

# RMP UPDATE

## 2016



A Report of the Regional Monitoring Program for Water Quality in San Francisco Bay



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COVER: Deployment of transplanted mussels. Photograph by Jennifer Sun.

INSIDE BACK COVER: The RMP Steering Committee. Photograph by Shira Bezalel.

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# RMP UPDATE 2016

A Report of the Regional Monitoring Program for Water Quality in San Francisco Bay



# PREFACE

The overarching goal of the Regional Monitoring Program for Water Quality in San Francisco Bay (RMP) is to answer the highest priority scientific questions faced by managers of Bay water quality.

The RMP is an innovative collaboration between the San Francisco Bay Regional Water Quality Control Board, the regulated discharger community, the San Francisco Estuary Institute, and many other scientists and interested parties.

Digital versions of all *RMP Updates* are available at:  
[www.sfei.org/rmp/update](http://www.sfei.org/rmp/update)

Digital versions of all *Pulses* are available at:  
[www.sfei.org/rmp/pulse](http://www.sfei.org/rmp/pulse)

**Note to Readers:** The RMP produces *The Pulse of the Bay* in odd years, and the *RMP Update* in even years. In contrast to *The Pulse*, which focuses on Bay water quality and summarizes information from all sources, the *RMP Update* has a narrower and specific focus on highlights of RMP activities.

The purpose of this document is to provide a concise overview of recent RMP activities and findings, and a look ahead to significant products anticipated in the next two years.

The report includes:

- a brief summary of some of the most noteworthy findings of this multifaceted Program;
- a description of the management context that guides the Program; and
- a summary of progress to date and future plans for addressing priority water quality topics.

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# PROGRAM IMPACT









# THE IMPACT OF THE RMP ON MANAGEMENT DECISIONS

## INFORMING HIGH-STAKES DECISIONS

Billions of dollars are at stake in the decisions that society makes regarding activities that are directly intended to protect Bay water quality. The region has made huge investments to build and operate the infrastructure to collect and treat the region's municipal and industrial wastewater, and continued investment at a similar scale will be needed to maintain, upgrade, and operate this infrastructure to serve a growing Bay Area population. The region has spent and will spend comparably large sums to manage stormwater and establish green infrastructure in our cities to minimize the adverse water quality impacts of stormwater on the Bay. Large investments have been and will be made to manage contaminated sediment in the Bay, both at sites identified for cleanup and for dredging to maintain channels for commercial and recreational vessels.

Billions more are at stake in decisions regarding activities that influence Bay water quality as unintentional side-effects. Commercial product formulation and usage (including pesticides, pharmaceuticals, personal care products, electrical equipment, home furnishings, automobile components, and many, many others), sediment management, water supply management, energy production, and habitat restoration and management are all immense and essential enterprises that have a tremendous influence on Bay water quality.



More than money is at stake. Protecting the health of people that enjoy eating fish and shellfish from the Bay is one of the primary objectives of water quality managers. Cleanup plans for many contaminants are driven by this objective, as are decisions regarding advisories to promote safe consumption of fish from the Bay.

The goal of the RMP is to collect data and communicate information about Bay water quality in support of all of these management decisions. The \$3.5 million annual budget for the RMP is used very judiciously so that these decisions on Bay water quality are informed by sound science.



## *FEATURED PUBLICATION*

# RMP RELEVANCE TO MANAGEMENT: LOOKING BACK, LOOKING FORWARD

The RMP was included in a recent synthesis article about successful coastal monitoring programs (Schiff et al. 2015; Trowbridge et al. 2015). It was an honor for the RMP to be highlighted along with three other distinguished programs: the Southern California Bight Program, the Chesapeake Bay Program, and the Tampa Bay Estuary Program. Despite differences in geography, governance, and questions being addressed, the four programs identified common keys to success: adaptability, collaborative governance, and, most importantly, relevance to management decisions. Over the past quarter century, the RMP has increasingly sharpened its focus on relevance to the many major decisions impacting water quality in the Bay. This article provides a brief summary of the major management decisions that were informed by RMP studies and monitoring data, and highlights how the Program continues to adapt to meet today's challenges.

## LOOKING BACK

The RMP was founded in 1993 to solve a management problem: inadequate information about Bay water quality. Since that time, the RMP has provided data and information to inform dozens of management decisions about water quality in the Bay. RMP contributions have ensured that these decisions were founded on robust science and local information.

### Establishing the Scientific Basis for TMDLs and Other Management Decisions

The Clean Water Act calls for states to establish pollutant Total Maximum Daily Loads (TMDLs) for water bodies that are not meeting water quality standards. A TMDL is the pollutant load that must be met in order to attain the water quality standard for a particular pollutant in a particular water body. TMDLs have far-reaching impacts on the regulated dischargers to the Bay and ultimately on all Bay Area communities. Monitoring, special studies, and data analysis conducted through the RMP have been instrumental in the development and refinement of TMDLs for pollutants such as PCBs and mercury, as well as risk communication strategies.

### TMDL FOR PCBs

The TMDL for PCBs in the Bay, approved in 2009, relied heavily on RMP information. Sediment concentrations were mapped Bay-wide to identify in-Bay masses and PCB hot spots. Loads from major pathways were measured. RMP scientists contributed to models to 1) identify the relative significance of sources; 2) determine the approximate time it would take to meet targets; and 3) determine how far concentrations of PCBs need to decline in the sediment to bring fish concentrations down to levels that are protective of human health.

The RMP continued to assist TMDL implementation by developing a PCB Strategy in 2009 and updating it in 2014. Studies to implement the Strategy focused on contaminated areas on the margin areas of the Bay, based on small fish data and observed spatial and temporal patterns in sediment contamination. These margin areas are important in terms of food web contamination and are where reductions in stormwater loading of PCBs from the watershed could lead to more rapid water quality improvements.

### TMDL FOR MERCURY

RMP measurements of mercury in suspended solids, bed sediment, and fish were used along with loading studies to develop a mass balance model and numeric targets in the mercury TMDL. These targets are intended to be protective of human health (through fish consumption) and wildlife (by protecting the most sensitive endpoint, bird reproduction). RMP-funded studies in 2008 and 2009 confirmed that the bird egg monitoring target established in the TMDL is protective. In 2014, the RMP produced a synthesis of information regarding methylmercury accumulation in the food web of San Francisco Bay. The findings of this synthesis report and the ongoing RMP monitoring for mercury and methylmercury in Bay water, sediment, bird eggs, and fish will inform adaptive implementation of the TMDL and the Water Board's consideration of revisions to the TMDL.



## TMDL FOR SELENIUM

A selenium TMDL for the North Bay was approved in 2016. Initial loading estimates for selected watersheds were developed by the RMP, and an impairment assessment analysis completed by the Water Board relied on RMP data. In 2014, the RMP formed a Selenium Strategy Team to evaluate information needs for the TMDL. A top priority of the team is expanded monitoring for selenium in the tissues of white sturgeon, which is the key target in the TMDL for evaluating impairment.

## FISH CONSUMPTION ADVISORIES

In 1998 and 1999, the RMP partnered with the California Department of Public Health to fund a study of fish consumption in the Bay. Using the results of the study, the Department of Public Health was able to develop an outreach and education program to inform the public about the fish consumption advisory and ways to prepare fish for consumption that minimize exposure to contaminants. This effort resulted in the posting of signs in six different languages describing the advisory, as well as outreach presentations to communities that are most at risk.

A report on the 2009 RMP sport fish sampling was released in 2011. At the same time, the California Office of Environmental Health Hazard Assessment released updated safe eating guidelines for the Bay. The guidelines replaced the earlier 1994 interim advisory, and drew on over a decade of more recent data, primarily from the RMP, that highlighted mercury and PCBs as the primary contaminants of concern in Bay fish. The guidelines also incorporated nutrition science showing that fish provide dietary protein and essential nutrients, including omega-3 fatty acids that promote heart health and support neurological development.

## Supporting Permit Conditions

In addition to supporting TMDLs and fish consumption advisories, RMP data have been and continue to be used by Water Board staff to develop regulatory guidelines for the Bay and to support permit conditions.

## DREDGED MATERIAL MANAGEMENT SUPPORT

In 1998, the Water Board conducted an assessment of data from the RMP and other sources to develop an understanding of ambient levels of contaminants in Bay sediment. RMP monitoring data continue to serve as the basis for the Dredged Material Testing Thresholds for mercury, polycyclic aromatic hydrocarbons, and PCBs. These thresholds determine when bioaccumulation testing will typically be required to approve permits for dredged material discharge at unconfined open water disposal sites in the Bay. The thresholds and process were established under an agreement to protect essential fish habitat between USEPA, the U.S. Army Corps of Engineers, and the National Marine Fisheries Service.



Anglers and consumption advisory sign. Photograph by Jay Davis.

## SEDIMENT BUDGETS FOR THE BAY

Management of sediment as a resource in the Bay requires understanding of the volumes, types, locations, and environmental drivers of sediment input. The RMP provides data to support sediment resource decisions through extensive monitoring of suspended sediment concentrations, along with monitoring of suspended sediment loads at select tributaries. These data support estimates of the overall sediment budget of the Bay that guide permitting decisions for sediment dredging, extraction, and disposal in the Bay.

## SMALL TRIBUTARIES LOADING STRATEGY

A key aspect of the policies for PCBs and mercury management in the Bay has been the identification of specific tributaries with disproportionately high loads or connections to sensitive Bay margins areas (“high-leverage” watersheds). During the first term of the municipal regional stormwater NPDES Phase I permit (2009-14), the RMP supported refinement of pollutant loadings with additional emphasis on finding high-leverage watersheds and source areas within watersheds, consistent with the implementation plans outlined in the PCBs and mercury TMDLs. The resulting data identified certain watersheds around the Bay with elevated PCB concentrations on suspended sediment particles. The RMP has continued to support these needs during the second municipal regional permit term through wet weather reconnaissance monitoring to identify contaminated sub-watersheds downstream from older industrial areas and potential source properties, and through improvements to geographic information about PCB and mercury sources within the framework of a Regional Watershed Spreadsheet Model.

## Tracking the Effectiveness of Management Actions and Long-Term Trends

For an estuary as large as San Francisco Bay, it can take years before the effects of management actions are detectable. Therefore, the long-term nature of the RMP Status and Trends Program is critical to tracking the effectiveness of actions and other changes that are occurring in the Bay over long time periods, and for making adjustments as needed.

## PHASE-OUT OF PBDES

Polybrominated diphenyl ethers (PBDEs) are a class of bromine-containing flame retardants that was widely used starting in the 1970s, but rarely studied until the 1990s. In response to rapidly increasing concentrations in humans and wildlife, including Bay studies that reported some of the highest values in the world, the California Legislature banned two types of PBDE mixtures in 2006; the last mixture (“deca”) was phased out in 2013. A decade of PBDE monitoring by the RMP resulted in a dataset covering periods during and after PBDE use, and consisting of hundreds of measurements of water, sediment, and aquatic organisms. Over time, PBDE levels in bird eggs and bivalves declined by 74-95%, and levels in Bay sport fish (shiner surfperch)

declined by nearly half. In sediment, concentrations of penta component BDE-47 also dropped, but the dominant sediment-bound PBDE compound, deca component BDE-209, has shown no sign of decline yet. Overall, RMP data were critical to demonstrating the success of these management actions.

