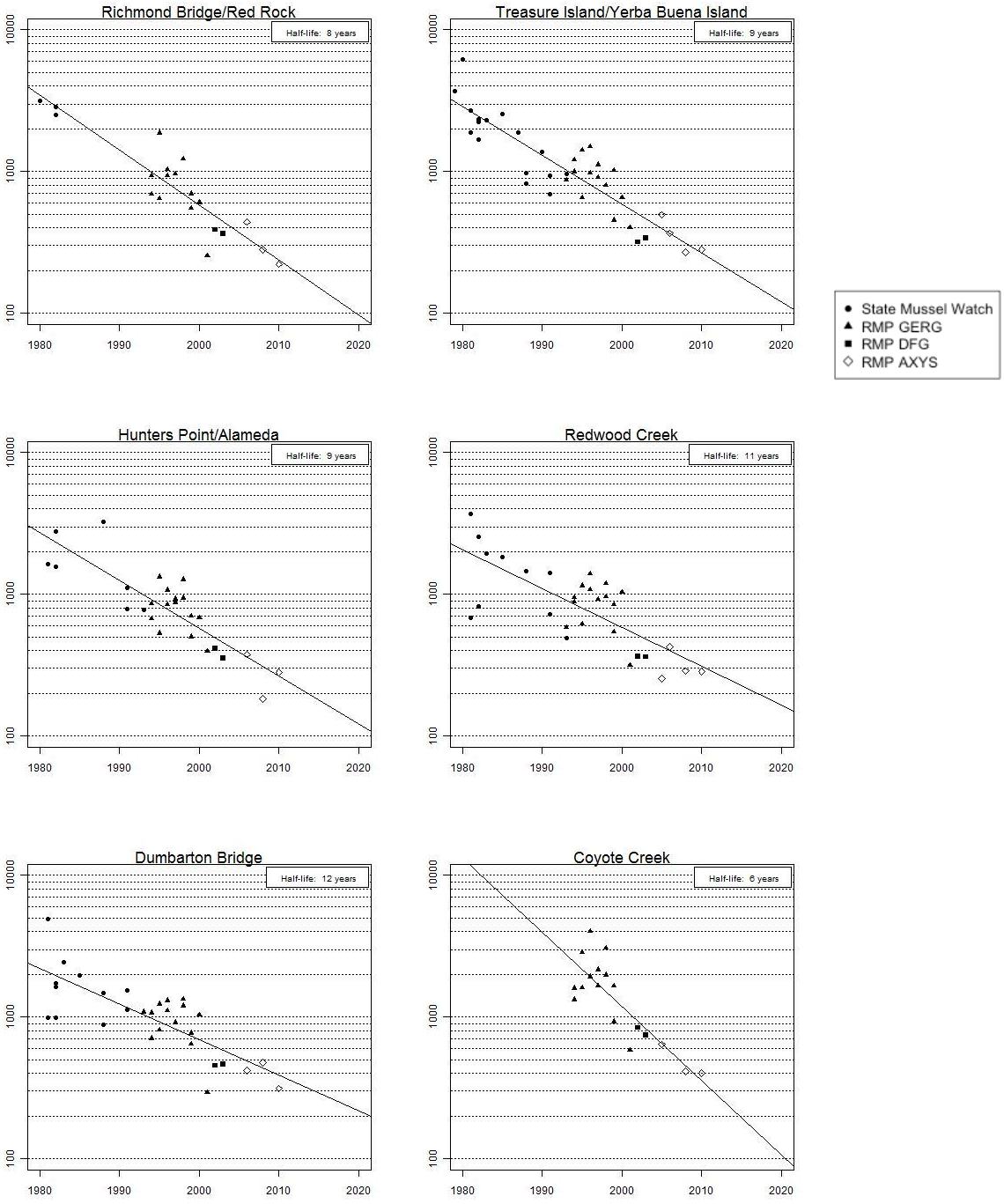


Figure 4.4 DDT concentrations (ng/g lipid) in transplanted mussels (RMP and SMW data), 1979-2010. Trends are calculated on resident clams, *Corbicula fluminea,* rather than transplanted mussels

Table 4.4 Linear regression statistics for DDT concentrations over time (RMP and SMW data). Trends are calculated on resident clams, Corbicula fluminea, rather than transplanted mussels

Code	Site Name	N	Years	Trend	Half-life (years)	Slope	p-value	R^2
BG20	Sacramento River[c]	18	1993-2010	▼	**8**	**-0.04**	**0.006**	**0.39**
BG30	San Joaquin River[c]	20	1993-2010	▼	**7**	**-0.04**	**0.001**	**0.46**
BD40	Davis Point	16	1993-2008	▼	**6**	**-0.05**	**0.001**	**0.54**
BD20	San Pablo Bay	16	1994-2010	▼	**6**	**-0.05**	**< 0.001**	**0.75**
BD30	Pinole Point	34	1981-2010	▼	**12**	**-0.03**	**< 0.001**	**0.56**
BC61	Richmond Bridge/ Red Rock	20	1980-2010	▼	**8**	**-0.04**	**< 0.001**	**0.83**
BC10	Treasure Island/ Yerba Buena Island	36	1979-2010	▼	**9**	**-0.03**	**< 0.001**	**0.81**
BB71	Hunters Point/Alameda	26	1981-2010	▼	**9**	**-0.03**	**< 0.001**	**0.73**
BA40	Redwood Creek	30	1981-2010	▼	**11**	**-0.03**	**< 0.001**	**0.57**
BA30	Dumbarton Bridge	30	1981-2010	▼	**12**	**-0.02**	**< 0.001**	**0.61**
BA10	Coyote Creek	18	1994-2010	▼	**6**	**-0.05**	**< 0.001**	**0.69**

All of these monitored Bay sites show statistically significant declines in bivalve tissue DDT concentrations. The estimated half-lives for bivalve DDT concentrations at these sites range from 6 to 12 years.

NMW – Sum of DDTs data (ng/dry g)

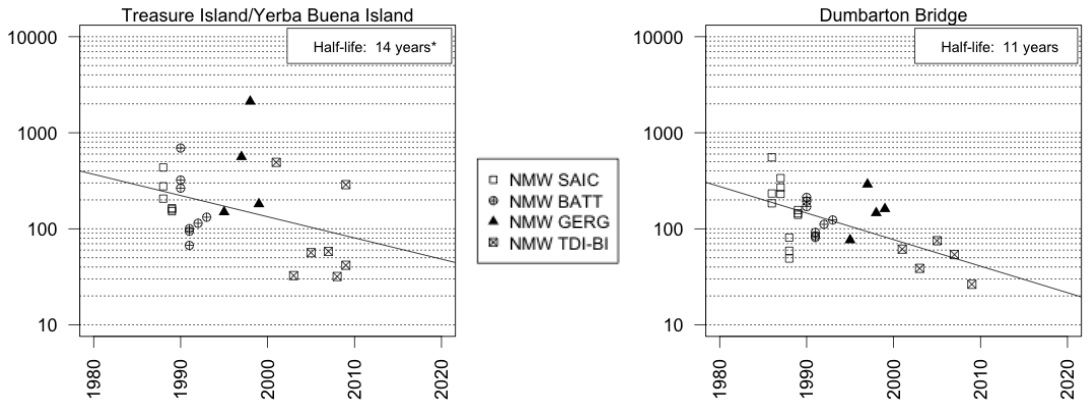


Figure 4.5 DDT concentrations (ng/g dry wt.) in transplanted mussels (NMW data), 1986-2009

Table 4.5 Linear regression statistics for DDT concentrations over time (NMW data).

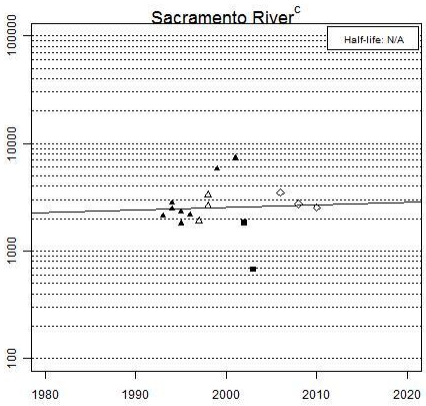
Code	Site Name	N	Years	Trend	Half-life (years)	Slope	p-value	R^2
BC10	Treasure Island/ Yerba Buena Island	25	1988-2009	**?**	14	-0.02	0.067	0.14
BA30	Dumbarton Bridge	29	1986-2009	**▼**	**11**	**-0.03**	**< 0.001**	**0.37**

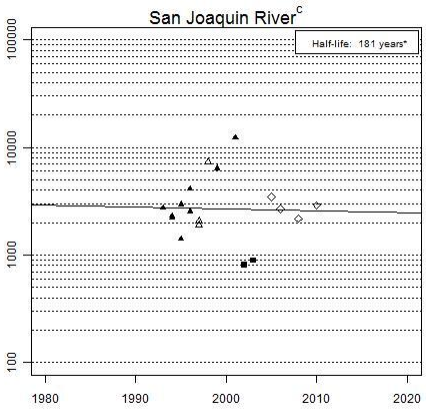
Both of these National Mussel Watch sites show declines in DDTs concentrations in bivalve tissue, but only one trend is statistically significant. The NMW data and the combined RMP and SMW data both give similar half-life estimates for bivalve DDTs concentration at the Dumbarton Bridge site.

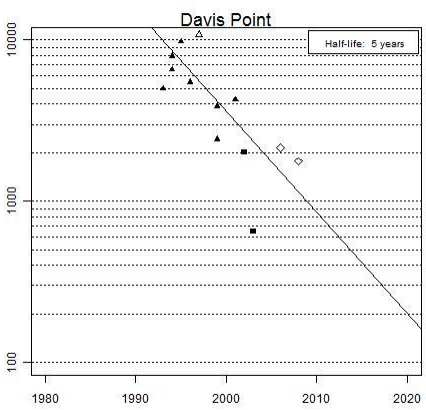
Polycyclic Aromatic Hydrocarbons (PAHs) in Bivalves

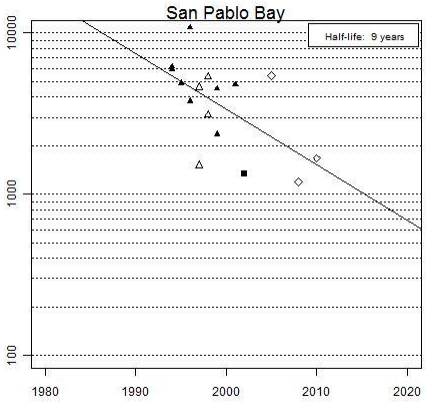
The RMP PAHs data set was normalized to bivalve lipid content, while the NMW PAHs data are presented as portion of dry tissue weight. No SMW data were available for PAHs. Both the RMP and the NMW data sets consisted of sums over low and high molecular weight PAHs, but not alkylated PAHs.

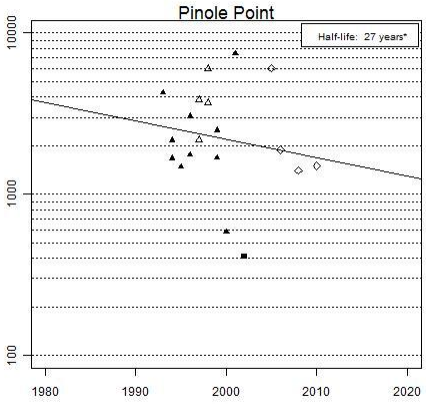
RMP – Sum of PAHs data (ng/lipid g)

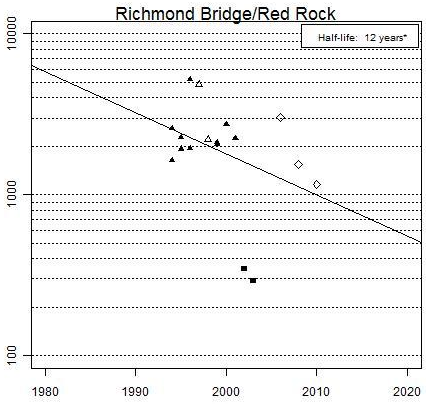


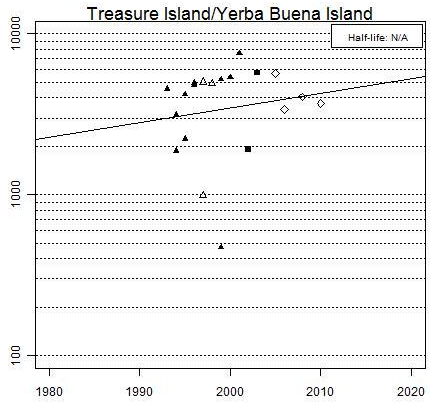


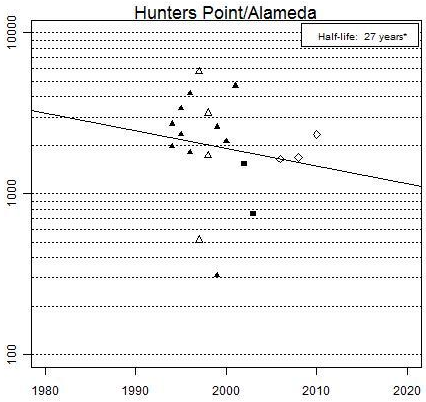


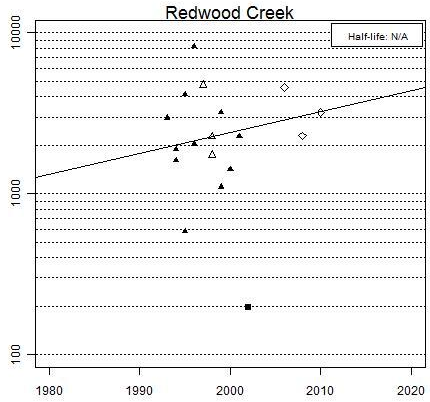





Richmond Bridge/Red Rock
Half-life: 12 years*
10000
1000
100
1980
1990
2000
2010
2020