## MERCURY AND PCBs IN FISH

Following up on a 1994 study by the Water Board, in 1997 the RMP started to measure contaminants in Bay fish periodically to determine temporal trends of contaminants in fish that people consume. Long-term monitoring of contaminants in fish is an essential means of measuring the effectiveness of management actions to reduce PCB and mercury loads to the Bay from TMDL implementation. Unfortunately, the latest data indicate no measurable change in mercury or PCB concentrations in Bay fish. Fish tissue monitoring will continue to be conducted every five years to gauge the success of management actions.

## SUSPENDED-SEDIMENT CONCENTRATIONS IN THE BAY

Long-term monitoring of suspended sediment concentrations, by the RMP and USGS, has allowed an unanticipated decline in the Bay to be identified in spite of the extremely noisy signal that characterizes these data. Declining sediment loads to San Francisco Bay are a concern for both water quality and habitat restoration. Increased erosion of relatively contaminated buried sediment could delay improvements in water quality, and increased light in the water column has contributed to increased phytoplankton blooms. Suspended sediment in Bay waters is a primary source of sediment needed for tidal wetland restoration, although deposition patterns are variable around the Bay. Many questions remain as to how this trend in suspended sediment will affect the health of the Bay.

## Preventing Future Problems

The RMP stakeholders share a common understanding that preventing a problem is far less expensive than resolving it after the fact. Therefore, a significant portion of the RMP resources are allocated toward understanding emerging issues that may require regulation in the future.

## CHEMICALS OF EMERGING CONCERN

In 1999, the RMP made a decision to proactively identify chemicals of emerging concern (CECs) before they reach concentrations at which beneficial uses are impacted and regulatory action is necessary. RMP CEC work began in 2000. In 2013, the RMP published a summary of the state of knowledge on CECs in the Bay, followed by a strategy for investigations over the next several years. Both documents are rich resources useful to scientists and managers working locally and statewide to protect water quality.



## NUTRIENT MANAGEMENT STRATEGY

Decreasing suspended sediments and increasing light availability may combine with high nutrient loads to cause eutrophication and other changes in the Bay. Concern about these changes has led a group of regulators, dischargers, scientists, and stakeholders to collaboratively develop a Nutrient Management Strategy for the Bay. The goal of this Strategy is to inform important and potentially costly management decisions related to nutrient load reductions. In the early stages of implementing the Strategy, the RMP has supported nutrient research through special studies funding. In particular, the RMP has funded the deployment of in-situ sensors to provide near-continuous measurements of nitrate, chlorophyll-a, and other nutrient-related parameters. The RMP is also supporting the development of conceptual models illustrating the current state of the science, defining the problem, and highlighting priority science needs.

### MORE INFORMATION:

Trowbridge, P.R., et al. 2015. The Regional Monitoring Program for Water Quality in San Francisco Bay, California, USA: Science in Support of Managing Water Quality. *Regional Studies in Marine Science* 4: 21-33. doi:10.1016/j.rsma.2015.10.002

Schiff, K., et al. 2015. Regional monitoring programs in the United States: Synthesis of four case studies from Pacific, Atlantic, and Gulf Coasts. *Regional Studies in Marine Science* 4: A1-A7. doi:10.1016/j.rsma.2015.11.007

## LOOKING FORWARD

The goal of the RMP is to collect data and communicate information about water quality in San Francisco Bay to support management decisions. By all measures, the RMP is achieving this goal. The success of the RMP stems from collaborative governance, clear objectives, adaptability and long-term institutional and monetary commitments. Over the past 24 years, high quality data and special studies from the RMP have guided dozens of important decisions about Bay water quality. Moreover, the governing structure and the collaborative nature of the RMP have created an environment that allowed it to adapt to address current challenges and needs.

Going forward, the goal of the RMP will remain the same but the specific management questions will continue to evolve over time. Each year, Program participants hold a workshop to anticipate upcoming management decisions and regulatory drivers and to develop a multi-year monitoring plan (typically 3-5 years into the future) to inform those decisions. The current top priorities are continued monitoring and special studies to inform permit decisions regarding nutrients and pollutant loadings to the Bay from stormwater. Emerging contaminants, PCBs, selenium, and exposure and effects are also active focus areas. Twenty years from now, the priorities for the RMP may be completely different but the end result will be the same: high-quality information about water quality in San Francisco Bay to promote enlightened management decisions.

# REGULATORY POLICIES INFORMED BY THE RMP

## Management of pollutant discharges to the Bay: wastewater, stormwater, dredged material

- **303(d) Listings**
- **TMDLs**
  - Mercury TMDL
  - PCBs TMDL
  - North Bay Selenium TMDL
  - Suisun Marsh TMDL for Methylmercury, Dissolved Oxygen, and Nutrients
- **Permits**
  - NPDES wastewater discharge permit provisions
  - Municipal Regional Stormwater Permit - Load reductions, green infrastructure planning
  - Mercury and PCBs Watershed Permit for Municipal and Industrial Wastewater
  - Nutrient Watershed Permit for Municipal Wastewater
- **Criteria**
  - USEPA site-specific criteria for selenium
  - Site-specific objectives and implementation plan for copper
  - Nutrient water quality objectives (under development)
- **Contaminant of emerging concern (CEC) action plans**

## Commercial product formulation and usage

- State legislative bans: microbeads, PBDEs, copper in brake pads
- State flammability standards for furniture and building materials: flame retardants
- State pesticide regulations: e.g., pyrethroids
- State Safer Consumer Products regulations
- Federal legislative bans: PCBs, microbeads
- Federal pesticide regulations: DDT, chlordane, dieldrin, diazinon, and chlorpyrifos
- County and local drug take-back ordinances and programs



## Dredging and dredged material management

- Dredging and dredged material disposal permits through the Dredged Material Management Office
- Long-Term Management Strategy for the Placement of Dredged Material in the San Francisco Bay Region
- Essential Fish Habitat Agreement for Maintenance Dredging Conducted Under the LTMS Program

## Public health protection

- Fish consumption advice and communication



# RMP IMPACT SUMMARY: MUNICIPAL WASTEWATER DISCHARGERS

## DECISIONS INFORMED BY THE RMP

- **Are treatment plant modifications or upgrades, or source reduction activities needed?**
  - **Which contaminants need to be reduced in municipal wastewater?**  
Examples of contaminants currently under consideration for reductions are nutrients, the pesticides fipronil and imidacloprid, and other contaminants of emerging concern.
  - **At which treatment plants are the reductions needed?**  
Different segments of the Bay vary greatly in their general characteristics, including in some cases their sensitivity to additional contaminant loads. The need for load reductions may therefore vary in different parts of the Bay.
  - **How much of a reduction is needed?**  
The goal of TMDLs and other control plans is to reduce concentrations in the Bay to levels that do not significantly impact beneficial uses. This requires a solid understanding of impairment and contaminant cycling in the Bay.
  - **What is the effect of the reductions or modifications on Bay water quality?**  
Monitoring is essential in demonstrating that load reduction efforts achieve the desired improvement in beneficial use attainment. Treatment plant modifications (e.g., implementation of reverse osmosis for water reuse) may have potential for adverse impacts on certain beneficial uses, and also require monitoring.
- **Are actions needed for other pathways to reduce loads and impairment from contaminants found in municipal wastewater?** A holistic understanding of the relative importance of loads for all pathways is needed to optimize overall load reduction efforts.

## REGULATIONS ADDRESSED

NPDES Permits

Mercury TMDL

PCBs TMDL

North Bay Selenium TMDL

Copper SSO Implementation Plan

Nutrient Watershed Permit

Mercury and PCBs Watershed Permit

CEC Action Plans

Cyanide SSO Implementation Plan

DTSC Safer Consumer Product Regulations

DPR state pesticide regulations

USEPA Federal Insecticide, Fungicide, and Rodenticide Act



# RMP IMPACT SUMMARY: MUNICIPAL STORMWATER DISCHARGERS

## DECISIONS INFORMED BY THE RMP

- **Which contaminants need to be reduced in municipal stormwater?** Reductions of legacy contaminants are currently a primary focus of stormwater management attention, but other contaminants, including contaminants of emerging concern, may also need to be reduced.
- **How much load reduction effort is needed?** The goal of TMDLs and other control plans is to reduce concentrations in the Bay to levels that do not significantly impact beneficial uses. This requires a solid understanding of impairment and contaminant cycling in the Bay.
- **Which tributaries should be priorities for actions to reduce loads?** Different parts of the Bay encompass variable watershed source areas and related loads, and vary greatly in their general characteristics, including in some cases their sensitivity to additional contaminant loads. The need for load reductions may therefore vary for tributaries discharging to different parts of the Bay.
- **Which sources or source areas in watersheds should be targeted for load reductions?** Identifying the sources and source areas in watersheds to target is a major challenge in reducing stormwater loads.
- **What is the effect of load reductions or other stormwater management and watershed modifications on Bay water quality?** Monitoring is essential to demonstrating that load reduction efforts achieve the desired improvement in beneficial use attainment. Other activities in the watershed (e.g., land use changes or changes in chemical use) may also affect contaminant loads in either beneficial or adverse ways.
- **Are actions needed for other pathways to reduce loads and impairment from contaminants found in municipal stormwater?** A holistic understanding of the relative importance of loads for all pathways is needed to optimize overall load reduction efforts.

## REGULATIONS ADDRESSED

NPDES Permits

Municipal Regional Stormwater Permit

Mercury TMDL

PCBs TMDL

North Bay Selenium TMDL

Copper SSO Implementation Plan

CEC Action Plans

DTSC Safer Consumer Product Regulations

DPR state pesticide regulations

USEPA Federal Insecticide, Fungicide, and Rodenticide Act

# RMP IMPACT SUMMARY: INDUSTRIAL WASTEWATER DISCHARGERS

## DECISIONS INFORMED BY THE RMP

- **Are treatment plant modifications or upgrades, or source reduction activities needed?**
  - **Which contaminants need to be reduced in industrial wastewater?** For example, the need for selenium reductions in refinery effluent was identified in the 1990s, and treatment upgrades implemented in the late 1990s achieved large reductions in selenium loads.
  - **At which treatment plants are the reductions needed?** Specific industrial discharges may contain higher levels of chemicals that may merit special attention. For example, sites where fire-fighting foams have been used may discharge higher levels of PFOS, a chemical of emerging concern present in older formulations. In addition, different parts of the Bay vary greatly in their general characteristics, including in some cases their sensitivity to additional contaminant loads. The need for load reductions may therefore vary in different parts of the Bay.
  - **How much of a reduction is needed?** The goal of TMDLs and other control plans is to reduce concentrations in the Bay to levels that do not significantly impact beneficial uses. This requires a solid understanding of impairment and contaminant cycling in the Bay.
  - **What is the effect of the reductions or modifications on Bay water quality?** Monitoring is essential in demonstrating that load reduction efforts achieve the desired improvement in beneficial use attainment. Treatment plant modifications also may have potential for adverse impacts on beneficial uses and these must also be monitored.
- 
- **Are actions needed for other pathways to reduce loads and impairment from contaminants found in industrial wastewater?** A holistic understanding of the relative importance of loads for all pathways is needed to optimize overall load reduction efforts.