Treasure Island/Yerba Buena Island
Half-life: N/A
10000
1000
100
1980
1990
2000
2010
2020


Hunters Point/Alameda
Half-life: 27 years*
10000
1000
100
1980
1990
2000
2010
2020


Redwood Creek
Half-life: N/A
10000
1000
100
1980
1990
2000
2010
2020

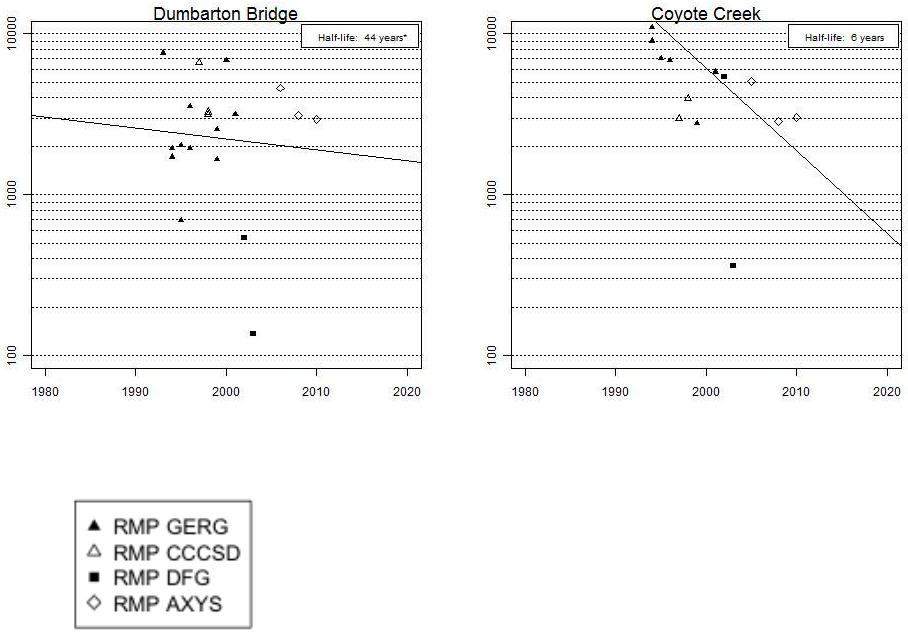


Figure 4.6 PAH concentrations (ng/g lipid) in transplanted mussels (RMP data), 1993-2010. Trends calculated on resident clams, Corbicula fluminea, rather than transplanted mussels.

Table 4.6 Linear regression statistics for PAH concentrations over time (RMP data).
Trends calculated on resident clams, Corbicula fluminea, rather than transplanted mussels

Code	Site Name	N	Years	Trend	Half-life (years)	Slope	p-value	R^2
BG20	Sacramento River[c]	16	1993-2010	**?**	(-132)	0	0.847	0
BG30	San Joaquin River[c]	18	1993-2010	**?**	181	0	0.908	0
BD40	Davis Point	15	1993-2008	**▼**	**5**	**-0.06**	**0.001**	**0.57**
BD20	San Pablo Bay	16	1994-2010	**▼**	**9**	**-0.03**	**0.016**	**0.35**
BD30	Pinole Point	19	1993-2010	**?**	27	-0.01	0.486	0.03
BC61	Richmond Bridge/ Red Rock	17	1994-2010	**?**	12	-0.03	0.136	0.14
BC10	Treasure Island/ Yerba Buena Island	20	1993-2010	**?**	(-33)	0.01	0.519	0.02
BB71	Hunters Point/Alameda	19	1994-2010	**?**	27	-0.01	0.509	0.03
BA40	Redwood Creek	19	1993-2010	**?**	(-23)	0.01	0.532	0.02
BA30	Dumbarton Bridge	19	1993-2010	**?**	44	-0.01	0.747	0.01
BA10	Coyote Creek	18	1994-2010	**▼**	**6**	**-0.05**	**0.037**	**0.25**

The RMP data show mixed trends for PAH concentrations in bivalve tissue. Only three of the monitored Bay sites show statistically significant trends in bivalve tissue PAHs concentrations. For the statistically significant trends, the estimated half-lives for bivalve PAH concentrations range from 5 to 9 years.

It should be noted that the RMP PAH data set is about a decade shorter than the PCB and DDT data sets.

NMW – Sum of PAHs data (ng/dry g)

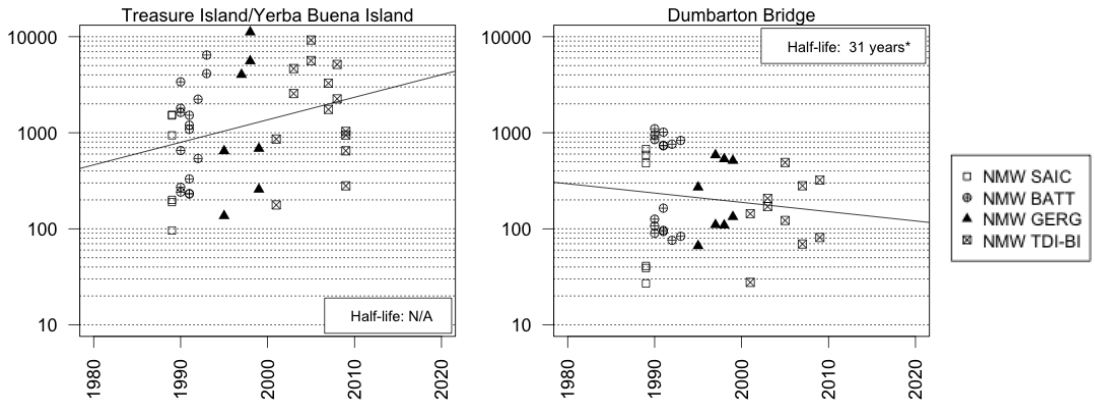


Figure 4.7 PAH concentrations (ng/g dry wt.) in transplanted mussels (NMW data), 1989-2009

Table 4.7 Linear regression statistics for PAH concentrations over time (NMW data)

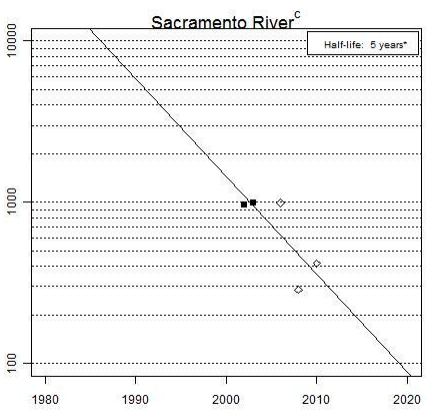
Code	Site Name	N	Years	Trend	Half-life (yrs)	Slope	p-value	R^2
BC10	Treasure Island/ Yerba Buena Island	44	1989-2009	**?**	(-13)	0.02	0.051	0.09
BA30	Dumbarton Bridge	40	1989-2009	**?**	31	-0.01	0.417	0.02

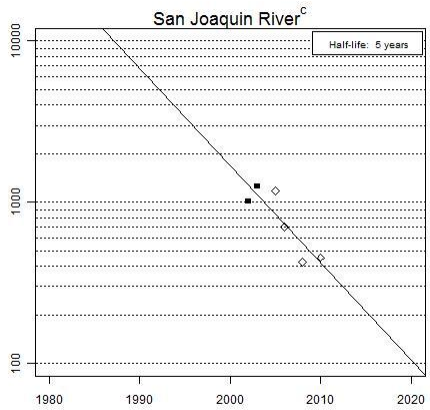
The NMW data set, which extends back further in time and includes more many samples per site, also shows mixed trends for PAHs concentrations in bivalve tissue. Neither of the NMW sites shows a statistically significant trend, but the seemingly increasing concentrations at the Treasure Island site are nearly statistically significant (p-value=0.051). Also the ostensible increase in bivalve PAHs levels corroborate with the RMP data set, which also suggests that bivalve PAHs concentrations are increasing at the Treasure Island site. Likewise, neither RMP or NMW data show a statistically significant trend for the Dumbarton Bridge site, but both data sets suggest that PAH concentrations are decreasing.

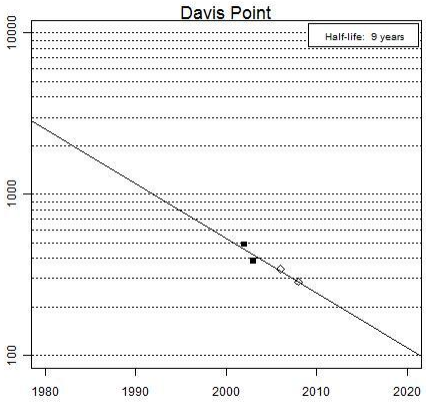
Polybrominated Diphenyl Ethers (PBDEs) Trends in Bivalves

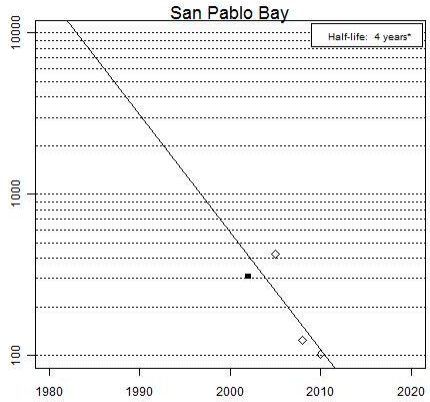
The RMP PBDEs data set was normalized to bivalve lipid content. No SMW data were available for PBDEs, and NMW data were not included since only one data point was available for each NMW site. The RMP Sum of PBDEs data set consists of the sum of over 50 different PBDE compounds.

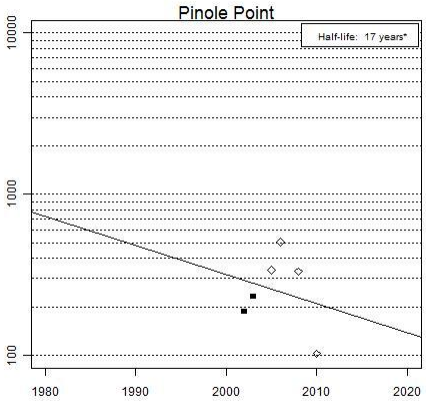
RMP – Sum of PBDEs data (ng/lipid g)

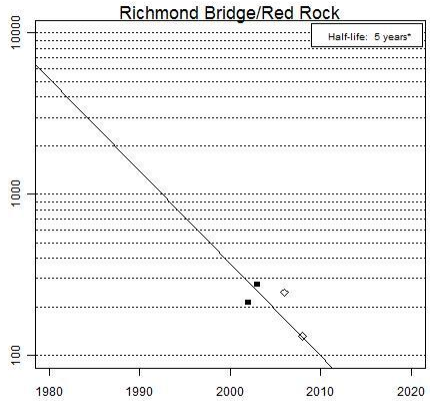












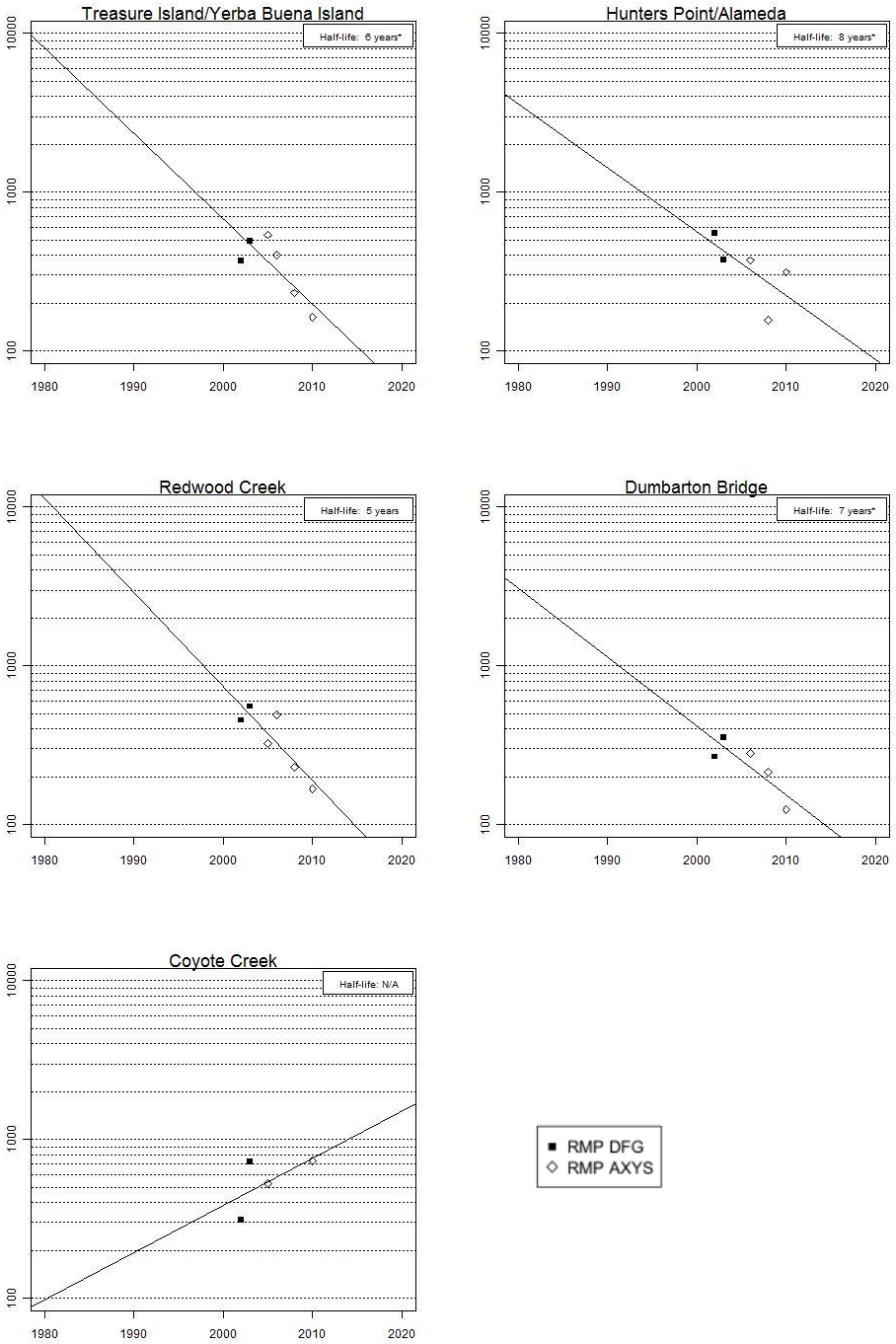


Figure 4.8 PBDE concentrations (ng/g lipid) in transplanted mussels (RMP data), 2002-2010. Trends calculated on resident clams, Corbicula fluminea, rather than transplanted mussels