## REGULATIONS ADDRESSED

NPDES Permits

Mercury TMDL

PCBs TMDL

North Bay Selenium TMDL

Copper SSO Implementation Plan

Mercury and PCBs Watershed Permit

CEC Action Plans

DTSC Safer Consumer Product Regulations



# RMP IMPACT SUMMARY: DREDGERS

## DECISIONS INFORMED BY THE RMP

- **Where can contaminated dredged material be disposed?** RMP sediment data are the basis for the Dredged Material Testing Thresholds for mercury, polycyclic aromatic hydrocarbons (PAHs), and PCBs. These thresholds determine when bioaccumulation testing will be required for dredged material to be discharged at unconfined open water disposal sites in the Bay. RMP sediment data also serve as the basis for in-Bay dredged material disposal limits called for in the PCBs and mercury TMDLs.
- **Should dredged material be reused within the Bay and where?** Management of sediment as a resource in the Bay requires understanding of the volumes, types, locations, and environmental drivers of sediment input. The RMP performs extensive monitoring of suspended sediment concentrations along with monitoring of suspended sediment loads at select tributaries.
- **Should dredging practices be modified to prevent impacts to fish and benthic species?** The benthic communities of the Bay provide important foraging habitat for many fish species. However, there is a lack of scientific information specific to the Bay about: 1) the degree of benthic community disruption caused by periodic maintenance dredging; 2) the rates of benthic community recolonization and recovery following dredging; and 3) the effects on fish foraging success or quality.

## REGULATIONS ADDRESSED

2011 Programmatic Essential Fish Habitat Agreement, Measure 1

2011 Programmatic Essential Fish Habitat Agreement, Measure 7

PCBs TMDL

Mercury TMDL

Long-Term Management Strategy

# PROGRAM HIGHLIGHTS









## THE RMP TOP TEN: RECENT ACTIVITIES AND ACCOMPLISHMENTS

### 1 EMERGING CONTAMINANTS: MICROPLASTIC STUDY INFLUENCES STATE AND FEDERAL LEGISLATION

A small RMP pilot study in 2015 placed the Bay at the forefront of the emerging issue of microplastic contamination of aquatic ecosystems in the US. RMP findings ultimately influenced both a California law passed in October 2015 that banned microbeads in personal care products, as well as a similar federal law - the Microbead-Free Waters Act of 2015 - passed in December. Media stories on microplastic in San Francisco Bay water and treated wastewater broadcast the RMP findings to a wide audience. The study results suggested that the Bay had higher levels of microplastic pollution than the Great Lakes and Chesapeake Bay. Clearly identifiable microbeads derived from personal care products were detected at all nine Bay sites examined. More monitoring is needed to confirm these results and track trends in microplastic levels in response to the microbead ban and other policy changes designed to reduce plastic pollution. In 2016, the RMP funded the development of a monitoring and science strategy for studies to better characterize the problem and support formulation and implementation of management approaches.

#### MORE INFORMATION:

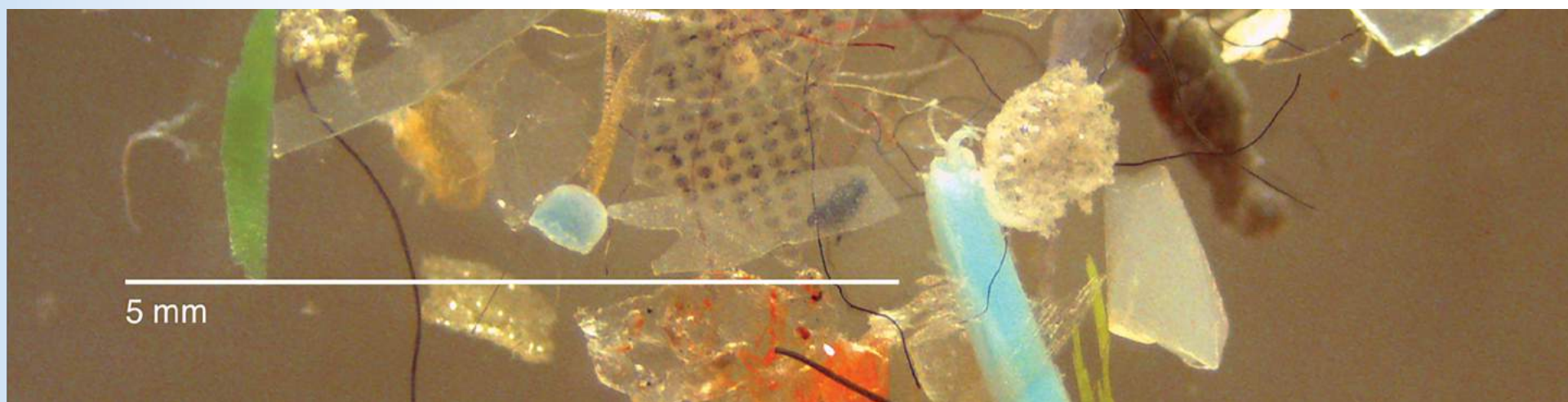
- Fact Sheet: Microplastic Contamination in San Francisco Bay (revised 2016)
- Journal Article: Microplastic contamination in the San Francisco Bay, California, USA (2016)

### 2 EMERGING CONTAMINANTS: INFORMING REGULATION OF CURRENT USE PESTICIDES

Findings from RMP monitoring are likely to influence ongoing efforts by the California Department of Pesticide Regulation and the US Environmental Protection Agency aimed at reducing environmental contamination and ecological impacts of fipronil and imidacloprid, two insecticides that are currently in wide use. Fipronil has been classified by the RMP as a moderate concern (Tier III) contaminant of emerging concern for the Bay. In 2016, the RMP monitored the influent and effluent from eight Bay municipal wastewater treatment plants for fipronil and its degradates. In addition, samples were analyzed for imidacloprid, the most widely used neonicotinoid pesticide and a compound that has been found to produce aquatic toxicity at extremely low levels. The study revealed the ubiquity and persistence of fipronil, its degradates, and imidacloprid during conventional wastewater treatment. Scientists from the RMP study team, which included the California Department of Pesticide Regulation, assessed the concentrations and concluded that the primary source of contamination is pet flea control products.

#### MORE INFORMATION:

- Journal Article: Passage of Fiproles and Imidacloprid from Urban Pest Control Uses Through Wastewater Treatment Plants in Northern California (submitted 2016)





### 3 SMALL TRIBUTARIES LOADING STRATEGY: INTEGRAL SUPPORT FOR THE MUNICIPAL REGIONAL STORMWATER PERMIT

The RMP Small Tributaries Loading Strategy (STLS) provides information that supports the implementation of PCB load reduction requirements in the Municipal Regional Stormwater Permit (MRP). STLS studies conducted during the first term of the MRP (2009-2015) were summarized in a synthesis report published in June 2016. The primary emphasis of these studies was to define baseline concentrations and loads in six watersheds and to refine estimates of overall loads to the Bay by developing and using a GIS-based regional “spreadsheet” model. In concert with the revised MRP issued in November 2015, the focus of the STLS has shifted to characterizing contaminant concentrations in a greater number of watersheds and subwatersheds in order to identify areas that have a disproportionately high impact on impairment in the Bay. Development and implementation of a plan to monitor trends in small tributary loads will be another key element of the STLS over the next few years. As the trends monitoring plan matures and implementation projects begin to accrue, RMP small tributary load monitoring will transition from a focus on identifying “high-leverage” watersheds to measuring trends in relation to management efforts. Continued development of the regional spreadsheet model is also planned in order to strengthen this tool for estimating loads to the Bay.

#### MORE INFORMATION:

- Technical Report: Pollutants of concern (POC) loads monitoring progress report, water years (WYs) 2012, 2013, and 2014 (2016)
- Technical Report: Sources, Pathways and Loadings: Multi-Year Synthesis with a focus on PCBs and Hg (2016)
- Technical Report: Pollutants of concern (POC) reconnaissance monitoring final progress report, water year (WY) 2015 (2016)
- Technical Report: Regional Watershed Spreadsheet Model (RWSM): Year 5 Progress Report (2016)

### 4 PCBS: INFORMING THE TMDL AND THE MUNICIPAL REGIONAL PERMIT FOR STORMWATER

The goal of studies under the RMP PCB Strategy over the next few years is to inform the review and possible revision of the PCBs TMDL and the corresponding requirements in the reissued Municipal Regional Permit for Stormwater, both of which are tentatively scheduled to occur in 2020. Conceptual model development for four margin areas that are high priorities for management and monitoring will provide a foundation for establishing effective and efficient monitoring plans to track responses to load reductions, and will also help guide management actions.

For each margin area, the following questions will be addressed:

- Can we expect a decline in PCB levels in response to projected load reductions in the watershed?
- How should tributary loads be managed to maximize recovery?
- How should the margin area be monitored to detect the expected reduction?

A thorough and thoughtful effort is warranted given the large investments that will be needed to implement management actions to reduce PCB loads from urban stormwater. The Emeryville Crescent, which receives stormwater runoff from Berkeley, Emeryville, and West Oakland, was the first area to be examined. San Leandro Bay, Steinberger Slough, and Richmond Harbor will be evaluated in the next three years.

#### MORE INFORMATION:

- Technical Report: Conceptual Model to Support PCB Management and Monitoring in the Emeryville Crescent Priority Margin Unit (2016)

## 5 NUTRIENTS: MOORED SENSOR MONITORING

In 2014, the Water Board adopted a watershed-wide permit for nutrients that required scientific studies in the Bay to inform whether nutrient reductions will be needed to avoid adverse effects in the future. RMP-funded monitoring of dissolved oxygen (DO) by in situ moored sensors is a critical contribution to this effort. While ongoing monthly grab samples have rarely detected DO below the water quality objective of 5 mg/L, the high-frequency moored in situ sensors installed at the Dumbarton Bridge have shown that DO frequently drops below this objective. The periods of low DO were strongly coupled to the tides, which led to the hypothesis that lower DO waters were being advected from margin habitats, including the extensive network of sloughs and creeks in Lower South Bay. In 2015, the network of moored sensors was expanded to include some margin areas and sloughs of Lower South Bay. Observations confirmed that DO frequently fell below 5 mg/L at multiple sites in these areas. The data also indicated that condition varied substantially among the sites, and that DO concentration was strongly influenced by the tides. Going forward, the moored sensors in Lower South Bay will continue to be maintained to collect data in the open channels and sloughs. The data from the sensors will be analyzed to identify the factors causing the low DO.