Table 4.8 Linear regression statistics for PBDE concentrations over time (RMP data).
Trends calculated on resident clams, Corbicula fluminea, rather than transplanted mussels

Code	Site Name	N	Years	Trend	Half-life (yrs)	Slope	p-value	R^2
BG20	Sacramento River[c]	5	2002-2010	**?**	5	-0.06	0.108	0.63
BG30	San Joaquin River[c]	6	2002-2010	**▼**	**5**	**-0.06**	**0.021**	**0.77**
BD40	Davis Point	4	2002-2008	**▼**	**9**	**-0.03**	**0.047**	**0.91**
BD20	San Pablo Bay	4	2002-2010	**?**	4	-0.07	0.154	0.91
BD30	Pinole Point	6	2002-2010	**?**	17	-0.02	0.669	0.05
BC61	Richmond Bridge/ Red Rock	5	2002-2010	**?**	5	-0.06	0.067	0.73
BC10	Treasure Island/ Yerba Buena Island	6	2002-2010	**?**	6	-0.05	0.054	0.65
BB71	Hunters Point/Alameda	5	2002-2010	**?**	8	-0.04	0.216	0.45
BA40	Redwood Creek	6	2002-2010	**▼**	**5**	**-0.06**	**0.024**	**0.76**
BA30	Dumbarton Bridge	5	2002-2010	**?**	7	-0.04	0.074	0.71
BA10	Coyote Creek	4	2002-2010	**?**	(-10)	0.03	0.394	0.37

The RMP began sampling PBDEs in 2002, and currently the bivalve PBDE data sets are too short (N=4 to 6 per site) to say much with confidence. Two sites with transplanted mussels, Davis Point and Redwood Creek, show statistically significant declines, as does the San Joaquin River site where resident clams are collected, despite having only four and six data points.

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http://www.fda.gov/Food/ScienceResearch/LaboratoryMethods/PesticideAnalysisManualPAM/ucm111455.htm

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5. APPENDIX TABLES

APPENDIX 1 RMP PROGRAM PARTICIPANTS IN 2010

Municipal Dischargers

Burlingame Waste Water Treatment Plant
Central Contra Costa Sanitary District
Central Marin Sanitation Agency
City of Benicia
City of Calistoga
City of Palo Alto
City of Petaluma
City of Pinole/Hercules
City of Saint Helena
City and County of San Francisco
City of San Jose/Santa Clara
City of San Mateo
City of South San Francisco/San Bruno
City of Sunnyvale
Delta Diablo Sanitation District
East Bay Dischargers Authority
East Bay Municipal Utility District (SD#1)
Fairfield-Suisun Sewer District
Las Gallinas Valley Sanitation District
Marin County Sanitary District #5, Tiburon
Millbrae Waste Water Treatment Plant
Mountain View Sanitary District
Napa Sanitation District
Novato Sanitation District
Rodeo Sanitary District
San Francisco International Airport
Sausalito Sanitation District
Sewer Agency of Southern Marin
Sonoma County Water Agency
South Bayside System Authority
Town of Yountville
Union Sanitary District
Vallejo Sanitation & Flood Control District
West County Agency

Cooling Water

Mirant of California, Pittsburgh and Potrero
Mirant Delta

Industrial Dischargers

C & H Sugar Company
Chevron Products Company
Crockett Cogeneration
Dow Chemical Company
Shell Oil Products - Martinez Refinery
Rhodia, Inc.
Tesoro Golden Eagle Refinery
ConocoPhillips - Rodeo Refinery
USS – POSCO Industries
Valero Refining Company

Dredgers

Alameda Point
BAE Systems (Formerly San Francisco Drydock)
Benicia Port Terminal Company, Pier 95
Chevron Richmond Long Wharf
City of Benicia Marina
Conoco Phillips Company
Emeryville Marina
Emeryville Entrance Channel
Emery Cove Marina
Paradise Cay Yacht Harbor
Port of Oakland
Port of San Francisco
San Rafael Yacht Harbor
U.S. Army Corps of Engineers
U.S. Coast Guard, Vallejo
Vallejo Ferry Terminal
Vallejo Yacht Club
Valero Refinery Terminal

Storm Water

Alameda Countywide Clean Water Program
California Department of Transportation
City and County of San Francisco
Contra Costa Clean Water Program
Fairfield-Suisun Urban Runoff Management Program
Marin County Stormwater Pollution Prevention Program
San Mateo Countywide Stormwater Pollution Prevention Program
Santa Clara Valley Urban Runoff Pollution Prevention Program
Vallejo Sanitation and Flood Control District

Municipal Dischargers

Burlingame Waste Water Treatment Plant
Central Contra Costa Sanitary District
Central Marin Sanitation Agency

Industrial Dischargers

C & H Sugar Company
Chevron Products Company
Crockett Cogeneration

City of Benicia
City of Calistoga
City of Palo Alto
City of Petaluma
City of Pinole/Hercules
City of Saint Helena
City and County of San Francisco
City of San Jose/Santa Clara
City of San Mateo
City of South San Francisco/San Bruno
City of Sunnyvale
Delta Diablo Sanitation District
East Bay Dischargers Authority
East Bay Municipal Utility District (SD#1)
Fairfield-Suisun Sewer District
Las Gallinas Valley Sanitation District
Marin County Sanitary District #5, Tiburon
Millbrae Waste Water Treatment Plant
Mountain View Sanitary District
Napa Sanitation District
Novato Sanitation District
Rodeo Sanitary District
San Francisco International Airport
Sausalito Sanitation District
Sewer Agency of Southern Marin
Sonoma County Water Agency
South Bayside System Authority
Town of Yountville
Union Sanitary District
Vallejo Sanitation & Flood Control District
West County Agency

Cooling Water

Mirant of California, Pittsburgh and Potrero
Mirant Delta

Other

Coyote Point Marina
Marin Co. Service Area 29
Marin Rowing Association
Dow Chemical Company
General Chemical Corporation
Martinez Refining Company
Rhodia, Inc.
Tesoro Golden Eagle Refinery
Tosco - Rodeo Refinery
USS – POSCO Industries
Valero Refining Company

Dredgers

BAE Systems
Chevron Richmond Long Wharf
City of Benicia
Conoco Phillips Company
Corinthian Yacht Club
Larkspur Ferry Terminal
Paradise Cay Yacht Harbor
Point San Pablo Yacht Club
Port of Oakland
Port of San Francisco
Strawberry Channel
Valero Refining Co.

Storm Water

Alameda Countywide Clean Water Program
California Department of Transportation
City and County of San Francisco
Contra Costa Clean Water Program
Fairfield-Suisun Urban Runoff Management Program
Marin County Stormwater Pollution Prevention Program
San Mateo Countywide Stormwater Pollution Prevention Program
Santa Clara Valley Urban Runoff Pollution Prevention Program
Vallejo Sanitation and Flood Control District

Logistical Coordinator; Shipboard Conductivity, Temperature, and Depth (CTD) Readings	Mr. Paul Salop Applied Marine Sciences (AMS), Livermore, CA
Ship Captain – Bivalve Cruise	Mr. David Morgan Captain, *RV Questuary* Romburg Tiburon Center
Ship Captain - Sediment Cruise	Mr. David Morgan Captain, *RV Questuary* Romburg Tiburon Center
Ship Captain – Water Cruise	Mr. Jim Christmann Captain, *RV Shana Rae* Monterey Canyon Research Vessels, Inc.
Bivalve Growth and Survival	Mr. Paul Salop Applied Marine Sciences (AMS), Livermore, CA
Bivalve Trace Organic Chemistry	Ms. Candice Navaroli AXYS Analytical Services Ltd. (AXYS), Sidney, BC
Water Trace Element Chemistry	Ms. Tiffany Stilwater Brooks-Rand Ltd. (BR), Seattle, WA
Water Trace Organic Chemistry	Ms. Candice Navaroli AXYS Analytical Services Ltd. (AXYS), Sidney, BC
Water Ancillary Measurements	Water Cognates: Ms. Nirmela Arsem and Mr. Ken Gerstman East Bay Municipal Utility District (EBMUD), Oakland, CA
	Water DOC and POC: Mr. Pradeep Divvela and Mike Shelton Columbia Analytical Services (CAS), Kelso, WA
Sediment Trace Element Chemistry	Sediment As, Se, Hg, and Methyl Mercury Ms. Tiffany Stilwater Brooks-Rand Ltd. (BR), Seattle, WA
	Sediment Al, Ag, Cd, Cu, Fe, Hg, Mn, Ni, Pb,and Zn Mr. Anthony Rattonetti and Mr. Lonnie Butler City and County of San Francisco (CCSF), San Francisco, CA
Sediment Trace Organics Chemistry	Mr. François Rodigari and Ms. Saskia van Bergen East Bay Municipal Utility District (EBMUD), Oakland, CA
Sediment Toxicity Testing	Dr. John Hunt, Dr. Brian Anderson, and Dr. Bryn Phillips Marine Pollution Studies Lab (MPSL), Granite Canyon, CA
Sediment Ancillary Measurements (Grainsize, TOC, TN)	Sediment TOC, TN and % Solids Mr. Pradeep Divvela and Mr. Mike Shelton Columbia Analytical Services (CAS), Kelso, WA
	Sediment Grainsize Dr. Ivano Aiello and Ms. Autumn Bonnema

	Geological Oceanography Lab at Moss Landing, Moss Landing, CA
USGS Water Quality	Dr. James Cloern, USGS, Menlo Park, CA
USGS Sediment Transport	Dr. David Schoellhamer, USGS, Sacramento, CA

APPENDIX 3 SUMMARY OF 2010 RMP SAMPLING STATIONS

CruiseType	Region	Site Code	Historic Site	Collection Date	Latitude	Longitude	Site Depth (m)
Water	Rivers	BG20	X	9/2/2010	38.05962	-121.812	9.5
Water	Rivers	BG30	X	9/2/2010	38.02042	-121.806	9.5
Water	Central Bay	BC10	X	8/27/2010	37.82167	-122.35	7.5
Water	Central Bay	BC20	X	8/30/2010	37.80145	-122.617	11
Water	South Bay	BA30	X	8/24/2010	37.5139	-122.135	7.3
Water	Suisun Bay	SU036W		9/1/2010	38.09617	-122.027	7.5
Water	Suisun Bay	SU037W		9/1/2010	38.07418	-122.07	3
Water	Suisun Bay	SU040W		9/1/2010	38.06187	-122.025	12
Water	San Pablo Bay	SPB030W		8/31/2010	38.02778	-122.313	3.5
Water	San Pablo Bay	SPB031W		8/31/2010	38.04692	-122.445	3
Water	San Pablo Bay	SPB032W		8/31/2010	38.046	-122.357	8
Water	Central Bay	CB030W		8/27/2010	37.74727	-122.274	3
Water	Central Bay	CB031W		8/30/2010	37.91483	-122.425	12
Water	Central Bay	CB032W		8/27/2010	37.68203	-122.349	8.5
Water	South Bay	SB058W		8/26/2010	37.56693	-122.219	13.5
Water	South Bay	SB059W		8/26/2010	37.6136	-122.325	4.5
Water	South Bay	SB060W		8/26/2010	37.61798	-122.218	3.5
Water	Lower South Bay	LSB044W		8/25/2010	37.49198	-122.092	5.8
Water	Lower South Bay	LSB045W		8/24/2010	37.49295	-122.099	6.5
Water	Lower South Bay	LSB046W		8/25/2010	37.47773	-122.073	4
Water	Lower South Bay	LSB048W		8/25/2010	37.48892	-122.085	4
Water	Lower South Bay	LSB049W		8/24/2010	37.48953	-122.105	4
Sediment	Rivers	BG20	X	2/10/2010	38.05888	-121.814	10.2
Sediment	Rivers	BG30	X	2/10/2010	38.02292	-121.808	3.7
Sediment	Suisun Bay	BF21	X	2/9/2010	38.11575	-122.04	2.8
Sediment	San Pablo Bay	BD31	X	2/8/2010	38.02382	-122.364	7.4
Sediment	Central Bay	BC11	X	2/4/2010	37.82208	-122.349	6.2
Sediment	South Bay	BA41	X	2/3/2010	37.55935	-122.21	2.3
Sediment	Lower South Bay	BA10	X	2/2/2010	37.46815	-122.063	3.5