### MORE INFORMATION:

- Technical Report: Lower South Bay Nutrient Synthesis (2016)
- Technical Report: Nutrient Science Program FY 2016 Progress Update (2016)
- Website: SF Bay Nutrients Visualization Tool ([enviz.org](http://enviz.org))
- Newsletter: The Mooring Report (<http://www.sfei.org/tmr/2016-06>)

## 6 NUTRIENTS: MODELING

Modeling is an essential tool, used in conjunction with observational data, both to understand how the Bay processes nutrients and to characterize the range of future conditions in the Bay. Biogeochemical models of the Bay are part of the scientific program to implement the watershed permit for nutrients. Development of a coupled hydrodynamic and biogeochemical model began in earnest in August 2015. To date, this work has yielded a high-resolution hydrodynamic model configured for water year 2013, and a preliminary water quality model for nitrogen species. The hydrodynamic model has been used in two tracer studies: a conservative tracer study of the municipal wastewater inputs into the Bay, and a proof-of-concept evaluation of monitoring program design. The model was also applied to Emeryville Crescent in order to understand the flushing mechanisms there in relation to the PCB study (page 21). The biogeochemical nutrient model, though currently incorporating only a fraction of the nutrient pathways, is already showing promise in its ability to replicate observed trends in space and time. Future near-term efforts on modeling include a quantitative assessment of model performance, extension of the domain into the Delta, and adding phytoplankton.

### MORE INFORMATION:

- Technical Report: Nutrient Science Program FY 2016 Progress Update (2016)
- Program Development Report: San Francisco Bay Nutrient Management Strategy: Detailed Modeling Workplan for FY15-FY21 (2014)



Water quality sensor. Photograph by Phil Bresnahan.



## 7

## SELENIUM: SUPPORTING THE NORTH BAY SELENIUM TMDL

Studies under the RMP Selenium Strategy began in 2014, and have been aimed at establishing improved methods for obtaining information on impairment in the North Bay to support implementation of the North Bay Selenium TMDL. Two lines of investigation have been pursued, with both occurring over multiple years. First, a non-lethal method of monitoring selenium concentrations in muscle biopsies from white sturgeon (the species and tissue established as the impairment indicator in the TMDL) was piloted in 2014 and 2015. This approach provides a means of greatly increasing the number of samples that can be collected to evaluate status and trends relative to the TMDL target. Second, correlations between selenium concentration in sturgeon muscle and concentrations in other sturgeon tissues have been evaluated through coordination with an annual sturgeon fishing derby in the western Delta. These sturgeon derby studies have been conducted in 2015 and 2016. In future years, the Selenium Strategy calls for identifying a robust suite of indicators for detecting trends in the North Bay, and information gathering in support of consideration of development of a TMDL for the South Bay.

### MORE INFORMATION:

- Technical Report: Selenium in White Sturgeon Muscle Plugs: 2014 (2016)
- Technical Report: Selenium in White Sturgeon - 2015 Sturgeon Derby. (2016)



Measuring a white sturgeon. Photograph by Jennifer Sun.



## 8

## STATUS AND TRENDS MONITORING: BIRD EGG TRENDS INFORM MANAGEMENT OF MULTIPLE CONTAMINANTS

As the largest estuary on the Pacific Coast of North America, the Bay is a critical habitat for many estuarine bird species. Aquatic and wetland birds are exposed to pollutants that are transferred through the food web, and may be harmed by substances such as mercury, PCBs, dioxins, selenium, DDT, PBDEs, PFOS, and other contaminants of emerging concern. Birds are valuable sentinels in water quality monitoring in the Bay and around the world, including the Great Lakes, the Canadian arctic, and the Baltic Sea. The RMP monitors trends in a broad suite of contaminants in the eggs of double-crested cormorants and Forster's terns. Eggs are collected on a three-year cycle, with a time series that began in 2002. The latest round of egg collections occurred in spring of 2016. A technical report summarizing the long-term dataset was published in May 2016. Long-term declines in PBDEs, DDT, and dioxins have been observed. Concentrations of PCBs and PFOS have been highest in the Lower South Bay. Concentrations of mercury in Forster's Terns are high enough to place the majority of the population at high risk, and represent the greatest toxicological threat.

### MORE INFORMATION:

- Technical Report: Contaminant Concentrations in Eggs of Double-crested Cormorants and Forster's Terns from San Francisco Bay: 2002-2012 (2016)





## 9 COPPER: ADDRESSING AN INFORMATION GAP IDENTIFIED IN THE SITE-SPECIFIC OBJECTIVES

Site-specific objectives (SSO) for copper, developed in 2007, establish criteria for various segments within the Bay. The SSO specifically called for further study on the potential toxicity of copper to the olfactory system of salmonids. The RMP, in partnership with the Copper Development Association, funded studies by researchers at the National Marine Fisheries Service to address this data gap. The studies indicated a threshold for copper olfactory toxicity in freshwater-phase juvenile salmon of around 5 µg/L in freshwater. As juveniles migrate into estuaries and encounter increased salinities of 10 parts per thousand (ppt), this threshold increases to >50 µg/L. After juvenile salmon transition to smolts within the Estuary, the threshold remains >50 µg/L in either estuarine water of 10 ppt or seawater. The current SSOs for copper (6.0 – 6.9 µg/L chronic and 9.4 – 10.8 µg/L acute in different segments of the Bay), therefore, appear to protect the olfactory system of juvenile salmon from toxicity under Bay conditions.

### MORE INFORMATION:

- Technical Report: Effect of Salinity on the Olfactory Toxicity of Dissolved Copper in Juvenile Salmon (2015)
- Journal Article: Effects of salinity on olfactory toxicity and behavioral responses of juvenile salmonids from copper (2016)

## 10 PROGRAM MANAGEMENT: NEW SOURCES OF FUNDING FOR THE RMP

A long list of information needs has been identified by RMP stakeholders and science advisors to support the investment of billions of dollars in management of wastewater and stormwater in coming years. Two new funding streams have recently been channeled into the RMP to allow the Program to more fully address these needs. First, the Water Board established an optional reduced monitoring schedule for municipal wastewater discharges to the Bay in exchange for increased payments to the RMP. The intended use of these funds is monitoring and special studies for contaminants of emerging concern. Second, the Water Board and SFEI entered into an agreement that made the RMP an authorized Supplemental Environmental Project (SEP) funds administrator in October 2015. Therefore, for enforcement actions, parties have the option to direct up to half of the penalty to the RMP as a SEP. The first SEP project through the RMP will fund PCB studies in San Leandro Bay, one of the priority margin areas identified in the RMP PCB Strategy. Together, these new funding streams are anticipated to make an additional several hundred thousand dollars per year available for high priority water quality studies.

## COMING ATTRACTIONS



### 1 25<sup>th</sup> Anniversary of the RMP

2017 marks the 25<sup>th</sup> year of RMP monitoring. Reflections on this milestone will provide a theme throughout the year.

### 2 Central Bay Margin Survey

Past RMP sediment monitoring covered subtidal areas, but not the intertidal zone. The Program has begun to address this information gap for this important portion of the ecosystem with a survey conducted in 2015. Results will be available at the end of 2016.

### 3 Conceptual Models for PCBs in Priority Margin Areas

San Leandro Bay will be the second priority margin area to be examined to evaluate its expected responsiveness to tributary load reductions. Conceptual model development will be supported by field studies using Supplemental Environmental Project funds. The conceptual model report will be completed in 2017, and the results of field studies will be published in 2018.

### 4 Moored Sensor Monitoring in South Bay Margins

Data on dissolved oxygen and other water quality parameters from the extensive network of moored sensors in Lower South Bay will be analyzed to identify the factors contributing to the observed conditions including tidal flushing, exchange with salt ponds, and nutrient cycling. Results will be published in 2017.

### 5 Continued Sturgeon Studies

Reports on the second year of the Sturgeon Derby and Sturgeon Muscle Plug studies will be completed in 2016.

### 6 Small Tributaries Loading Strategy

Stormwater in watersheds with older urban and industrial land use will be tested for PCB and mercury concentrations to identify high leverage areas for management actions. A report will be produced in early 2017 covering sampling in 2015 and 2016.

### 7 Dredging Impacts on Benthos

A study of dredging impacts being conducted by USGS, with joint funding from the RMP and the US Army Corps, will be completed in 2017. The study will address the lack of information specific to the Bay about the degree of benthic community disruption caused by periodic maintenance dredging, rates of benthic community recolonization and recovery following dredging, and effects on fish foraging success or quality.

### 8 2014 Sport Fish Monitoring Report

The RMP monitors contaminants in sport fish on a 5-year cycle, most recently in 2014. A report on the findings will be available in 2016.

### 9 Non-targeted Analysis of Water-Soluble Contaminants

A broad scan of Bay water and treated wastewater for water-soluble compounds will seek to identify untargeted contaminants that may merit further investigation. Results will be available in 2017.

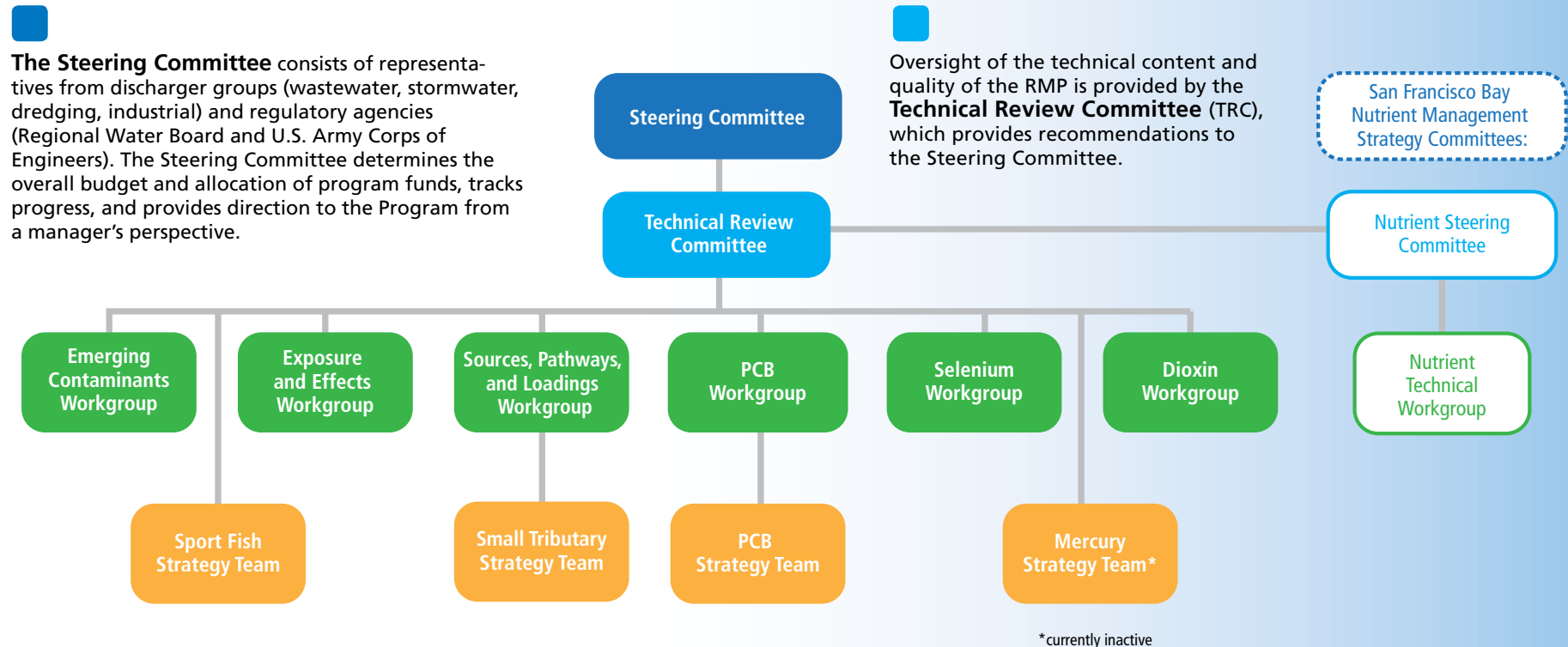
### 10 Microplastic Monitoring and Science Strategy

The RMP will develop a strategy for further microplastic monitoring guided by stakeholder management questions and informed by leading experts. A report will be completed in late 2016.



# PROGRAM OVERSIGHT

Collaboration and adaptation in the RMP are achieved through the engagement of stakeholders and scientists in frequent committee and workgroup meetings.



**Workgroups** report to the TRC and address the main technical subject areas covered by the RMP. The Nutrient Technical Workgroup was established as part of the committee structure of a separate effort - the Nutrient Management Strategy - but makes recommendations to the RMP committees on the use of the RMP funds that support nutrient studies. The workgroups consist of regional scientists and regulators and invited scientists recognized as authorities in their field. The workgroups directly guide planning and implementation of special studies.

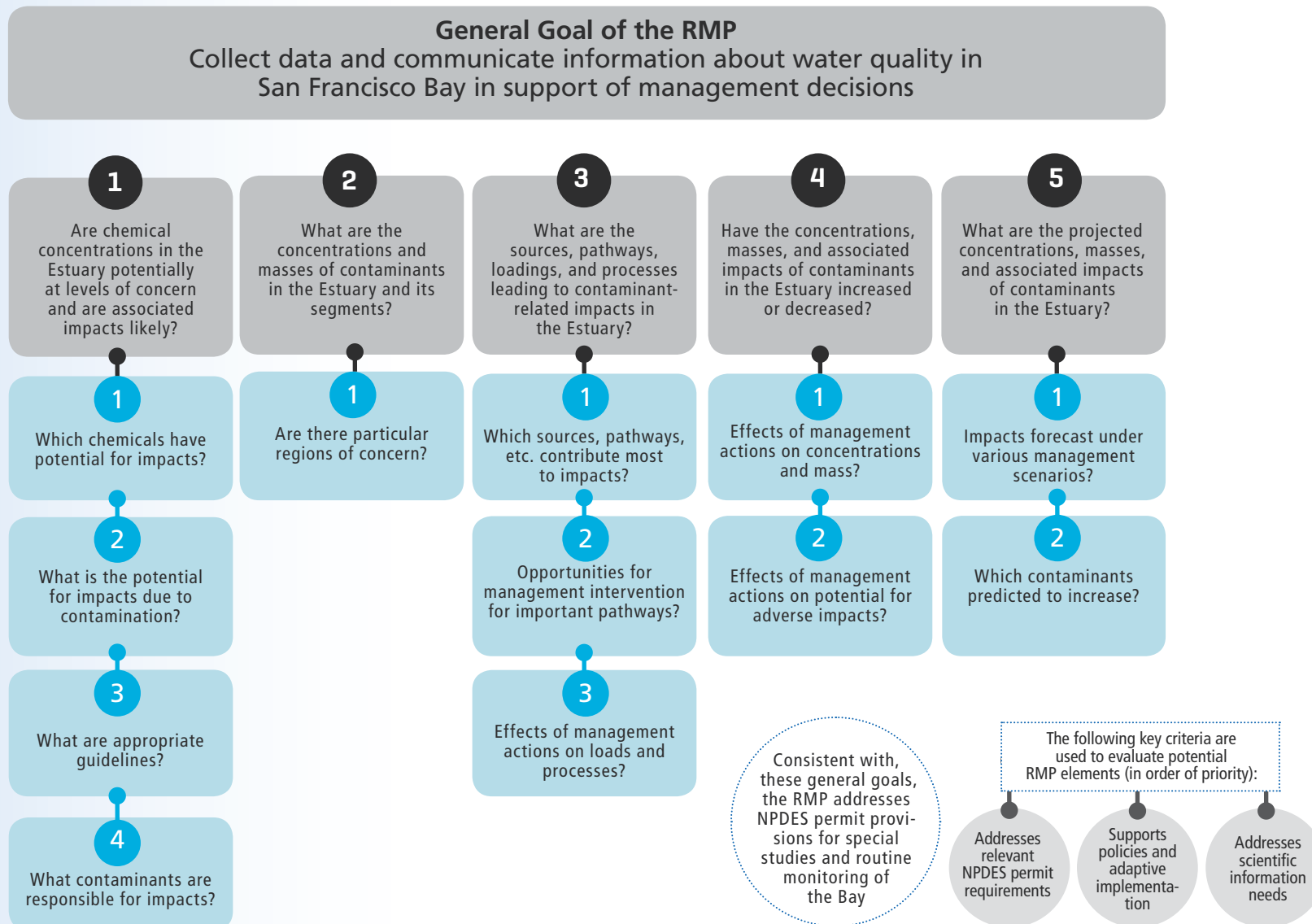
**RMP strategy teams** constitute one more layer of planning activity. These stakeholder groups meet as needed to develop long-term RMP study plans for addressing high priority topics.

## RMP GOAL AND MANAGEMENT QUESTIONS

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

### LEVEL 1 QUESTIONS

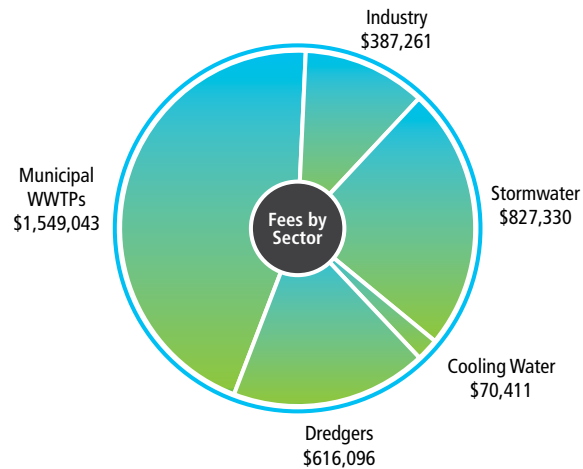
### LEVEL 2 QUESTIONS





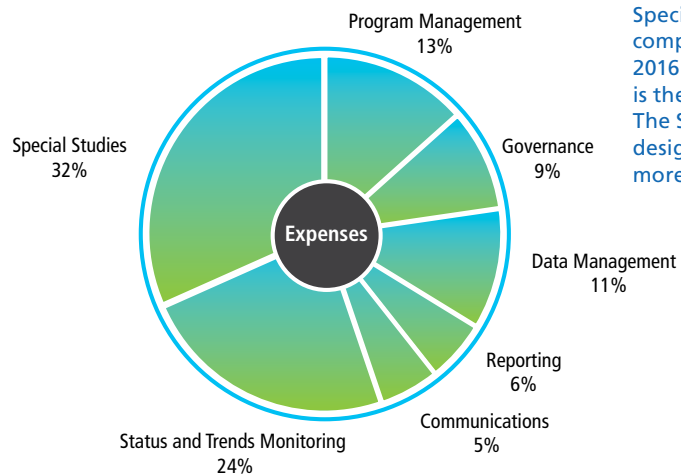
# PROGRAM MANAGEMENT

## RMP FEES BY SECTOR: 2016



Total fees in 2016 (\$3.45 million) were lower than the target due to two factors: 1) a phase-out of Cooling Water payments through 2018 at which point this sector will have ceased discharging to the Bay and will no longer be included in the Program; and 2) below-target fees from dredgers. The dredger fee deficit accumulated through 2016 will not be recovered.

## RMP EXPENSES: 2016



Special studies was the largest component of the RMP budget in 2016. Status and Trends monitoring is the second largest component. The Status and Trends monitoring design was optimized in 2012 to be more efficient.

## COMMUNICATIONS



Includes the *Pulse of the Bay*, Annual Meeting, Multi-Year Plan, State of the Estuary report, RMP website, Annual Monitoring Report, technical reports, journal publications, newsletter, oral presentations, posters, and media outreach.

## PROGRAM MANAGEMENT AND GOVERNANCE

Includes internal coordination (staff management), committee and workgroup meetings, coordination with Program participants, external coordination with related groups, program planning, contract and financial management, and workgroup and peer review coordination.

## DATA MANAGEMENT AND QUALITY ASSURANCE

The RMP database contains approximately 1.1 million records generated since the Program began in 1993. Web-based data access tools include user-defined queries, data download and printing functionality, maps of sampling locations, and visualization tools.





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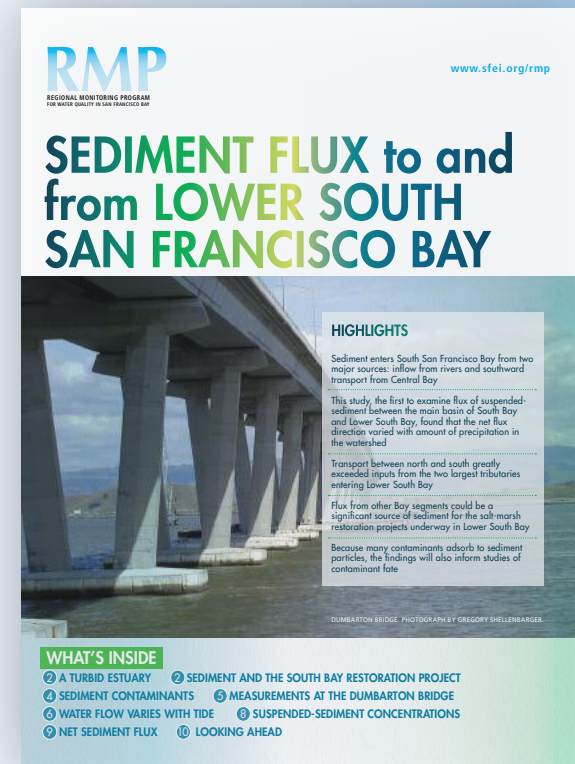
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Transplanted mussels. Photograph by Jennifer Sun.