Sediment	Central Bay	CB001S		2/4/2010	37.87657	-122.362	3.1
Sediment	Central Bay	CB042S		2/4/2010	37.73002	-122.283	3.7
Sediment	Central Bay	CB122S		2/4/2010	37.69867	-122.298	5.9
Sediment	Central Bay	CB055S		2/4/2010	37.9034	-122.404	9
Sediment	Lower South Bay	LSB002S		2/2/2010	37.47922	-122.078	9.1
Sediment	Lower South Bay	LSB072S		2/2/2010	37.49253	-122.079	2.8
Sediment	Lower South Bay	LSB109S		2/2/2010	37.48513	-122.105	2.8
Sediment	Lower South Bay	LSB140S		2/2/2010	37.48423	-122.08	3.6
Sediment	San Pablo Bay	SPB002S		2/8/2010	38.01638	-122.342	3.2
Sediment	San Pablo Bay	SPB043S		2/8/2010	38.1027	-122.467	2
Sediment	San Pablo Bay	SPB120S		2/8/2010	38.06952	-122.332	2.7
Sediment	San Pablo Bay	SPB051S		2/8/2010	38.03488	-122.462	3.1
Sediment	South Bay	SB002S		2/3/2010	37.61025	-122.167	1.7
Sediment	South Bay	SB087S		2/3/2010	37.65298	-122.226	2.1
Sediment	South Bay	SB095S		2/3/2010	37.63982	-122.249	3.5
Sediment	South Bay	SB091S		2/3/2010	37.5999	-122.322	3.3
Sediment	Suisun Bay	SU073S		2/9/2010	38.111	-122.049	3
Sediment	Suisun Bay	SU109S		2/9/2010	38.05578	-122.09	8.6
Sediment	Suisun Bay	SU084S		2/9/2010	38.12025	-122.016	3
Sediment	Suisun Bay	SU060S		2/9/2010	38.08182	-122.036	3.1
Bivalve	Central Bay	BC10	X	9/16/2010	37.81363	-122.359	4.8
Bivalve	Central Bay	BC61	X	9/16/2010	37.92833	-122.469	5.8
Bivalve	San Pablo Bay	BD20	X	9/14/2010	38.04533	-122.429	3.6
Bivalve	San Pablo Bay	BD30	X	9/14/2010	38.01667	-122.368	4.8
Bivalve	Rivers	BG20	X	9/17/2010	38.0557	-121.806	12
Bivalve	Rivers	BG30	X	9/17/2010	38.0236	-121.801	12
Bivalve	Lower South Bay	BA10	X	9/15/2010	37.46983	-122.064	6
Bivalve	South Bay	BA30	X	9/15/2010	37.51333	-122.135	4.3
Bivalve	South Bay	BA40	X	9/15/2010	37.547	-122.195	3.2
Bivalve	Central Bay	BB71	X	9/16/2010	37.6955	-122.34	11.8
Bivalve	Reference	T-0Bodega		6/10/2010	38.30477	-123.066	0
Bivalve	Reference	T-1Bodega		9/10/2010	38.30477	-123.066	0

APPENDIX 4 RMP TARGET PARAMETER LIST IN 2010

Field Measures – CTD Meter (Water, Sediment and Bivalve Cruises)	**Reporting Units**
Backscatter	Ftu
ElectricalConductivity	S/m
Temperature	Deg C
Density	kg/m3
Oxygen, Dissolved	mg/L
Pressure	Db
Salinity	psu
Field Measures - Shipboard (Water Cruise)	**Reporting Units**
Oxygen, Dissolved	mg/L
pH	pH
Salinity	ppt
SpecificConductivity	uS/cm
Temperature	Deg C
Field Measures - Shipboard (Sediment Cruise) *pH from interstitial water in undisturbed section of sediment grab	**Reporting Units**
pH*	pH
Eh	mV

[Basis codes: dw=dry weight, ww=wet weight]

Conventional Water Quality Parameters	**Reporting Units**	**Basis**
Ammonium as N	mg/L	ww
Chlorophyll a	mg/m3	ww
Dissolved Organic Carbon	ug/L	ww
Hardness as CaCO3	mg/L	ww
Nitrate as N	mg/L	ww
Nitrite as N	mg/L	ww

Oxygen, Dissolved	mg/L	ww
Particulate Organic Carbon	ug/L	ww
pH	pH	ww
Pheophytin a	mg/m3	ww
Phosphate as P	mg/L	ww
Salinity	psu	ww
Silica as SiO2	mg/L	ww
SpecificConductivity	umho	ww
Suspended Sediment Concentration	mg/L	ww
Temperature	Deg C	ww
Sediment Quality Parameters	**Reporting Units**	**Basis**
% Solids	%	dw
CollectionDepth	m	
Nitrogen, Total	%	dw
Total Organic Carbon	%	dw
Grainsize Parameters [**Sum of Clay and Silt]	**Reporting Units**	**Basis**
Clay <0.0039 mm	%	dw
Fine <0.0625 mm**	%	dw
Granule + Pebble 2.0 to <64 mm	%	dw
Sand 0.0625 to <2.0 mm	%	dw
Silt 0.0039 to <0.0625 mm	%	dw
Sediment Toxicity Parameters – Homogenate (RMP tests CHIR, EOHA and HYAL) SD = Standard Deviation	**Reporting Units**	**Basis**
Mean % Survival	%	dw
SD - Mean % Survival	%	dw
Mean mg/Individual (af growth)	mg	na
Mean mg/Individual (growth)	mg	na
Sediment Toxicity Parameters - Surface Water Interface (RMP tests MCAL)	**Reporting Units**	**Basis**
SWI Mean % Normal Alive	%	dw

SWI SD - Mean % Normal Alive	%	dw
Bivalve Tissue Parameters 1. Reported with Trace Metals 2. Reported with Trace Organics	**Reporting Units**	**Basis**
% Solids[1]	%	dw
% Survival per Species	%	dw
% Survival per Species (caged)	%	dw
Dry Weight	g	dw
Dry Weight Standard Error	g	dw
Growth Mean	g	dw
Growth Standard Error	g	dw
Lipid	%	dw
Moisture[2]	%	dw
Fish Tissue Parameters	**Reporting Units**	**Basis**
Lipid	%	ww or dw
Moisture	%	ww or dw
Length	cm	

Trace elements analyzed in water, sediment, and tissue samples:

Target Method Detection Limits (MDLs) are in parentheses following the reporting units.

Basis codes: dw=dry weight, ww=wet weight.

- Parameter is not sampled for the matrix.

* Dry and wet weight mercury concentrations are reported for fish tissue.

	Water	**Sediment**	**Bivalve Tissue**	**Fish Tissue**
Basis	ww	dw	dw	ww
Aluminum	-	mg/Kg (200)	ug/g (1)	-
Arsenic	ug/L (0.1)	mg/Kg (0.2)	-	-
Cadmium	ug/L (0.001)	mg/Kg (0.001)	ug/g (0.01)	-
Cobalt	ug/L (.0005)	-	-	-
Copper	ug/L (0.01)	mg/Kg (2)	ug/g (0.2)	-
Cyanide	ug/L (0.4)	-	-	-

Iron	ug/L (10)	mg/Kg (200)	-	-
Lead	ug/L (0.001)	mg/Kg (0.5)	ug/g (0.01)	-
Manganese	ug/L (0.01)	mg/Kg (20)	-	-
Mercury*	ug/L (.0001)	mg/Kg (0.00001)	-	ug/g
Mercury, Methyl	ng/L (0.005)	ug/Kg (0.005)	-	ug/g
Mercury, Acid Labile	ug/L	-	-	-
Mercury (II)R	ug/L	-	-	-
Nickel	ug/L (0.01)	mg/Kg (5)	ug/g (0.2)	-
Selenium	ug/L (0.02)	mg/Kg (0.01)	ug/g (0.01)	ug/g
Silver	ug/L (0.0001)	mg/Kg (0.001)	ug/g (0.001)	-
Zinc	ug/L (0.005)	mg/Kg (5)	ug/g (10)	-

Trace organic parameters (reporting units) analyzed in water (pg/L), sediment (ug/Kg), and bivalve tissue (ng/g)

Note: PAHs, Pesticides and PCBs are reported biennially in water. Sums calculated by SFEI.

Organochlorines in tissue from CDFG analyzed by GC-ECD will be determined using two columns of differing polarity.

Polycyclic Aromatic Hydrocarbons (PAHs)

(Target MDLs: water – 200 pg/L, sediment -- 5 ug/Kg, tissue – 5 ng/g)

[1]*Sum of LPAHs and HPAHs*

[2]*Reported in sediment only*

[3]*Reported in water only*

Low molecular weight PAHs	High molecular weight PAHs	Alkylated PAHs
Acenaphthene	Benz(*a*)anthracene	Benz(a)anthracenes/Chrysenes, C1-[3]
Acenaphthylene	Benzo(*a*)pyrene	Benz(a)anthracenes/Chrysenes, C2-[3]
Anthracene	Benzo(*b*)fluoranthene	Benz(a)anthracenes/Chrysenes, C3-[3]
Biphenyl	Benzo(*e*)pyrene	Benz(a)anthracenes/Chrysenes, C4-[3]
Dibenzothiophene	Benzo(g,h,i)perylene	Chrysenes, C1-[2]
Dimethylnaphthalene, 2,6-	Benzo(*k*)fluoranthene	Chrysenes, C2-[2]
Fluorene	Chrysene	Chrysenes, C3-[2]
Methylnaphthalene, 1-	Dibenz(*a,h*)anthracene	Chrysenes, C4-[2]
Methylnaphthalene, 2-	Fluoranthene	Dibenzothiophenes, C1-
Methylphenanthrene, 1-	Indeno(1,2,3-c,d)pyrene	Dibenzothiophenes, C2-
Naphthalene	Perylene	Dibenzothiophenes, C3-

Phenanthrene Trimethylnaphthalene, 2,3,5- Sum of LPAHs (SFEI)	Pyrene *Sum of HPAHs (SFEI)* *Sum of PAHs (SFEI)*[1]	Fluoranthene/Pyrenes, C1- Fluorenes, C1- Fluorenes, C2- Fluorenes, C3- Naphthalenes, C1- Naphthalenes, C2- Naphthalenes, C3- Naphthalenes, C4- Phenanthrene/Anthracene, C1- Phenanthrene/Anthracene, C2- Phenanthrene/Anthracene, C3- Phenanthrene/Anthracene, C4-

SYNTHETIC BIOCIDES ***(Target MDLs: water – 2 pg/L, sediment - 1 ug/Kg, tissue – 1 ng/g)*** [1] *Parameter reported for water matrix only.* [2]*Parameter reported for sediment matrix only.* *Sums calculated by SFEI.*				
Cyclopentadienes Aldrin Dieldrin Endrin	**Chlordanes** Chlordane, cis- Chlordane, trans-Heptachlor Heptachlor Epoxide Nonachlor, cis- *Nonachlor, trans-* *Oxychlordane* Sum of Chlordanes (SFEI)	**DDTs** DDD(o,p') DDD(p,p') DDE(o,p') DDE(p,p') DDT(o,p') DDT(p,p') Sum of DDTs (SFEI)	**HCH** HCH, alpha HCH, beta HCH, delta HCH, gamma Sum of HCHs (SFEI)	**Other Synthetic Biocides** Chlorpyrifos[1] Dacthal[1] Diazinon[1] Endosulfan I[1] Endosulfan II[1] Endosulfan sulfate[1] Fipronil desulfinyl[2] Fipronil sulfide[2] Fipronil sulfone[2] Fipronil[2] Hexachlorobenzene Mirex

OTHER SYNTHETIC COMPOUNDS **Polychlorinated Biphenyls (PCBs)** **(Target MDLs: water – 2 pg/L, sediment - 1 ug/Kg , tissue – 1 ng/g)** IUPAC numbers listed. Sums calculated by SFEI. *Congeners included in the Sum of 40 PCBs (SFEI). [1]Coplanar PCBs						
PCB 001	**PCB 031***	PCB 061	PCB 091	PCB 121	**PCB 151***	PCB 181
PCB 002	PCB 032	PCB 062	PCB 092	PCB 122	PCB 152	PCB 182
PCB 003	**PCB 033***	PCB 063	PCB 093	PCB 123[1]	**PCB 153***	**PCB 183***
PCB 004	PCB 034	PCB 064	PCB 094	PCB 124	PCB 154	PCB 184
PCB 005	PCB 035	PCB 065	**PCB 095***	PCB 125	PCB 155	PCB 185
PCB 006	PCB 036	**PCB 066***	PCB 096	PCB 126[1]	**PCB 156*[1]**	PCB 186
PCB 007	PCB 037	PCB 067	**PCB 097***	PCB 127	PCB 157[1]	**PCB 187***
PCB 008*	PCB 038	PCB 068	PCB 098	**PCB 128***	**PCB 158***	PCB 188
PCB 009	PCB 039	PCB 069	**PCB 099***	PCB 129	PCB 159	PCB 189[1]
PCB 010	PCB 040	**PCB 070***	PCB 100	PCB 130	PCB 160	PCB 190
PCB 011	PCB 041	PCB 071	**PCB 101***	PCB 131	PCB 161	PCB 191
PCB 012	PCB 042	PCB 072	PCB 102	**PCB 132***	PCB 162	PCB 192
PCB 013	PCB 043	PCB 073	PCB 103	PCB 133	PCB 163	PCB 193[1]
PCB 014	**PCB 044***	**PCB 074***	PCB 104	PCB 134	PCB 164	**PCB 194***
PCB 015	PCB 045	PCB 075	**PCB 105*[1]**	PCB 135	PCB 165	**PCB 195***
PCB 016	PCB 046	PCB 076	PCB 106	PCB 136	PCB 166	PCB 196
PCB 017	PCB 047	PCB 077[1]	PCB 107	PCB 137	PCB 167[1]	PCB 197
PCB 018*	PCB 048	PCB 078	PCB 108	**PCB 138***	PCB 168	PCB 198
PCB 019	**PCB 049***	PCB 079	PCB 109	PCB 139	PCB 169[1]	PCB 199
PCB 020	PCB 050	PCB 080	**PCB 110***	PCB 140	**PCB 170*[1]**	PCB 200
PCB 021	PCB 051	PCB 081[1]	PCB 111	**PCB 141***	PCB 171	**PCB 201***
PCB 022	**PCB 052***	PCB 082	PCB 112	PCB 142	PCB 172	PCB 202
PCB 023	PCB 053	PCB 083	PCB 113	PCB 143	PCB 173	**PCB 203***
PCB 024	PCB 054	PCB 084	PCB 114[1]	PCB 144	**PCB 174***	PCB 204
PCB 025	PCB 055	PCB 085	PCB 115	PCB 145	PCB 175	PCB 205
PCB 026	**PCB 056***	PCB 086	PCB 116	PCB 146	PCB 176	PCB 206
PCB 027	PCB 057	**PCB 087***	PCB 117	PCB 147	**PCB 177***	PCB 207