# PROGRAM AREA UPDATES

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# STATUS AND TRENDS

## BACKGROUND

The Status and Trends monitoring program represents the core of the RMP's long-term monitoring strategy. Since the beginning of Status and Trends monitoring in 1993, water, sediment, and bivalve tissues have been monitored regularly in the open Bay. Sport fish and bird egg monitoring were added to the program in 1997 and 2002, respectively.

Annual sampling of water and sediment chemistry has documented trends and spatial patterns that vary by pollutant. Between 2011 and 2014, monitoring was scaled back to free up resources for special studies and other topics.

Sediment monitoring in the shallow margin areas of the Bay is currently being considered for addition to the Status and Trends program through a pilot study focused on the Central Bay.

### USES OF RMP STATUS AND TRENDS DATA FOR MANAGEMENT DECISIONS

- Defining ambient conditions in the Bay
- Water Quality Assessment – 303(d) impairment listings or de-listings
- Determination of whether there is reasonable potential that a NPDES-permitted discharge may cause violation of a water quality standard
- Evaluation of water and sediment quality objectives
- Dredged material management
- Development and implementation of TMDLs for mercury, PCBs, and selenium
- Site-specific objectives and anti-degradation policies for copper and cyanide
- Development and evaluation of a Nutrient Assessment Framework (i.e., development of water quality objectives)

### PRIORITY QUESTIONS

- 1 Are contaminants at levels of concern?
- 2 What are the concentrations and masses of priority contaminants in the Bay, its compartments, and its segments?
- 3 Are there particular regions of concern?
- 4 Have concentrations and masses increased or decreased?

### RELATION TO PERMIT REQUIREMENTS

#### NPDES Permits

- Receiving water compliance monitoring for NPDES discharge permit holders
- Provides data for Reasonable Potential Analyses
- Provides data for evaluating site specific objectives for copper and cyanide

#### Essential Fisheries Habitat Consultation, PCBs TMDL, Mercury TMDL

- Provides data to calculate dredged material testing thresholds in sediment and in-Bay disposal limits

# STATUS AND TRENDS

## RECENT FINDINGS

● ● PBDE levels have declined in bivalves, bird eggs, sport fish and sediment following nationwide phase-outs and state bans of these toxic and persistent flame retardant chemicals.

● ● Mercury concentrations in Bay sediment do not appear to be increasing or decreasing.

● ● PAH concentrations in Bay sediment may be trending upward. Average concentrations of PAHs in sediment have been highest along the southwestern shoreline of Central Bay.

● ● A sudden decrease in suspended-sediment concentrations occurred in 1999 and has persisted since that time.

● ● Nitrogen concentrations vary considerably by Bay segment and season. Late summer chlorophyll in South Bay increased from roughly 1995 to 2005 but has since leveled off. At the same time, decreasing chlorophyll concentrations have been observed in Suisun Bay and the Delta.

## WORKPLAN HIGHLIGHTS

● ● Long-term monitoring of

- water biennially,
- sediment once every four years,
- bivalves biennially,
- bird eggs triennially, and
- sport fish once every five years

● ● **Bay Margins:** a pilot study of surface sediment contaminant concentrations in the mud flats and adjacent shallow areas of the Bay, beginning with Central Bay. These areas are more productive and highly utilized by biota. Pilot sampling was conducted in 2015. A report summarizing the results will be completed in 2016.

● ● **California Toxics Rule:** The latest round of sampling for California Toxic Rule parameters (organic pollutants, VOCs, and metals) in ambient Bay water was completed in 2015. A report will be prepared in 2016.

● ● **Long-term monitoring of contaminants in fish** is an essential means of measuring the effectiveness of management actions to reduce PCB and mercury loads to the Bay. Unfortunately, data through 2009 indicate no measurable change in mercury or PCB concentrations in Bay fish. Monitoring was repeated in 2014 and will be reported in 2016.



## COLLABORATORS

- San Francisco Regional Water Quality Control Board
- US Environmental Protection Agency
- Applied Marine Sciences
- AXYS Analytical
- Brooks Analytical Laboratories
- City and County of San Francisco
- USGS
- California Department of Fish and Wildlife
- ALS Environmental
- Caltest Analytical Laboratory
- Pacific EcoRisk
- Moss Landing Marine Laboratory
- Marine Pollution Studies Laboratory
- Coastal Conservation & Research
- City of San Jose



# EMERGING CONTAMINANTS

## BACKGROUND

Emerging contaminants are not regulated or routinely monitored, yet have the potential to enter the environment and harm people or wildlife. Through its focus on emerging contaminants, the RMP aims to identify problem chemicals *before* they harm Bay wildlife. The RMP's decade-long effort has made

the Bay one of the most thoroughly studied estuaries in the world. Surveillance has identified four contaminants of moderate concern:

- PFOS - a stain and water repellent
- Fipronil - a widely used insecticide

- Nonylphenol and nonylphenol ethoxylates - a class of detergent ingredients
- PBDEs - a once-common class of flame retardants



### USES OF RMP EMERGING CONTAMINANT DATA FOR MANAGEMENT DECISIONS

- Regional Action Plans for emerging contaminants
- Early management intervention, including green chemistry and pollution prevention
- State and federal pesticide regulatory programs

### PRIORITY QUESTION

- 1 What emerging contaminants have the potential to adversely impact beneficial uses of the Bay?

### RELATION TO PERMIT REQUIREMENTS

- Municipal wastewater dischargers may select a cost-saving alternative monitoring and reporting permit requirement and provide additional funds to support the RMP and its emerging contaminants monitoring.
- The revised municipal regional stormwater permit (2015) requires monitoring studies of key emerging contaminants, including flame retardants, PFOS and related compounds, and pesticides.

# EMERGING CONTAMINANTS

## RECENT FINDINGS

- PFOS and related compounds were detected in treated wastewater discharged to the Bay. Higher levels were observed at two facilities, SFO Airport and Fairfield-Suisun, impacted by industrial firefighting agents that contain these chemicals. At other facilities, PFOS-related compounds had shorter carbon chains, consistent with known use trends. A large number of compounds could not be identified with available methods.
- Levels of PFOS may finally be declining in Bay wildlife following a nationwide phase-out of this former Scotchgard ingredient in 2002. However, other members of the same chemical family are still in use, present in the Bay and its wildlife, and may have similar toxic properties.
- Fipronil and imidacloprid, broad-spectrum insecticides with growing urban uses, were detected in Bay Area sewage, treated wastewater, and biosolids. Pesticides appear to persist despite wastewater treatment. Topical flea control treatments are one likely source of this contamination.
- Microplastic pollution in the Bay may be greater than in other major urban US water bodies studied. Microbeads from beauty products and tiny fibers from clothing and textiles were found at all nine sites examined. Tiny particles passed through Bay Area wastewater treatment plants, even those using advanced technologies. Fibers made up most of the particles in treated wastewater, though not all fibers are known to be plastic. State and federal legislation has banned use of microbeads in rinse-off personal care products starting in 2017.

## WORKPLAN HIGHLIGHTS

- **Non-targeted Analysis of Water-Soluble Compounds:** A broad scan of Bay water and treated wastewater for water-soluble (polar) compounds will be used to identify unexpected contaminants that may merit further investigation. Potential contaminants include detergents and surfactants, pesticides and pharmaceuticals, and plastic additives.
- **Revised Emerging Contaminants Strategy:** New developments, particularly around bioanalytical tools and non-targeted analysis, will be incorporated into a revised RMP strategy in 2016. The document will also provide guidance on the contaminant evaluation process.
- **Microplastic Monitoring and Science Strategy:** The RMP will develop a strategy for further microplastic monitoring guided by stakeholder management questions and informed by leading experts.
- **Coordination of Pharmaceuticals Monitoring in Wastewater:** RMP staff will provide scientific guidance and technical assistance to wastewater agencies conducting pharmaceuticals monitoring.

## COLLABORATORS

- Arizona State University
- AXYS Analytical
- Bay Area Clean Water Agencies
- California Department of Toxic Substances Control
- Duke University
- San Francisco Bay Regional Water Quality Control Board
- Southern Illinois University
- Southern California Coastal Water Research Project
- SUNY Fredonia
- TDC Environmental
- University of Florida
- California Department of Pesticide Regulation



# SOURCES, PATHWAYS, AND LOADINGS

## BACKGROUND

San Francisco Bay PCB and mercury TMDLs were established to address health risks to humans and wildlife. Urban tributary loads are named in the TMDLs as the primary controllable source for reducing impairment. Other pollutants of concern in urban

stormwater include copper, PBDEs, nutrients, pesticides, and emerging pollutants.

Given these issues and challenges, the Small Tributaries Loading Strategy (STLS) was written in 2009 to help prioritize and coordinate

the activities of the RMP and Bay Area Stormwater Management Agencies Association permittees that support locating, quantifying, and managing PCBs, mercury, and other pollutants in the urban environment.

Note: "Small tributary" refers to the rivers, creeks, and storm drains that enter the Bay from the nine counties that surround the Bay.

### USES OF RMP SOURCES, PATHWAYS, AND LOADINGS DATA FOR MANAGEMENT DECISIONS

- Refining pollutant loading estimates for TMDL updates
- Informing provisions of the current and future versions of the Municipal Regional Stormwater Permit (MRP)
- Identifying small tributaries to prioritize for management actions
- Informing decisions on best management practices for reducing concentrations and loads

### PRIORITY 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?
- 5 Which sources or watershed source areas provide the greatest opportunities for reductions of Pollutants of Concern (POCs) in urban stormwater runoff?

### RELATION TO PERMIT REQUIREMENTS

Partially satisfies monitoring requirements specified in the Municipal Regional Stormwater Permit

- Pollutants of Concern Monitoring
- Wet Weather Pesticides and Toxicity Monitoring
- Implement Control Measures to Achieve Mercury/PCB Load Reductions
- Assess Mercury/PCB Load Reductions from Stormwater
- Plan and Implement Green Infrastructure to Reduce Mercury/PCB loads
- Prepare Implementation Plan and Schedule to Achieve TMDL Allocations

# SOURCES, PATHWAYS, AND LOADINGS

## RECENT FINDINGS

- ● The most polluted watersheds with regard to PCBs appear to be those draining to Pulgas Creek Pump Station North and South, Santa Fe Channel, Lower Silver Creek, and the Ettie Street Pump Station. Mercury is also relatively high at the Santa Fe and Ettie Street sites.
- ● PCB legacy source areas include electrical distribution use and production areas, waste handling areas, railway yards and lines, older industrial areas, and buildings and pavements where caulking was used in concrete joint sealants.
- ● The most recent estimates based on simple scaling of climatically adjusted empirical data for PCB loads are similar to those in the TMDL (20 kg), whereas new evidence suggests a regional load of 113 kg mercury, which is lower than that of the TMDL (160 kg).
- ● Pulgas Creek Pump Station-South has the highest PCB load per unit area, or "yield" (85 g/km<sup>2</sup>), measured to date, and Guadalupe River has the highest mercury yield (387 g/km<sup>2</sup>).
- ● Mercury sources include older urban areas, waste handling areas, cement plants, crematoria, refineries, and legacy mining areas.

## WORKPLAN HIGHLIGHTS

- ● **Regional Watershed Spreadsheet Model:** The RWSM is an average annual time step planning level model designed to estimate sub-regional scale loads of any pollutant of interest. Presently development efforts are mostly focused on PCBs and mercury. Once calibrated, model outputs will include maps, tables, and graphs of watershed scale loads and yields, and land use based event mean concentrations, loads and yields. These model outputs can be used to help rank watersheds of interest and provide a baseline for comparing conditions before and after management efforts.
- ● **Stormwater Reconnaissance Winter Sampling:** To support a weight-of evidence approach for the identification and management of PCBs and mercury sources, this effort provides further data on concentrations and particle ratios with a focus on the stormwater flowing from of older urban and industrial land use areas.
- ● **Trends Strategy:** The determination of stormwater loading trends in relation to management efforts and beneficial use impacts is an important new focus area. To support this focus, a trends strategy is being developed that will provide a rationale for monitoring site and water quality indicator selection, analytes, and sampling design, including the choice of discrete versus composite sampling, storms to focus on and how often to sample. To support this change in direction, a STLS Trends team has been assembled that includes several of the nation's leading experts on trends design and analysis.



Stormwater sampling. Photograph by Jennifer Sun.

## COLLABORATORS

- San Francisco Bay Regional Water Quality Control Board
- Bay Area Stormwater Management Agencies Association
- UCLA
- US Geological Survey
- TDC Environmental



# NUTRIENTS

## BACKGROUND

San Francisco Bay has high nitrogen and phosphorus concentrations, but has not historically experienced the eutrophication problems typical of other nutrient-enriched estuaries. Observations over the last decade, however, have indicated that the Bay's resistance to

elevated nutrient concentrations may be weakening, possibly due to decreasing suspended sediment concentrations and increasing light availability. In response, the San Francisco Bay Regional Water Quality Control Board and stakeholders launched the San Francisco

Bay Nutrient Management Strategy (NMS). The Regional Monitoring Program has funded a number of the work elements of the NMS, including modeling and high-frequency, sensor-based monitoring.

### USES OF RMP NUTRIENT DATA FOR MANAGEMENT DECISIONS

- Development of nutrient numeric endpoints and assessment framework
- Evaluating need for revised objectives for dissolved oxygen and other parameters
- Assessment of water quality impairment status
- Implementation of NPDES permits for wastewater and stormwater

### PRIORITY QUESTIONS

- ● 1 What conditions in different Bay habitats would indicate that beneficial uses are being protected versus experiencing nutrient-related impairment?

- ● 2 In which subembayments or habitats are beneficial uses being supported? Which subembayments or habitats are experiencing nutrient-related impairment?

- ● 3 A) To what extent is nutrient over-enrichment, versus other factors, responsible for current impairments?
- B) What management actions would be required to mitigate those impairments and protect beneficial uses?

- ● 4 A) Under what future scenarios could nutrient-related impairments occur, and which of these scenarios warrant pre-emptive management actions?

B) What management actions would be required to protect beneficial uses under those scenarios?

- ● 5 What nutrient sources contribute to elevated nutrient concentrations in subembayments or habitats that are currently impaired, or would be impaired in the future, by nutrients?

- ● 6 When nutrients exit the Bay through the Golden Gate, where are they transported and how do they influence water quality in the Gulf of Farallones or other coastal areas?

- ● 7 What specific management actions, including load reductions, are needed to mitigate or prevent current or future impairment?

### RELATION TO PERMIT REQUIREMENTS

The Bay-wide nutrient permit that went into effect in 2014 includes a provision to support science and monitoring to inform future permitting decisions

# NUTRIENTS

## RECENT FINDINGS

- ● Dissolved oxygen concentrations in the sloughs of Lower South Bay are often below the water quality objective of 5 mg/L, and frequently 2-3 mg/L, usually on ebb tides.
- ● Toxin-producing algal species are frequently detected in the Bay, and algal toxins are often present in the water column and biota.
- ● Restored salt ponds in Lower South Bay could be transforming nutrients and loading organic matter into adjacent sloughs.
- ● Preliminary computer models of major wastewater treatment plant discharges are clarifying their relative zone of influence.
- ● High-frequency and shipboard monitoring data illustrate that the Bay is quite variable in its response to high nutrient loads, on time-scales ranging from tidal to interannual.

## WORKPLAN HIGHLIGHTS

- ● Water quality modeling: With the arrival of a full-time water quality modeler in August 2015, work is underway to refine the underlying hydrodynamics. At the same time, basic multi-box water quality modeling is underway for Lower South Bay to inform the direction of future modeling activities.
- ● Harmful algal species/toxins monitoring: In response to frequent detection of toxin-producing algal species throughout the Bay, monitoring for algal toxins in the water column, and more recently in mussels, is now an on-going element of the NMS.
- ● Dissolved oxygen investigations in Bay sloughs: In summer 2015, the size of the moored sensor network was tripled. It now includes 6 slough sites and 2 open Bay sites. Data from this network has informed our understanding of spatial and temporal heterogeneity in nutrient-related parameters (chlorophyll-a, dissolved oxygen), as well as the interaction between margin habitats and the open Bay.

## COLLABORATORS

- San Francisco Bay Regional Water Quality Control Board
- Bay Area Clean Water Agencies
- Additional members of the Nutrient Management Strategy Steering Committee
- US Geological Survey – Sacramento
- US Geological Survey – Menlo Park
- UC Santa Cruz
- Deltares
- UC Berkeley
- San Francisco State University





# SELENIUM

## BACKGROUND




San Francisco Bay has been listed as impaired by selenium since 1990. Although water concentrations are below water quality thresholds, several wildlife species may be at risk for selenium toxicity. White sturgeon, a benthic species, is recognized as a key indicator of selenium impairment in the Bay due to its susceptibility to selenium bioaccumulation.

In 2016, a TMDL for North Bay was approved, which established numerical selenium targets for water and white sturgeon tissue. In addition, USEPA proposed criteria for selenium in Bay-Delta fish, clams, and water in June 2016.














The RMP Selenium Workgroup was established in 2014 to develop monitoring strategies to inform implemen-

tation of the North Bay TMDL and consideration of a TMDL for the South Bay. Selenium in water, sediment, and tissues are regularly monitored through the Status and Trends program. Recent special studies have focused on developing tissue monitoring methods for white sturgeon. Development of other monitoring indicators that can provide an early indication of changing selenium exposure is currently under consideration.

### USES OF RMP SELENIUM DATA FOR MANAGEMENT POLICIES AND DECISIONS

-  North Bay Selenium TMDL
-  USEPA Selenium Criteria for the Bay-Delta
-  South Bay Selenium TMDL (under consideration)

### PRIORITY QUESTIONS

-   **1** What are appropriate thresholds?  

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

-   **3** What is the spatial pattern of selenium impairment?  

-   **4** How do selenium concentrations and loadings change over time?
-   **5** What is the relative importance of each pathway of selenium loading in the Bay?

### RELATION TO PERMIT REQUIREMENTS

Supports the development and implementation of selenium TMDLs for North and South Bay, as well as USEPA site-specific selenium criteria for the San Francisco Bay-Delta.

# SELENIUM

## RECENT FINDINGS

● Muscle tissue selenium concentrations exceed the North Bay TMDL target in individual sturgeon, but medians have remained below the target.

● Selenium concentrations measured in sturgeon muscle plugs and muscle fillets are well-correlated.

● No long-term trend has been apparent in sturgeon selenium concentrations since 1987.

● Selenium concentrations in bird eggs are usually well below a target developed to protect birds in Newport Bay.

● The highest tissue selenium concentrations were measured in white sturgeon caught in Suisun Bay; the lowest were in Central Bay.

● The Lower South Bay has higher average selenium concentrations in water than the other Bay segments, but white sturgeon collected in South Bay have had lower concentrations than North Bay sturgeon.

## WORKPLAN HIGHLIGHTS

● **Sturgeon Derby Study:** Studying the relationship between selenium measured in white sturgeon tissues that can be sampled non-lethally (muscle plugs, fin rays) and those of toxicological concern (ovary, liver). Fish are collected in collaboration with an annual sturgeon derby held out of Bay Point over Super Bowl Weekend.

● **Selenium in Sturgeon Muscle Plugs:** Non-lethal monitoring of selenium in white sturgeon muscle tissue using muscle plugs. Samples are collected in North Bay in a partnership with the California Department of Fish and Wildlife.

● **Selenium Monitoring Design:** Developing a regional long-term selenium monitoring plan for North Bay, including sturgeon, clam, and water monitoring. The primary objective is early detection of changes in selenium exposure and risk.

● **Telemetry Information Synthesis:** Identifying sturgeon telemetry studies and sources of telemetry data that can provide information about the movements and habitat use of sturgeon in both North and South Bay.

## COLLABORATORS

- US Geological Survey - Menlo Park
- Stantec
- United States Fish and Wildlife Service, Lodi Fish and Wildlife Office
- California Department of Fish and Wildlife
- United States Fish and Wildlife Service, Bozeman Fish Technology Center
- Foundation Sportsman's Club

The Sturgeon Derby. Photograph by Jennifer Sun.





# PCBs

## BACKGROUND

PCB contamination is a high priority for Bay water quality managers due to concerns for risks to humans and wildlife. A TMDL was approved in 2009. Monitoring of small fish along the margins of the Bay in 2010 showed higher PCB concentrations than in the open Bay. In 2014, the RMP completed a synthesis report

summarizing advances in understanding of PCBs in the Bay since the data synthesis for the PCBs TMDL. An updated conceptual model presented in that report called for monitoring and management to focus on contaminated areas on the Bay margins. Local-scale actions within a margin area, or in upstream watersheds,

will be needed to reduce exposure within that area. The multi-year workplan for PCBs is focusing on preparing to detect improvements in Bay margin sites in response to anticipated stormwater load reductions.