PCB 028*	PCB 058	PCB 088	**PCB 118***[1]	PCB 148	PCB 178	PCB 208
PCB 029	PCB 059	PCB 089	PCB 119	**PCB 149***	PCB 179	PCB 209
PCB 030	**PCB 060***	PCB 090	PCB 120	PCB 150	**PCB 180***[1]	Sum of 40 PCBs (SFEI)
						Sum of 209 PCBs (SFEI)

Polybrominated Diphenyl Ethers (PBDEs) **(Target MDLs: water – 1 pg/L, sediment – 1 ug/Kg, tissue – 1 ng/g)** IUPAC number listed. *Only analyzed in sediment.			
PBDE 007	PBDE 035	PBDE 105	PBDE 183
PBDE 008	PBDE 037	PBDE 116	PBDE 190
PBDE 010	PBDE 047	PBDE 119	PBDE 196*
PBDE 011	PBDE 049	PBDE 120	PBDE 197
PBDE 012	PBDE 051	PBDE 126	PBDE 203
PBDE 013	PBDE 066	PBDE 128	PBDE 204
PBDE 015	PBDE 071	PBDE 138	PBDE 205
PBDE 017	PBDE 075	PBDE 140	PBDE 206
PBDE 025	PBDE 077	PBDE 153	PBDE 207
PBDE 028	PBDE 079	PBDE 154	PBDE 208
PBDE 030	PBDE 085	PBDE 155	PBDE 209
PBDE 032	PBDE 099	PBDE 166	
PBDE 033	PBDE 100	PBDE 181	

Pyrethroids **(Target RDLs: sediment – 1 to 10 ug/kg)** *Sum of individual isomers. Sums calculated by SFEI.		
Allethrin	Deltamethrin	Phenothrin
Bifenthrin	Esfenvalerate/Fenvalerate, total*	Prallethrin
Cyfluthrin, total*	Fenpropathrin	Resmethrin
Cyhalothrin, lambda, total*	Permethrin, cis-	Tetramethrin
Cypermethrin, total*	Permethrin, trans-	Tralomethrin
		Sum of Pyrethroids (SFEI)

Dioxins and Furans (PCDD/F) **(sediment and tissue – ug/Kg; water – pg/L)**	
Dioxins	**Furans**
HpCDD, 1,2,3,4,6,7,8- HxCDD, 1,2,3,4,7,8- HxCDD, 1,2,3,6,7,8- HxCDD, 1,2,3,7,8,9- OCDD, 1,2,3,4,6,7,8,9- PeCDD, 1,2,3,7,8- TCDD, 2,3,7,8- Sum of Dioxin-Furan TEQs (WHO 2005;ND=0 SFEI)*	HpCDF, 1,2,3,4,6,7,8- HpCDF, 1,2,3,4,7,8,9- HxCDF, 1,2,3,4,7,8- HxCDF, 1,2,3,6,7,8- HxCDF, 1,2,3,7,8,9- HxCDF, 2,3,4,6,7,8- OCDF, 1,2,3,4,6,7,8,9- PeCDF, 1,2,3,7,8- PeCDF, 2,3,4,7,8- TCDF, 2,3,7,8-
* NDs should be set to zero as the default	

Perfluorinated Compounds (PFC) **(Target RDLs: water – 1 ng/L or * 2 ng/L; tissue – ng/g; water – ng/L; sediment ug/Kg)**	
<u>Carboxylic Acids</u>	**<u>Sulphonic Acids</u>**
Perfluorobutanoate Perfluorodecanoate Perfluorododecanoate Perfluoroheptanoate Perfluorohexanoate Perfluorononanoate Perfluorooctanoate (PFOA) Perfluoropentanoate Perfluoroundecanoate	Perfluorobutanesulfonate* Perfluorohexanesulfonate* Perfluorooctanesulfonamide Perfluorooctanesulfonate* (PFOS)

Appendix 5 analytes reported in water samples (1993-2010)

Shaded areas indicate that results are available for RMP Status and Trends Sampling.

Parameter Type Codes: ANC = Ancillary Parameters, ORGS = Organic Parameters, PESTs = Pesticide Parameters, SYN = Synthetic Parameters, TE = Trace Metal parameters, WaterTOX = Toxicity Parameters

* Data available upon request

Reportable Water Parameter	Type	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Ammonium as N	ANC	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Chlorophyll a	ANC	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
CTD*	ANC		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Dissolved Organic Carbon	ANC	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Hardness as CaCO3	ANC	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Nitrate as N	ANC	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Nitrite as N	ANC	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Oxygen, Dissolved	ANC	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	
Particulate Organic Carbon	ANC												■	■	■	■	■	■	■
pH	ANC	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	
Pheophytin a	ANC	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Phosphate as P	ANC	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Salinity (by salinometer)	ANC	■		■	■	■	■	■	■	■	■	■	■	■	■				
Salinity (by SCT)	ANC	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Salinity (by Solomat)	ANC					■													
Silica	ANC	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
SpecificConductivity	ANC	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	
Suspended Sediment Concentration	ANC										■	■	■	■	■	■	■	■	■
Temperature	ANC	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	
Total Suspended Solids	ANC	■	■	■	■	■	■	■	■	■				■	■	■			
Alkanes (C10-C34)	ORGS	■	■	■															
Dioxins/Furans	ORGS																	■	
PAHs (biennially beginning 2008)	ORGS	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■		
PAHs Alkylated (biennially beginning 2008)	ORGS						■	■	■	■	■	■	■	■	■	■	■		
PBDEs (annually)	ORGS										■	■	■	■	■	■	■	■	■

Reportable Water Parameter	Type	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
PCBs 209 (biennially beginning 2008)	ORGS																		
PCBs 40 (biennially beginning 2008)	ORGS																		
Pharmaceuticals	ORGS																		
Phthalates	ORGS																		
Chlordanes	PESTs																		
Chlorpyrifos	PESTs																		
Cyclopentadienes	PESTs																		
Dacthal	PESTs																		
DDTs	PESTs																		
Diazinon	PESTs																		
Endosulfan I	PESTs																		
Endosulfan II	PESTs																		
Endosulfan Sulfate	PESTs																		
HCHs	PESTs																		
Hexachlorobenzene	PESTs																		
Mirex	PESTs																		
Oxadiazon	PESTs																		
p-Nonylphenol	SYN																		
Triphenylphosphate	SYN																		
Arsenic	TE																		
Cadmium	TE																		
Chromium	TE																		
Cobalt	TE																		
Copper	TE																		
Cyanide	TE																		
Iron	TE																		
Lead	TE																		
Manganese	TE																		
Mercury	TE																		
Mercury, Methyl	TE																		
Nickel	TE																		
Selenium	TE																		

Reportable Water Parameter	Type	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Silver	TE																		
Zinc	TE																		
Cell Count	WaterTox																		
Mean % Normal Development	WaterTox																		
Mean % Survival	WaterTox																		
SWI Mean % Normal Alive	WaterTox																		

Appendix 6 Analytes Reported in Sediment Samples (1993-2010)

Shaded areas indicate that results are available for RMP Status and Trends Sampling.

Parameter Type Codes: ANC = Ancillary Parameters, EC=Emerging Contaminants, ORGS = Organic Parameters, PESTs = Pesticide Parameters, SedTOX = Toxicity Parameters, SYN = Synthetic Parameters, TE = Trace Metal parameters

* Data available upon request

Reportable Sediment Parameter	Type	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
% Solids	ANC																		
Ammonia	ANC																		
Clay <0.0039 mm	ANC																		
Clay <0.005 mm	ANC																		
CTD*	ANC																		
Eh*	ANC																		
Fine <0.0625 mm	ANC																		
Granule + Pebble 2.0 to <64 mm	ANC																		
Hydrogen Sulfide	ANC																		
pH	ANC																		
Sand 0.0625 to <2.0 mm	ANC																		
Silt 0.0039 to <0.0625 mm	ANC																		
Total Nitrogen	ANC																		
Total Organic Carbon	ANC																		
Total Sulfide	ANC																		

Reportable Sediment Parameter	Type	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Benthos	Benthos																		
Dioxins/Furans	ORGS																		
PAHs	ORGS																		
PAHs Alkylated	ORGS																		
PBDEs	ORGS																		
PCBs 209	ORGS																		
PCBs 40	ORGS																		
Phthalates	ORGS																		
Chlordanes	PESTs																		
Cyclopentadienes	PESTs																		
DDTs	PESTs																		
Fipronil	PESTs																		
HCHs	PESTs																		
Hexachlorobenzene	PESTs																		
Mirex	PESTs																		
Pyrethroids	PESTs																		
Mean % Normal Alive	SedTox																		
Mean % Survival	SedTox																		
p-Nonylphenol	SYN																		
Aluminum	TE																		
Arsenic	TE																		
Cadmium	TE																		
Copper	TE																		
Chromium	TE																		
Iron	TE																		
Lead	TE																		
Manganese	TE																		
Mercury	TE																		
Mercury, Methyl	TE																		
Nickel	TE																		
Selenium	TE																		
Silver	TE																		
Zinc	TE																		

Appendix 7 Analytes Reported in Bivalve Tissue Samples (1993-2010)

Shaded areas indicate that results are available for RMP Status and Trends Sampling.

Parameter Type Codes: ANC = Ancillary Parameters, ORGS = Organic Parameters, PESTs = Pesticide Parameters, SYN = Synthetic Parameters, TE = Trace Metal parameters

[1]Beginning in 2007, bivalve monitoring occurs biennially for trace organics and every 5 years for trace metal parameters. Bivalves were not deployed in 2007.

Reportable Bivalve Tissue Parameter	Type	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007[1]	2008	2009[1]	2010
% Moisture	ANC		■	■	■	■	■	■	■	■	■	■	■		■		■		■
% Solids	ANC	■	■	■	■	■	■	■	■	■	■	■	■				■		
% Survival per Species	ANC	■	■	■	■	■	■	■	■	■	■	■	■				■		
% Survival per Species (caged)	ANC														■		■		
Condition Index Mean	ANC	■	■	■	■	■	■	■	■								■		
CTD	ANC							■	■	■	■	■	■		■		■		■
Dry Weight	ANC	■	■	■	■	■	■	■	■	■	■	■	■		■		■		■
Gonad Index CI Mean	ANC							■	■	■									
Growth Mean	ANC							■	■	■	■	■	■		■		■		■
209 PCBs	ORGS																		■
40 PCBs	ORGS	■	■	■	■	■	■	■	■	■	■	■		■	■		■		■
Alkanes (C10-C34)	ORGS	■	■	■															
Musk	ORGS										■	■	■						
PAHs	ORGS	■	■	■	■	■	■	■	■	■	■	■		■	■		■		■
PAHs Alkylated	ORGS	■	■	■	■	■	■	■	■	■	■	■			■		■		■
PBDEs	ORGS										■	■		■	■		■		■
Phthalates	ORGS										■	■	■						
Chlordanes	PESTs	■	■	■	■	■	■	■	■	■	■	■		■	■		■		■
Cyclopentadienes	PESTs	■	■	■	■	■	■	■	■	■	■	■		■	■		■		■
DDTs	PESTs	■	■	■	■	■	■	■	■	■	■	■		■	■		■		■
HCHs	PESTs	■	■	■	■	■	■	■	■	■	■	■		■	■		■		■
Hexachlorobenzene	PESTs	■	■	■	■	■	■	■	■	■	■	■		■	■		■		■
Mirex	PESTs	■	■	■	■	■	■	■	■	■	■	■		■	■		■		■
p-Nonylphenol	SYN										■	■	■						
Triphenylphosphate	SYN										■	■	■						
Aluminum	TE		■	■		■	■	■	■	■							■		
Arsenic	TE	■	■	■	■	■	■	■											

Reportable Bivalve Tissue Parameter	Type	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007[1]	2008	2009[1]	2010
Cadmium	TE	■	■	■	■	■	■	■	■	■							■		
Copper	TE	■	■	■	■	■	■	■	■	■							■		
Cromium	TE	■	■	■	■	■	■	■											
DBT (Dibutyltin)	TE	■	■	■	■	■	■	■	■	■									
Iron	TE						■	■									■		
Lead	TE	■	■	■	■	■	■	■	■	■							■		
Manganese	TE						■	■									■		
MBT (Monobutyltin)	TE	■	■	■	■	■	■	■	■	■									
Mercury	TE	■	■	■	■	■	■	■											
Methyl Mercury	TE	■																	
Nickel	TE	■	■	■	■	■	■	■	■	■							■		
Selenium	TE	■	■	■	■	■	■	■	■	■							■		
Silver	TE	■	■	■	■	■	■	■	■	■							■		
TBT (Tributyltin)	TE	■	■	■	■	■	■	■	■	■									
TTBT (Tetrabutyltin)	TE		■	■	■	■	■	■	■	■									
Zinc	TE	■	■	■	■	■	■	■	■	■							■		

APPENDIX 8 – CHANGES TO THE RMP PROGRAM 1993-2011

Action Codes: A= Analyte added or removed from sampling design; D= Data rejected or not available/data comparability issues; L= Change in laboratory conducting analysis or in laboratory methods; P= Change in program/sampling design; S= Station added or removed; T= Trends analysis performed.