### USES OF RMP PCB DATA FOR MANAGEMENT DECISIONS

- PCB TMDL and potential update
- Implementation of NPDES permits
- Selecting management actions for reducing PCB impairment

### PRIORITY QUESTIONS

- 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 Which small tributaries and contaminated margin sites are the highest priorities for cleanup?
- 5 What management actions have the greatest potential for accelerating recovery or reducing exposure?
- 6 What are the near-term effects of management actions on the potential for adverse impacts on humans and aquatic life due to Bay contamination?

### RELATION TO PERMIT REQUIREMENTS

Addresses critical information needs identified in the PCB TMDL to be addressed by municipal and industrial wastewater dischargers and stormwater management agencies.

Addresses a requirement in the Municipal Regional Stormwater Permit: Fate and transport study of PCBs - Urban runoff impact on San Francisco Bay margins.

# PCBs

## RECENT FINDINGS

- ● Shiner surfperch have concentrations 12 times higher than the TMDL target, and these have resulted in an advisory from the Office of Environmental Health Hazards Assessment (OEHHA) recommending no consumption for all surfperch in the Bay. Concentrations in shiner surfperch and white croaker show no clear sign of decline.
- ● Wetland sediment cores provide evidence of dramatic declines from the 1960s to the present.
- ● The RMP list of 40 congeners has been confirmed as the most appropriate PCB index for monitoring in support of the PCB TMDL.
- ● Santa Fe Channel, Pulgas Creek Pump Station North and South, Ettie Street Pump Station, and North Richmond Pump Station appear to have relatively polluted sediment particles and have the potential to be high leverage watersheds where control actions are a cost-effective way of reducing downstream impacts.
- ● For birds, seals, and fish there is evidence of PCB exposures in certain locations that may be reducing health and survival.
- ● Recent estimates of total loads for POTWs and industrial facilities were well below the wasteload allocations in the TMDL.
- ● Average concentrations in Suisun Bay sediments are lower than in the other Bay segments.

## WORKPLAN HIGHLIGHTS

- ● A program of study for detecting the response to management actions in Bay margin sites, including: prioritization of sites for study, development of conceptual models for high priority sites; and initiating monitoring at these sites.
- ● The Emeryville Crescent, San Leandro Bay, Steinberger Slough, and Richmond Harbor have been identified as priority margin areas that will be the subject of detailed conceptual model development efforts to assess their responsiveness to tributary load reductions.
- ● Development of a multi-year plan for PCBs to support revision of the PCBs TMDL.

## COLLABORATORS

- Bay Area Stormwater Management Agencies Association
- AXYS Analytical
- Moss Landing Marine Laboratory
- Simon Fraser University
- San Francisco Bay Regional Water Quality Control Board
- Stanford University

Bay margin sediment sampling. Photograph by Don Yee.





# EXPOSURE AND EFFECTS

## BACKGROUND

RMP Exposure and Effects studies began in 2001. The primary goal of early work was to develop indicator species to measure contaminant risks to wildlife and ecosystem health at various trophic levels, spatial scales, and levels of biological organization (e.g., cellular, organism, or

population). Ongoing studies focus on developing tests and metrics to measure the potential toxicological effects of contamination on aquatic life. The Exposure and Effects Workgroup also supports the Status and Trends components of the RMP.

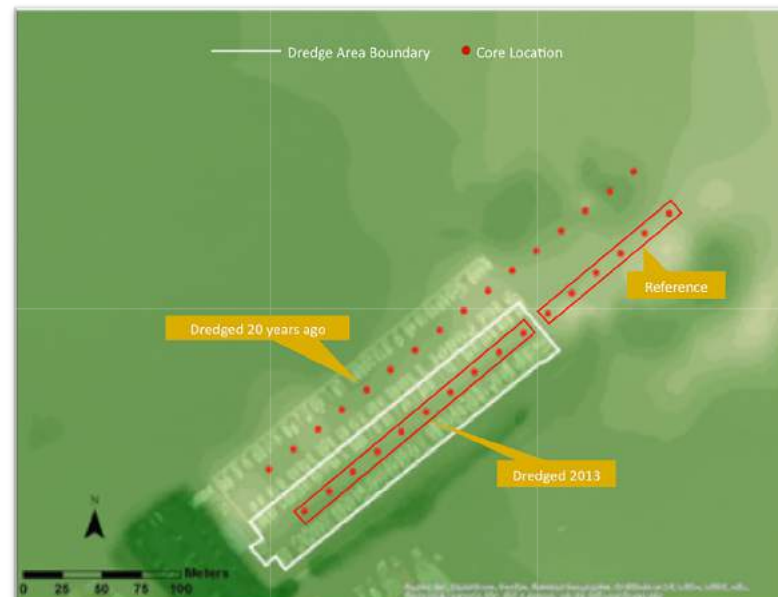
### USES OF RMP EXPOSURE AND EFFECTS DATA FOR MANAGEMENT DECISIONS

- Implementation of narrative water quality objectives for toxicity, bioaccumulation, and aquatic organisms population and community ecology
- Implementation of sediment quality objectives
- Permitting decisions regarding dredging projects
- Contaminated sediment 303(d) listing and delisting decisions

### RELATION TO PERMIT REQUIREMENTS

2011 Programmatic Essential Fish Habitat Agreement:

- PCBs TMDL In-Bay Disposal Limits
- Mercury TMDL In-Bay Disposal Limits



Sampling scheme for one study area (Richardson Bay Marina) in the "Assessing the Impacts of Periodic Dredging on Benthic Habitat Quality" project.

## PRIORITY QUESTIONS

- 1 What are the spatial and temporal patterns of impacts of sediment contamination?
- 2 Which pollutants are responsible for observed impacts of sediment contamination?
- 3 Are the toxicity tests, benthic community assessment approaches, and overall Sediment Quality Objectives (SQO) assessment framework reliable indicators of impacts?
- 4 Do spatial patterns in bioaccumulation in birds indicate particular regions of concern?
- 5 What are appropriate thresholds of concern for contaminant concentrations in Bay fish species?

# EXPOSURE AND EFFECTS

## RECENT FINDINGS

- ● SGO analyses do not indicate severe impacts to benthos. SGO analyses of 125 RMP sites from 2008 to 2012 indicate that severe impacts to the benthic community are not observed in the Bay. Forty percent of the Bay was classified as Possibly Impacted, indicating that the impacts are small or uncertain due to conflicting lines of evidence.
- PBDE impacts to tern reproduction are unlikely. Tern embryos are less sensitive to PBDE exposure than the most sensitive species studied (American Kestrel). Reproductive and developmental effects on tern embryos at the concentrations found in the Bay do not appear likely.

- The site-specific objectives for copper in the Bay appear to be protective of migrating salmon. RMP studies conducted by NOAA indicate that even at very high concentrations of copper in seawater (> 100 ug/L), Chinook salmon's sense of smell is not impaired. For juvenile salmon, copper concentrations up to 50 ug/L did not have impacts on the olfactory system at salinities >10 ppt. No further work on this topic is planned.
- **Bioanalytical Tools:** A project funded by the RMP in 2013 and 2014 evaluated linkages between in vitro assays and in vivo endpoints that point to population level effects in estuarine fish. The study succeeded in establishing a linkage between in vitro estrogen assays and in vivo feminization of juvenile fish, but further work is needed to better quantify the relationship.

- ● Amphipod sediment toxicity tests can be affected by grain size. Laboratory studies showed that clay has size-specific mortality effects on the amphipod species used in RMP sediment toxicity testing. Larger amphipods appear to be more sensitive to clay particles. In 2016, additional studies using sediment samples from the Bay confirmed these findings. Future RMP sediment toxicity testing will focus on smaller amphipods to minimize this effect.

## WORKPLAN HIGHLIGHTS

- ● **Assessing the Impacts of Periodic Dredging on Benthic Habitat Quality:** The objective of this effort is to assess the quality of benthic assemblages from a fish forage standpoint, in areas that are periodically dredged in the Central Bay compared to non-dredged areas. A literature review will be conducted regarding fish feeding and benthic invertebrate assemblages and a field study design will be developed. The project is co-funded by the RMP and the Long Term Management Strategy for Dredging.

- Additional work in 2017 will better quantify the relationship between in vitro estrogenicity assays and in vivo feminization of juvenile fish, and will also demonstrate the utility of the estrogenicity assay as a screening tool for Bay water and sediment.

## COLLABORATORS

- Southern California Coastal Water Research Project
- UC Davis – Granite Canyon
- University of Florida
- US Geological Survey – Western Ecological Research Center
- US Army Corps of Engineers
- Bay Conservation and Development Commission
- National Oceanic and Atmospheric Administration - Northwest Fisheries Science Center



# DIOXINS

## BACKGROUND

San Francisco Bay was placed on the State of California's 303(d) list of impaired waterways in 1998 as a result of elevated concentrations of dioxins and furans (commonly referred to as only 'dioxin') in fish. RMP studies of contaminants in Bay sport fish conducted

since 1994 have found that dioxin concentrations have remained relatively unchanged over this time period and, in some species, continue to exceed screening values for human consumption. Our understanding of dioxin in the Bay is extremely limited, and improving

this knowledge is a necessary first step in the process to reduce concentrations in Bay fish and resulting health risks to humans and wildlife.

### USES OF RMP DIOXIN DATA FOR MANAGEMENT DECISIONS

- Review 303(d) listings and establish TMDL development plan or alternative

### PRIORITY QUESTIONS

- 1 What is the dioxin reservoir in Bay sediments and water?
- 2 Have dioxin loadings or concentrations changed over time?
- 3 What is the relative contribution of each loading pathway as a source of dioxin impairment in the Bay?

### RELATION TO PERMIT REQUIREMENTS

The Dioxin Strategy is generating the information needed to support development of appropriate effluent limits for municipal and industrial discharges.

# DIOXINS

## RECENT FINDINGS

- The key sport fish indicator species (shiner surfperch and white croaker) have higher tissue levels than the Water Board screening value of 0.14 ppt and show no sign of decline, but there is a great deal of uncertainty regarding the human health risk associated with dioxins in sport fish.
- Dioxin toxic equivalents in Least Tern, Caspian Tern, and Forster's Tern eggs are at or above estimated thresholds for adverse effects; risks are especially significant in combination with dioxin-like PCBs.
- Wetland sediment cores suggest rapidly declining inputs from local watersheds during recent decades, although additional coring data are needed to support this hypothesis.
- Recent monitoring of open Bay water and sediment did not show patterns suggesting large localized sources of dioxins in different areas of the Bay, although it is unknown whether some margin areas may be disproportionately affected.
- Few data on dioxins are available on other priority questions - the Dioxin Strategy was developed to address this need.

## WORKPLAN HIGHLIGHTS

- Activities are planned for 2017 to summarize and synthesize results of monitoring conducted between 2008 and 2011 in response to information needs identified in the 2004 Dioxin Conceptual Model and Impairment Assessment report, and prioritized by the RMP Dioxin Workgroup.

Fishing on the Bay. Photograph by Shira Bezael.



## COLLABORATORS

- Bay Area Clean Water Agencies
- AXYS Analytical



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