Action Code	Year	Action	Detail/Rationale
D	1993-1998	CTD data are not available for tissue	CTD cast was not deployed.
D	1999-2001	CTD data are available for Deployment, maintenance and retrieval tissue cruises	Began deploying CTD casts during tissue cruises.
D	1998-1999	Iron in bivalves is a non-target analyte and not reported via WQT	Iron in bivalves reported by lab, but is not available via WQT.
D	2004-2005	Tissue PAHs analzed by CDFG were rejected due to the method sensitivity	Most PAH measurements in transplant bivalve samples were below detection limits and thus not usable for trends analysis.
A	1993	MeHg in bivalve tissue samples was only analyzed in 1993.	Since this was part of a pilot study, the results are not displayed via the WQT. Total mercury was analyzed each year through 1999.
P	1993	Implemented Regional Monitoring Program for Trace Substances in the San Francisco Estuary (RMP). Samples collected three times per year for conventional water quality parameters and trace analytes.	Samples were collected during the rainy season (March), during declining Delta outflow (May), and during the dry season (Aug - Sept).
P	1993	Implemented Regional Monitoring Program for Trace Substances in the San Francisco Estuary (RMP) samples. Samples collected twice a year for sediment quality parameters and trace analytes.	Samples were collected during the rainy season (March) and during the dry season (Aug-Sept).
P	1993	Implemented Regional Monitoring Program for Trace Substances in the San Francisco Estuary (RMP). Bivalve samples collected twice a year for transplanted, bagged bivalve bioaccumulation and condition.	Samples were deployed during the rainy season (March-May) and during the dry season (Aug-Sept) and retrieved between 90 and 100 days after deployment.
S	1993	Collected samples along the spine of the estuary at 16 set stations for water and sediment; toxicity was measured at 8 of these stations for each matrix. Bivalves were deployed at 11 of the stations.	Original RMP sampling design.

Action Codes: A= Analyte added or removed from sampling design; D= Data rejected or not available/data comparability issues; L= Change in laboratory conducting analysis or in laboratory methods; P= Change in program/sampling design; S= Station added or removed; T= Trends analysis performed.			
Action Code	**Year**	**Action**	**Detail/Rationale**
D	1994	Prior to 2003, there are no records for individual fish stored in the database. Therefore, there are no records in the POEFish table.	Only composite information is available.
P	1994	Status and Trends Sport Fish Monitoring	• Sport fish monitoring began as a pilot study funded by the Bay Protection and Toxics Cleanup Program. • All fish were analyzed as individuals for mercury, PCBs, pesticides, and selenium.
S	1994	Added 2 stations for water and sediment sampling (previously 22) as part of the Local Effects Monitoring Program (LEMP): C-1-3 (Sunnyvale) and C-3-0 (San Jose)	Sites located by water pollution control plants. Added on a trial basis by Water Board. Sites were treated identically as RMP stations. Total water stations =24.
S	1994	Added 4 stations (previously 11) for bivalve tissue sampling	Total bivalve stations = 15.
S	1994	Added 6 stations for water and sediment sampling (previously 16): San Bruno Shoal (BB15), Alameda (BB70), Red Rock (BC60), Honker Bay (BF40), Petaluma River mouth (BD15), Coyote Creek mouth (BA10)	Sites selected to fill large areas in Estuary where no samples were taken and to better monitor areas around tributaries. Total water stations = 22.
A	1996	Added trace organics analysis for Southern Slough stations Sunnyvale (C-1-3) and San Jose (C-3-0)	Trace organics were not analyzed for Sunnyvale (C-1-3) during the July 1996 or August 1997 rainy season cruises, however samples were analyzed for trace metals and ancillary parameters.
S	1996	1996-04 Corbicula fluminea (CFLU) clams were collected from Putah Creek.	1996-04 Corbicula fluminea (CFLU) couldn't be retrieved from Lake Isabella so clams were collected from Putah Creek. Due to concerns with contamination, both pre- and post-depuration analysis was performed, but only the post-depurated results were reported. In September 1996, only post-depurated analysis was performed.
S	1996	Added 2 stations for water and sediment sampling (previously 24) as part the Estuary Interface Pilot Study: Standish Dam (BW10) and Guadalupe River (BW15)	Added as part of the Estuary Interface Pilot Study. Total water and sediment stations = 26.
A	1997	Identified 40 target PCB congeners for labs to report: PCB 008, 018, 028, 031, 033, 044, 049,	Analysis of RMP data collected from 1993-1995 showed 40 congeners consistently quantified in Bay samples. It was found that 40 congeners would be a good representation (~80% representative) of the total mass of PCBs in the bay.

Action Codes: A= Analyte added or removed from sampling design; D= Data rejected or not available/data comparability issues; L= Change in laboratory conducting analysis or in laboratory methods; P= Change in program/sampling design; S= Station added or removed; T= Trends analysis performed.			
Action Code	**Year**	**Action**	**Detail/Rationale**
		052, 056, 060, 066, 070, 074, 087, 095, 097, 099, 101, 105, 110, 118, 128, 132, 138, 141, 149, 151, 153, 156, 158, 170, 174, 177, 180, 183, 187, 194, 195, 201, 203	
D	1997	Prior to 2003, there are no records for individual fish stored in the database. Therefore, there are no records in the POEFish table.	Only composite information is available.
D	1997	Total salinity measurements taken in the field are not available for the April cruise.	Measurements not available.
L	1997	Changed analytical lab for analysis of PCBs and PAHs in bivalve tissue samples	Central Contra Costa Sanitary District began analysis of PCBs and PAHs in bivalve tissue.
P	1997	Implemented Sport Fish Contaminant Study - Sport Fish will be collected on a three year cycle and analyzed for mercury, PCBs, legacy pesticides (DDT, dieldrin, chlordane), and Se	Study implemented as a follow up to a 1994 study conducted by the San Francisco Bay Regional Water Quality Control Board (SFBRWQCB).
P	1997	Status and Trends Sport Fish Monitoring	• A special study was done to compare skin-on versus skin-off organics concentrations in white croaker. • Analytes measured: mercury, PCBs, DDT's, chlordanes, dieldrin, dioxin and dioxin-like compounds, and selenium. • Most samples were analyzed as composites except for mercury in striped bass and California halibut, and selenium in white sturgeon. • EWG analyzed some archive 1997 RMP samples for PBDEs in 2002. These data are not available on the WQT.
A	1998	T-1 samples analyzed for trace organics and trace elements	While T-0 samples have been consistently analyzed throughout the years, T-1 samples were analyzed for only two cruises: 1998-04 and 2001-09. The decision to analyze was because a lot of the transplants died during deployment.
D	1998	Status and Trends Sport Fish Monitoring	• Bivalves and crustaceans were analyzed as part of the sport fish study.
D	1998	Tissue results are not available for Sept. 1998 for BF20 (Grizzly Bay)	The bivalves *Corbicula fluminea* (CFLU) could not be found at the reference site Lake Chabot
D	1999	Status and Trends Sport Fish Monitoring	• Bivalves and crustaceans were analyzed as part of the sport fish study.

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Action Code	**Year**	**Action**	**Detail/Rationale**
L	1999	Changed analytical lab for analysis of mercury in water samples	University of Maryland, Center of Environmental Studies began analysis of Hg in water.
S	1999	Removed 1 station (previously 15) for bivalve tissue sampling BF20 (Grizzly Bay)	A bivalve reference site could not be found for *Corbicula fluminea* (CFLU). Total bivalve tissue stations = 14.
A	2000	Added Cobalt (Co) analysis in water and sediment samples	Co is a useful marker of geochemical processes in the Estuary, particularly as an indicator of metal fluxes from sub-oxic sediments. Added as part of the Fe/Mn/Co group.
A	2000	Added gonadal index and growth analysis in bivalve tissue samples	Growth analysis calculated by SFEI in 2000 and 2001. AMS started calculating growth analysis in 2002.
A	2000	Added Methyl Mercury analysis in water and sediment samples	Ratios of Methyl Mercury to Total Mercury can be used to determine environments that methylation is most likely to occur in.
A	2000	Removed Mercury (Hg) and Arsenic (As) analysis in bivalve tissue samples	RMP results (1993-99) indicated that there was very little bioaccumulation of Hg beyond background concentrations and there was an absence of serious As contamination.
D	2000	Prior to 2003, there are no records for individual fish stored in the database. Therefore, there are no records in the POEFish table.	Only composite information is available.
L	2000	Changed analytical lab for analysis of PCBs and PAHs in bivalve tissue samples	Texas A&M Geochemical and Environmental Research began analysis of PCBs and PAHs in bivalve tissue.
P	2000	Changed frequency of water sampling to twice a year for ancillary and trace metal analytes	Discontinued sampling during declining Delta outflow (May). Samples were collected during the rainy season (March) and during the dry season (Aug-Sept). It was determined that samples collected during the dry season were most indicative of ambient concentrations.
P	2000	Changed frequency of sediment sampling to once a year for ancillary, trace metal and organic analytes	Samples collected during the dry season (Aug-Sept).
P	2000	Changed frequency of water sampling to once a year for organic analytes	Samples collected during the dry season were analyzed for organic contaminants. Most organic contaminants are legacy pollutants which degrade slowly so analyzing more that once a year for these analytes was found to be unnecessary.
P	2000	Status and Trends Sport Fish Monitoring	• A special study was done to compare organics concentrations across time during one year in the Oakland Inner Harbor. This study was to look at the

Action Codes: A= Analyte added or removed from sampling design; D= Data rejected or not available/data comparability issues; L= Change in laboratory conducting analysis or in laboratory methods; P= Change in program/sampling design; S= Station added or removed; T= Trends analysis performed.			
Action Code	**Year**	**Action**	**Detail/Rationale**
			seasonal variation of organic contaminants pre- and post-spawning. • Analytes measured: mercury, PCBs, DDTs, chlordanes, dieldrin, PBDEs (qualitative), dioxin and dioxin-like compounds, and selenium. • The 1998 crab data and 1999 clam data were reported in the 2000 report. • Most samples were analyzed as composites except for mercury (California halibut, white sturgeon, leopard shark and striped bass) and selenium in white sturgeon.
A	2001	Removed Gonadal Index analysis in bivalve tissue samples	Unable to obtain sufficient level of precision in separating somatic and gonadal tissue.
A	2001	T-1 samples analyzed	While T-0 samples have been consistently analyzed throughout the years, T-1 samples were analyzed for only two cruises: 1998-04 and 2001-09. No rational was found for analyzing these samples.
D	2001	PBDE Tissue Data not reported	A minimum amount of QA/QC was conducted. Dataset was missing replicates and SRMs. Data was treated as a special study and not added to S&T db.
D	2001	Status and Trends Sport Fish Monitoring	• Bivalves and crustaceans were analyzed as part of the sport fish study.
A	2002	Added PBDEs, phthalates, and p-nonylphenol analysis in water and sediment samples	Added potential persistent pollutants with the ability to bioaccumulate and cause toxicity.
A	2002	Added PBDEs, phthalates, p-nonylphenol, triphenylphosphate and nitro and polycyclic musks analysis in bivalve tissue samples	Added potential persistent pollutants with the ability to bioaccumulate and cause toxicity.
A	2002	Changed health indicator from Condition Index Mean to Growth Mean in bivalve tissue samples	Condition index is the ratio of tissue mass to shell volume and may be affected by factors other than health. Growth compares the pre- and post- deployment weight of each mussel and is a more direct measurement of health.
A	2002	Reduced bivalve Trace Metals (Ag, Al, Cd, Cu, Ni, Pb, Se, Zn) analysis in bivalve tissue samples to 5 year cycle and removed tributyltin analysis in bivalve tissue samples	RMP results indicated that Trace Metals and tributyltin do not appreciably accumulate in bivalve tissue. Report link: http://www.sfei.org/rmp/Technical_Reports/RMP_2002_No109_RedesignProcess.pdf
A	2002	Removed chromium analysis in water, sediment and bivalve tissue samples	Technical Review Committee made decision based on findings by Khalil Abu-Saba that stated that the chromium found in the estuary was mostly of the trivalent form and none of the hexavalent form was detected. The concentrations in water and

Action Codes: A= Analyte added or removed from sampling design; D= Data rejected or not available/data comparability issues; L= Change in laboratory conducting analysis or in laboratory methods; P= Change in program/sampling design; S= Station added or removed; T= Trends analysis performed.			
Action Code	**Year**	**Action**	**Detail/Rationale**
			sediment were found to be essentially the same as those from the soils in the watersheds draining into the estuary.
D	2002	CTD casts were not taken during 2002 bivalve tissue maintenance cruise	The water and bivalve maintenance cruise occurred concurrently and it was decided that it was more important to take casts on the water cruise.
D	2002	Data unavailable/rejected for BDEs 82, 128, 203, 204, 205, 206, 207, and 209 for bivalve tissue samples	BDEs 82, 128, and 209 not part of standard mix reported by lab. BDEs 203, 204, 205, 206, 207 and 209 do not elute off of the GC-ECD columns.
D	2002	Data unavailable/rejected for PCB 132 analyzed in bivalve tissue samples	PCB 132 not analyzed in the lab due to co-elution problems.
L	2002	Changed analytical lab for analysis of mercury and methyl mercury in water	University of California, Santa Cruz Dept. of Environmental Toxicology began water Hg and MeHg analysis (formerly conducted by University of Maryland).
L	2002	Changed analytical lab for analysis of trace organics in bivalve samples	California Dept. of Fish and Game, Marine Pollution Control Laboratory began analysis of trace organics in bivalve tissue (including pesticides, PAHs, and PCBs).
L	2002	Changed analytical lab for water trace organics to AXYS	Analysis formerly conducted by University of Utah Energy and Geoscience Institute (UUEGI)
L	2002	Changed method for analysis of Total Suspended Solids (TSS) in water to Suspended Solid Content (SSC) in water	The SSC method analyzes the whole sample while TSS is a subsetting method. SSC poses less variability by human interference and attains better precision because heavier sand and sticky clay particles are not lost during analysis.
P	2002	Changed Aquatic Toxicity Testing from yearly to a five year cycle	From 1993 to 2002, a noticeable decline in aquatic toxicity to organisms was observed, especially during the dry season.
P	2002	Implemented new random sampling design. Random sampling design based on spatially balanced probabilistic sampling design. The bay was divided into 5 hydrographic regions plus the Rivers segments. 7 Historic RMP sites were maintained in the program for sediment trends analysis and 3 (now 5) historic sites were maintained for water analysis	Sampling design will provide better statistical basis to answer regulatory questions. Will provide unbiased estimate of ambient conditions.
P	2002	Status and Trends Sport Fish Monitoring	• The Environmental Working Group collected fish in 2002 from fishing piers around the Bay and analyzed fish for PBDE levels. SFEI reviewed this data set and added it to our Sportfish database. The data are not currently being

Action Codes: A= Analyte added or removed from sampling design; D= Data rejected or not available/data comparability issues; L= Change in laboratory conducting analysis or in laboratory methods; P= Change in program/sampling design; S= Station added or removed; T= Trends analysis performed.			
Action Code	**Year**	**Action**	**Detail/Rationale**
			included in the WQT due to some issues with the data. EWG also analyzed some archive RMP samples (1997) for PBDEs. These data are also not being displayed externally.
P	2002	Stopped Bivalve Maintenance Cruise	Cruise was found to be unnecessary.
A	2003	Added PBDE analysis in sport fish samples collected for the Sport Fish Contaminant Study	Increasing PBDE concentrations in the bay area coupled with concern about the health effects on humans and wildlife led to adding PDBEs.
A	2003	CTD casts were not taken during 2003 bivalve tissue maintenance cruise	The water and bivalve maintenance cruise occurred concurrently and it was decided that it was more important to take casts on the water cruise.
D	2003	Data rejected for PAHs in bivalve tissue	Data was rejected by SFEI QA Officer due to many samples being qualified as Non Detect.
D	2003	Data unavailable/rejected for pesticide, PCB, and PBDE sediment samples	Samples are to be reanalyzed using HRGC/MS since there has been a change in analytical method.
P	2003	Changed container for bivalves deployed from bags to cages. Some of the cages were maintained and some were un-maintained at each site	Findings from side by side deployment of bivalves in cages and in bags indicated that cages reduced the effects of bivalve predation. Report link: http://www.sfei.org/rmp/reports/431_AMS_bivalvestudies.pdf.
P	2003	Status and Trends Sport Fish Monitoring	• A special study to do preliminary screening of additional species began in 2003. Additional species were analyzed for mercury and PCBs. Species included anchovy, barred surfperch, black surfperch, brown rockfish, herring, Chinook salmon, diamond turbot, sardine, smooth hound shark, starry flounder, and walleye surfperch. • Analytes measured: mercury, PCBs, DDT, chlordane, dieldrin, PBDEs. • Most samples were analyzed as composites except for mercury (California halibut, striped bass, leopard shark, white sturgeon) and selenium in white sturgeon.
P	2003	Stopped deployment of bivalves *Corbicula fluminea* (CFLU) in the estuary. CFLU collection was continued in the delta by trawling at the Rivers sites BG20 (Sacramento River) and BG30 (San Joaquin River)	Findings from 2000-2002 special studies concluded that bioaccumulation of contaminants in the estuary could be monitored using only one species *Mytilus californianus* (MCAL).
S	2003	Removed three stations (previously 14)	Findings indicated that only 2-3 stations were required to track long term changes in

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		BD50 (Napa River), BD15 (Petaluma River in San Pablo Bay), and BC21 (Horseshoe Bay in Central Bay) for bivalve tissue monitoring	contaminant concentrations in bivalves. Stations = 11.
S	2003	Removed two water and sediment stations (previously 24) C-1-3 (Sunnyvale) and C-3-0 (San Jose), part of the Local Effects Monitoring Program (LEMP)	Funding ended for monitoring of trace organics in water and sediment which began in 1996 at these stations as part of the NPDES. Stations = 24.
S	2003	Removed water sampling from one random site in the South Bay segment and one random site in the Lower South Bay segment in order to add water sampling at historic sites BA30 (Dumbarton Bridge) in the South Bay and BC10 (Yerba Buena Island) in the Central Bay	Dropping these two random sites enabled the two historic sites to be added back into the sampling design at no additional cost to the program. These sites, along with BG20 (Sacramento River) are used by the Water Board for NPDES permit processing
A	2004	Added Particulate Organic Carbon (POC) analysis in water samples	Began analyzing for POC in order to be able to calculate Total Organic Carbon values (DOC+POC).
A	2004	Data unavailable for pesticides, PAHs, PCBs, and PBDEs in bivalve tissue samples	Poor recovery and high detection limits created “too many holes in the dataset”. Samples will be archived but not re-analyzed.
A	2004	Removed PBDEs, phthalates, p-nonylphenol, triphenylphosphate and nitro and polycyclic musks analysis in bivalve tissue samples	These analytes posed low levels of concern for the San Francisco Bay Region based on current literature.
A	2004	Removed phthalates and p-nonylphenol analysis in water and sediment samples	These analytes posed low levels of concern for the San Francisco Bay Region based on current literature.
D	2004	Bivalve Organics data are not available for pesticides, PAHs, PCBs, and PBDEs	Poor recovery and high detection limits created “too many holes in the dataset”. Samples will be archived but not re-analyzed.
A	2005	Expanded target BDE analyte list for sediment and water samples	Based on results from BDEs sampled in previous years and capabilities of the RMP laboratories, increased number of analytes.
A	2005	Removed Toxicity Identification Evaluations (TIEs) from sediment toxicity analysis	Method development is needed to aid in understanding the toxicity found in the bay sediments. Toxicity Identification Evaluations (TIEs) will be conducted using contingency funds when sufficient toxicity is observed.

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D	2005	2005 Bivalve samples were analyzed for orgaincs by CDFG. PAHs were rejected. PBDEs, PCBs and PESTS were approved.	About half the analytes in each group were NDs.
D	2005	7 archived bivalve samples (T-0,BA10,BA40,BC10,BD20,BD30,BG30) were reanalyzed in 2007 by AXYS for PBDES, PCBs, Pests and PAHs. 3 samples (BA40, BD20, BD30) were reanalyzed for PAHs using Base Extraction Method as a demonstration of appropriate lab method. Results were approved. Samples not reanalyzed included BB71, BC61, BG20, BD40, BA30. Due to lack of archived material not all samples were re-analyzed.	Reanalyzed in 2007 by AXYS as part of Intercomparison study with CDFG. The data available on the WQT include the 7 reanalyzed samples from AXYS and 5 samples analyzed in 2005 by CDFG.
D	2005	Mallard Island PBDE Data for study year 2005 – 2006 should not be used in load calculations due to blank contamination and missing samples (especially 209).	Data should not be used in load calculations. Flagged during internal ratio review due to blank contamination and missing samples (especially 209).
L	2005	2005-09 archived bivalve tissue samples reanalyzed for organics by AXYS and CDFG in 2007	Data analyzed by two different labs: 5 samples were analyzed by CDFG and 7 samples reanalyzed by AXYS.
L	2005	Changed method for extraction of organic analytes in water samples	High blank contamination in 2003 PAH samples led to a change from the Soxhlet extraction method to an ambient temperature extraction method.
A	2006	Began collecting hardness data for all water stations where salinity <5ppt	Previously hardness data was collected at riverine stations where salinity <1ppt and estimated for estuarine sites.
A	2006	Removed BDE 82 from target analyte list	BDE 082 is not in any commercial mixtures and its rationale for reporting it was unclear as it is not a major congener.
D	2006	Analyses of 2006 bivalves for trace organics data were delayed until 2008.	Analysis was delayed pending a decision regarding a demonstration of lab capabilities.
D	2006	Tissue data are unavailable for Coyote Creek (BA10)	Nearly full mortality (1% survival) due to heavy biofouling and sedimentation

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D	2006	Tissue data are unavailable for San Pablo Bay (BD20)	Mooring was removed during deployment period
D	2006	Water diazinon and chlorpyrifos data are not available	Initially, samples were not analyzed due to analytical issues. These issues were resolved. In 2010, the TRC decided to cancel the analysis due to the high cost and the lack of a pressing need for the data
L	2006	Changed lab for the water diazinon and chlorpyrifos analysis from CDFG to AXYS	Changed labs based on new method development for this analysis and difficulties with prior method for analyzing these compounds.
L	2006	Changed method for analysis of arsenic in water samples	Method changed from HGAA to ICP-MS as a cost saving measure for method development.
P	2006	Annual Bivalve Maintenance Cruise discontinued and biannual cruise implemented	TRC approved dropping the maintenance cruise after a study conducted from 2002-2005 showed no significant difference in survival of bivalves in maintained and non-maintained cages
P	2006	Changed program name to Regional Monitoring Program for Water Quality in the San Francisco Estuary	Previous name was the Regional Monitoring Program for Trace Substances in the San Francisco Estuary. This change is intended to more adequately express the objectives of the RMP.
P	2006	Status and Trends Sport Fish Monitoring	• The special study to look at contaminants in other species continued in 2006. Barred surfperch, brown rockfish, black surfperch, Chinook salmon, rubber lip surfperch, walleye surfperch, and northern anchovy were analyzed for PCBs, PBDEs and mercury. • Analytes measured: mercury, PCBs, PBDEs, dioxins, DDTs, dieldrin, chlordane, dioxin, and selenium. • Archived 2003 white croaker samples were analyzed and reported with 2006 white croaker data in the 2006 report. • Jacksmelt, leopard shark, and California halibut were discontinued as status and trends species. • Most samples were analyzed as composites except for mercury in striped bass and selenium in white sturgeon.
P	2006	Stopped analyzing the dissolved water fraction for organics in water	California Toxics Rule (CTR) has only been established for the total fractions of organic contaminants. The dissolved fraction was removed as a cost saving measure. At three stations, the RMP will report our dissolved and particulate fractions separately for comparative purposes.
S	2006	Changed bivalve tissue site BD20 (San Pablo Bay) by a nautical mile. BD20 will be	USGS replaced the channel marker where bivalve mooring BD20 was attached. The site was moved from Petaluma Light 1 to Petaluma Light 4. A new mooring will be

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		renamed.	installed at that site.
A	2007	Added BDE 197 to target analyte list for water and sediment and BDE 196 for sediment only.	This will provide a more accurate estimate of total PBDEs since these congeners constitute a relatively high percentage of the Deca-BDE mix.
A	2007	Nitrogen results will be reported as "Nitrogen, Total Kjeldahl" in sediment. This is different from the historical RMP data.	Lab changed from UCSCDET to AMS-Texas.
D	2007	No bivalves data for 2007	Bivalves were not deployed in 2007. Sampling was changed to every other year.
D	2007	Water diazinon and chlorpyrifos data are not available	Initially, samples were not analyzed due to analytical issues. These issues were resolved. In 2010, the TRC decided to cancel the analysis due to the high cost and the lack of a pressing need for the data.
L	2007	Changed lab for the bivalve tissue analysis from CDFG to AXYS	2006 tissue analyses were conducted by AXYS. A subset of 2005 archive bivalves were reanalyzed by AXYS in 2007 and results much improved.
L	2007	Changed lab from UCSCDET to AMS-Texas for analysis of sediment quality samples	Changed labs based on an evaluation of turnaround time, cost, and analytical capabilities.
L	2007	Intercomparison study with UCSC (POC only) and AMS-Texas (POC/DOC) for ancillary analytes in water	UCSC sampled 9 of the 22 sites, AMS-Texas sampled all 22 sites.
L	2007	Intercomparison study with UCSC and AMS-Texas for grainsize, Total Organic Carbon and Total Nitrogen in sediment	UCSC sampled 9 of the 47 sites; AMS-Texas sampled all 47 sites.
L	2007	Intercomparison study with UCSC and BR for trace metals in water samples	UCSC sampled 9 of the 22 sites, BR sampled all 22 sites.
L	2007	Intercomparison study with UCSC and EBMUD for analysis of SSC, Pigments Nutrients, salinity, and hardness in water	UCSC sampled 9 of the 22 sites, EBMUD sampled all 22 sites. (Pigments (Chlorophyll & phaeophytin) & Nutrients (ammonia, phosphate, nitrate/nitrite, silica))
L	2007	SFEI begins taking shipboard total salinity measurements.	Switched labs for water ancillary data; new lab does not participate in cruises. UCSC used to also report salinity by SCT along with their analytical measurements.
P	2007	Modified sediment toxicity sampling design.	During 2002-2006, every other sediment sample was analyzed for toxicity, which spatially biased the samples to the Lower South Bay
P	2007	The number of water sites was changed from 31 to 22. Sampling will occur at 3	The power analysis from San Jose suggests that this change will be able to detect about a 1 ug/L change (give or take) in dissolved copper in every segment at a very

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		sites in each of the upper 4 segments and 5 sites in the Lower South Bay segment. The 5 historic sites will continue to be sampled.	high 99% power. The TRC approved this change in December 2006.
P	2007	The S&T monitoring program was expanded to triennial bird egg monitoring (cormorant and tern).	Part of the redesign process implemented in 2006.
P	2007	Water toxicity sampling occurred in 2007. Toxicity sampling has been changed to a screening effort approximately every five years	RMP S&T aquatic toxicity monitoring in the Estuary has shown no toxicity over the past several years. Next scheduled sampling will occur in 2012.
A	2008	Added benthos analysis (CCSF) and (MLML)	The addition of benthos collection will enable sediment assessments in accordance with the SQOs which use three lines of evidence, benthos, sediment chemistry and sediment toxicity.
A	2008	Added pyrethroids analysis in sediment (CDFG)	To investigate the potential toxicity of pyrethroids in the Bay.
A	2008	Added selenium analysis in tissue (BR)	Added to provide information for the Selenium TMDL
A	2008	PCBs were not analyzed in water. PAHs and Pesticides in water were not scheduled to be analyzed but were added into the sampling plan.	PCBs, PESTS, PAHs will be sampled every other year in water (on a biennial basis) based on recommendations from the redesign process. PAHs were analyzed because of the Cosco Busan oil spill, and PESTS were analyzed to validate the detection level for AXYS Analytical's MRES method using both whole water samples and 100L High volume extracts. Pesticide results were not reported because they were part of the Intercomparison study.
D	2008	2008 grainsize granule fraction is not available	Granule fraction was not analyzed. In 2008, RMP switched labs from UCSC-DET to MLML-Aiello. MLML did not analyze larger grainsize fractions, and only fractions <2mm are available.
D	2008	Grainsize determination changed to an optical method.	In 2008, RMP switched grainsize labs from UCSC-DET to MLML-Aiello where they employ a different method.
D	2008	Grainsize for 2008 are not comparable to previous years.	Grainsize in 2008 and later is reported for fractions 2mm and smaller, as a percentage of total volume determined by an optical (laser) method, as opposed to gravimetric measurement (as a percentage of mass) for mechanically separated samples used prior. Additionally, split samples analyzed mechanically in 2009 showed poor comparability to the optical method due to possible artifacts of handling in the

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			mechanical separation method, usually yielding higher apparent coarse material due to aggregation of smaller particles during the drying of samples. The lab is currently testing a wet seiving method to resolve these artifacts.
D	2008	Manganese and iron in bivalves are non-target analytes and not reported via WQT	Manganese and iron are not reported as target analytes via WQT.
D	2008	Missing % Lipids for the trace metals bivalve analysis	Lab could not analyze for this.
D	2008	MRS Pesticide Results should not be combined with prior years for Trends Analysis.	Axys switched to a multiple residue (MRES) method for pesticides. Whole water MRES samples typically showed higher concentrations than in solid phase (XAD) extracted samples, due to only partial retention of pesticides by the XAD. Interannual trends should therefore be evaluated only within any given collection type (i.e. whole water 2008 and later or XAD 2007 and before).
D	2008	Oxadiazon was not reported	The MRES method cannot analyze for Oxadiazon and because the 2008 demonstration project used only the MRES method, it was not possible to collect this data.
D	2008	Pyrethroid tralomethrin not analyzed in sediment samples	Tralomethrin was not analyzed in 2008 by CDFG, but will be in the future.
D	2008	Water MRES pesticide data	The 2008 samples were part of a demonstration project for the MRES method and were conducted on a subset of stations using whole water grabs (7 samples). These results were then compared to the extracts from the 100-liter infiltrex samples at the same location. These results will not be reported on the web.
L	2008	Added sediment-water interface cores exposure (SWIC) toxicity testing method for bivalve larval (*Mytilus galloprovincialis*) SWIC will be analyzed for toxicity by UCD-GC.	The Sediment Quality Objectives recommend using sediment–water interface core exposure (SWIC) for bivalve larva toxicity instead of elutriate testing for toxicity. Toxicity testing for amphipods will continue to be conducted using the elutriate method. TIEs will be conducted in samples that show significant toxicity.
L	2008	Changed lab for analysis of Total Organic Carbon and Total Nitrogen in sediment from UCSC to MLML – Hunter	Changed labs based on an evaluation of turn around time, cost, and analytical capabilities.
L	2008	Changed lab for analysis of grainsize in sediment from UCSC to MLML - Aiello	Changed labs based on an evaluation of turn around time, cost, and analytical capabilities.
L	2008	Changed lab for analysis of SSC, Pigments, Nutrients, salinity, and hardness in water	Changed labs based on an evaluation of turn around time, cost, and analytical capabilities.

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		from UCSC to EBMUD	
L	2008	Changed lab for POC and DOC analysis from UCSC and AMS-Texas to Columbia Analytical Services	Changed labs based on an evaluation of turn around time, cost, and analytical capabilities/ AMS-Texas went out of business.
L	2008	Changed principle lab for trace metals in water from UCSC to BR and changed principle lab for trace metals in tissue from UCSC to BR (Se) and CCSF (other metals)	Changed labs based on an evaluation of turn around time, cost, and analytical capabilities such as elevated methyl mercury quantitation limits. Due to BR's method, metals (Al, Cd, Cu, Fe, Pb, Mn, Ni, Ag, and Zn) are no longer reported as near-total concentrations. UCSC extracted with a weak acid (pH < 2) for a minimum of one month, resulting in measurements that approximate bioavailability of these metals to Estuary organisms. BR used reductive precipitation according to EPA Method 1640.
L	2008	Intercomparison study with BR and City and County of San Jose for Copper and Nickel in water	Samples were analyzed by both labs at all 22 sites.
L	2008	Pesticide water analysis conducted by AXYS was performed using MRES method on samples collected on 100L infiltrix system. In previous years pesticides were analyzed using GC/LRMS which could not detect chlorpyrifos/diazinon.	The MRES method is able to detect the standard suite of RMP pesticides including chlorpyrifos/diazinon (oxadiazon is not tested for using MRES).
P	2008	Began reporting water particulate trace organic results.	New design of web query tool makes it easier to post particulate results.
P	2008	Benthos sampling was added as part of the sediment sampling cruise.	With all three lines of evidence (i.e., benthos, sediment chemistry and sediment toxicity), it will be possible to conduct sediment assessments in accordance with the Sediment Quality Objectives (SQOs), which are scheduled to be promulgated in 2008.
T	2008	Bivalve Trends	These are available in the AMR beginning in 2008 for years bivalves are collected, biennially for trace organic contaminants and every five years for trace metal contaminants.
A	2009	Cyanide was analyzed in water.	New site specific objective was developed for cyanide in water in San Francisco Bay.
A	2009	Dioxins were added as part of the Small Tributary Loading Study.	Data will fill the dearth of information that currently exists for dioxin. This is a special study.
A	2009	Dioxins were analyzed for all 22 water stations, all 47 sediment stations, and in sportfish.	Data will fill the dearth of information that currently exists for dioxin. This is a 5 year special study that is not a part of the Status and Trends Component.

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A	2009	Oxadiazon was dropped from the RMP target analyte list.	The different MRES method for analyzing pesticides in water adopted by the RMP doesn't include oxadiazon. Since concentrations of oxadiazon have remained relatively constant over time, the TRC approved removing it from the target list in July 2009.
A	2009	PFC analysis was added to bird samples.	Part of Exposure and Effects Pilot Study.
A	2009	PFC analysis was added to sportfish samples.	Part of Emerging Contaminants Special Study.
A	2009	PFC samples were collected at a subset of water stations.	Special Study - Added because of concern over elevated concentrations found in Bay Area tissue samples as compared to reference samples from Tomales Bay.
A	2009	The RMP PCB list was expanded from 40 congeners to 209 congeners for all matrices.	The non-Aroclor PCB, PCB 11, was unexpectedly observed in air and effluent samples outside the Bay Area in significant concentrations, prompting the expansion of the RMP PCB congener list to include all possible congeners.
A	2009	Water PAHs were not analyzed.	Due to the Cosco Busan oil spill, PAHs were analyzed in 2008. Because no significant changes in the water column were identified, PAH sampling was skipped in 2009 and 2010. Water PAHs are scheduled to be sampled again in 2011.
A	2009	Whole water samples were collected at 22 sites for analysis of pesticides.	Whole water samples are collected for the analysis of pesticides using MRES methods. Beginning in 2009, pesticides analyzed using the MRES method are considered the RMP's target analytes.
D	2009	2009 total cyanide water results are not reported.	The RMP's previous California Toxics Rule (CTR) work was based on the Weak Acid Dissociable (WAD) fraction. Total cyanide will most likely give an over-estimation of the bio-available fraction. Several of the 2009 total cyanide water results were above the cyanide trigger level (1.0 ug/L) for ambient monitoring as stated in the Basin Plan Amendment, which is based on the WAD fraction. Hence, at the request of the Water Board these samples were not reported to avoid confusion.
D	2009	Water PBDEs 196, 201, and 202 are not available.	AXYS has not developed a method for detecting these PBDEs in water.
L	2009	Contra Costa County Sanitation District will analyze water for cyanide.	New analyte for analysis in water only.
P	2009	Added Pesticides Fipronil, Fipronil desulfinyl, Fipronil sulfide, and Fipronil sulfone for sediment analysis	These pesticides are highly used in the Bay Area and are of emerging concern. Fipronil is widely-used in flea/tick applications. It is exceedingly toxic to insects/crustaceans. There is relatively little Bay Area data so it would be very helpful to report these data when available.
P	2009	Changed the statistical design for	Changed to incorporate rainy season sediment sampling which will occur every other

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		sediment sampling from five-year panels to six-year panels	year starting in 2010. Rainy season sediment sampling will occur at 20 random sites and 7 historic sites. Dry season sediment sampling will continue to occur at 40 random sites and 7 historic sites.
P	2009	Dioxins were analyzed in water, sediment, sediment core, bird egg, small tributary loading, and sportfish samples.	The Dioxin Pilot Study is not part of the Status and Trends component, but samples were collected during regular RMP sampling events.
P	2009	Status and Trends Sport Fish Monitoring	• The 2009 monitoring effort was combined with the BOG coast year 1 sampling effort. This resulted in adding one additional species to the RMP list: Jacksmelt. • Most samples were analyzed as composites except for mercury in striped bass and selenium in white sturgeon. • Analytes measured: mercury, PCBs, DDTs, dieldrin, chlordanes, PBDEs, dioxins, PFCs, and selenium. • There were two side-by-side studies in 2009: ○ Comparison of selenium concentrations in filet, muscle plug, and liver of white sturgeon. This was done for the development of the North Bay selenium TMDL. The comparison was also to determine if we could use muscle plugs (nonlethal) instead of filet (lethal) to determine selenium levels in white sturgeon. ○ Comparison of skin-on and skin-off PCBs, legacy pesticides, PBDEs, and dioxin concentrations in white croaker. Starting in 2009, white croaker will be analyzed skin-off.
T	2009	Sport Fish	SWAMP/RMP/Bight Program Report on Contaminants in Fish from the California Coast. 2011.
A	2010	Began reporting Sum of PCBs 208 (SFEI)	This sum provides an index of the PCBs present in Aroclor mixtures. PCB-11 is excluded from the sum because it is a by-product of dye manufacturing and is not related to Aroclors. PCB 11 does not have dioxin-like potency and has different sources than Aroclors.
A	2010	Pyrethroids Tetramethrin and piperonyl butoxide moved to a status of "Information only" by analytical lab	Compounds have a history of persisting high variability in Ongoing Precision and Recovery (OPR) and linearity data. Results are estimated to be accurate only within an order of magnitude.
D	2010	Added new PrepPreservation Code: FieldFiltered,FieldSolventPres,FieldFrozen	This code is used for Chlorophyll-a and Pheophytin samples beginning in 2010. We will not update previous years' sample records which have codes "FieldFiltered,

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			LabAcidified" and "FieldFiltered, FieldFrozen" because it was determined that the benefit does not justify the time and effort at this time.
D	2010	Bivalve data not available for BD40 Davis Point Station because it was not sampled.	BD40 was not sampled due to terminal construction and weather issues.
D	2010	TRC cancelled scheduled analysis of archived 2006 and 2007 water samples for Diazinon and Chlorpyrifos	Initially, water samples were stored during method development for analysis once analytical issues were resolved. These issues have since been resolved. In 2010, TRC decided to cancel the analysis due to the high cost ($60,000) and the lack of a pressing need for the data.
D	2010	Whole water PBDE sample results are not available through the Web Query Tool.	In 2010, 4L whole water samples were analyzed for PBDEs as part of an intercomparison study. The Web Query Tool Does note report data from Intercomparison studies.
D	2010	YSI data collected by SFEI on water cruise are not available for 2010	Data were inadvertently deleted from YSI machine by staff working on another project before it was downloaded.
L	2010	Began adding LabPoisoned to the PrepPreservation code for organic water samples when samples tested positive for residual chlorine.	It was decided that we will not update the PrepPreservation code for samples prepped with poison from 2002-2009 because the benefit does not justify the time and effort at this time.
P	2010	Sediment samples will be collected in alternate seasons starting with a rainy season (winter) sampling event in February 2010.	There appears to be a seasonal element to sediment toxicity with winter sampling exhibiting higher toxicity. 27 samples will be collected during the dry season and 47 samples will be collected during the rainy season. February of 2010 was the first rainy season collection. The next sampling event is August 2011.
A	2011	Range dropped from grainsize parameter names and is now stored in fraction field.	Changed as part of effort to incorporate SWAMP comparability to SFEI data reporting.
A	2011	Sediment toxicity test organisms changed.	The TWG and EEWG recently decided to change the test organisms at the river sites to Hyalella and Ceriodaphnia for 2011. Prior years used Eohaustorius and Mytilus.
A	2011	Three sum of PCBs: 40, 208, 209 will be reported through the Web Query Tool.	Three sum of PCBs: 40, 208, 209 for all matrices and all studies. Sum of 209 PCBs is provided solely for comparison to other studies that use this statistic. SFEI does not recommend using this sum for comparison to any Aroclor-based thresholds (the TMDL target, OEHHA thresholds, etc.) - the Sum of 208 PCBs is better for that purpose.
D	2011	SWAMP has changed the definition of LCS Sample Type. The new definition says that	SWAMP has provided a new definition for samples that have not gone through the entire QA process. The new sample type code is 'UnkAcc' – Control Sample used to

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		LCS samples have gone through the entire QA process.	assess accuracy, unknown whether or not taken through the full analytical process. We will not go back and update the database for samples previously called LCS since we do not always know whether the samples have gone through the entire analytical process but in future data sets we will use the code 'UnkAcc'.
D	2011	Updated coelution flag for PCB 156(Surrogate) to DO156L. In previous years, the flag DO156 was reported.	The L indicates that it is a labeled compound. Including the 'L' in the coelution flag increases accuracy.
L	2011	Beginning in 2011, the MDLs from EBMUD for sediment trace organics are all 40CFRs.	EBMUD wanted to provide consistent MDLs between analytes.
P	2011	The name of the Web Query Tool (WQT) changed to Contaminant Data Download and Display (CD3).	This name is more descriptive and is more representative of what the SFEI data query tool does.
T	2011	Small fish Trends Report.	Report by Ben Greenfield will be published in 2011.