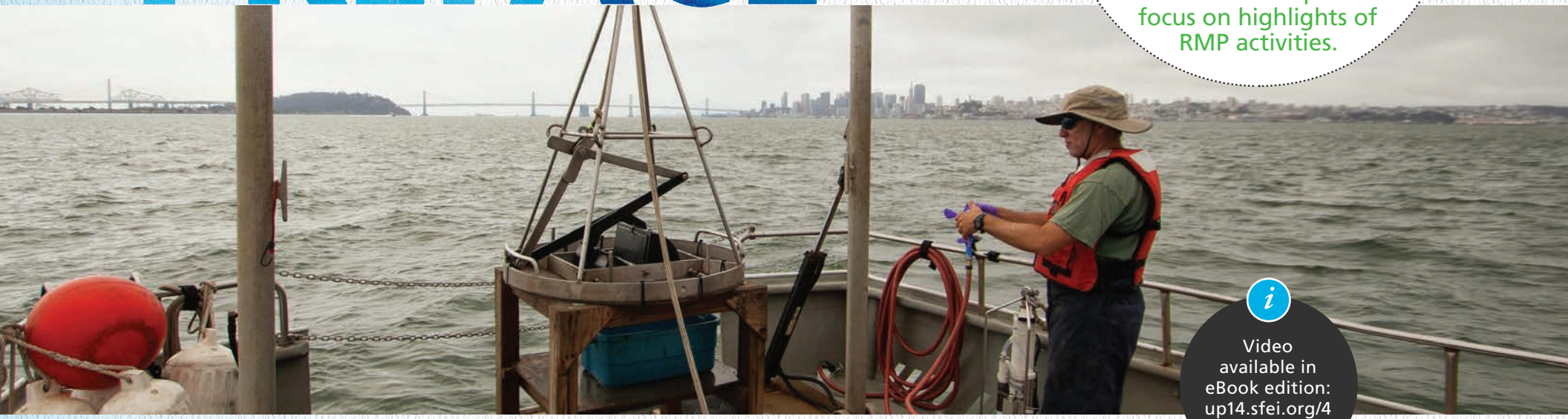
RMP UPDATE 2014

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

PREFACE

Note to *Pulse* 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.



Video available in eBook edition: up14.sfei.org/4

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.

The sediment sampling cruise. Photograph by Thomas Jabusch.

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:

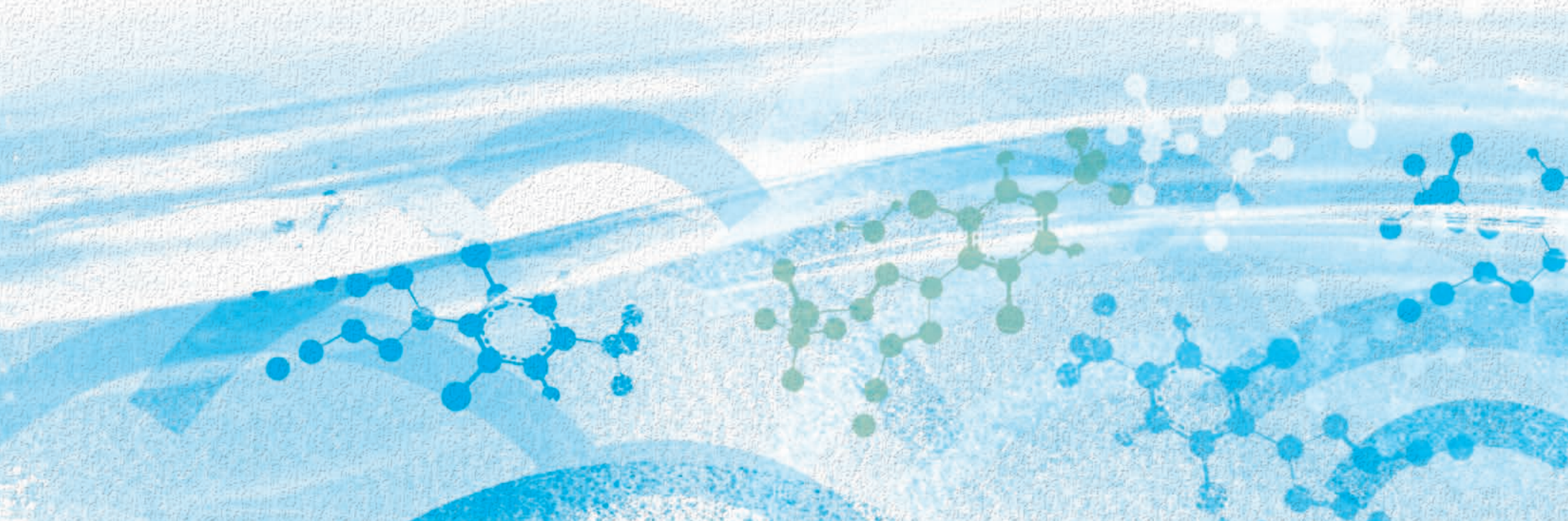
- a brief summary of some of the most note-worthy findings of this multifaceted Program;
- a description of the management context that guides the Program;
- a summary of progress in and plans for addressing priority water quality topics; and
- the latest monitoring results and updated trend plots for key pollutants, water quality indicators, or factors that influence water quality.

TABLE OF CONTENTS

New for 2014: an eBook version featuring interactive elements, indicated by the *i* symbol.

Glossary of Acronyms on Page 54

PROGRAM HIGHLIGHTS



RMP HIGHLIGHTS: PRESENT AND FUTURE

The Regional Monitoring Program for Water Quality in San Francisco Bay (RMP) is a multi-faceted collection of studies and activities. The RMP must consider thousands of contaminants, the many different types of information needed to manage all of these substances, and a myriad of policies to address potential impacts on various beneficial uses of the Bay. This section of the RMP Update provides brief summaries of some of the most noteworthy recent RMP activities and accomplishments, followed by a look ahead to anticipated highlights over the next few years.

Ponar grab sediment sampler. Photograph by Thomas Jabusch.

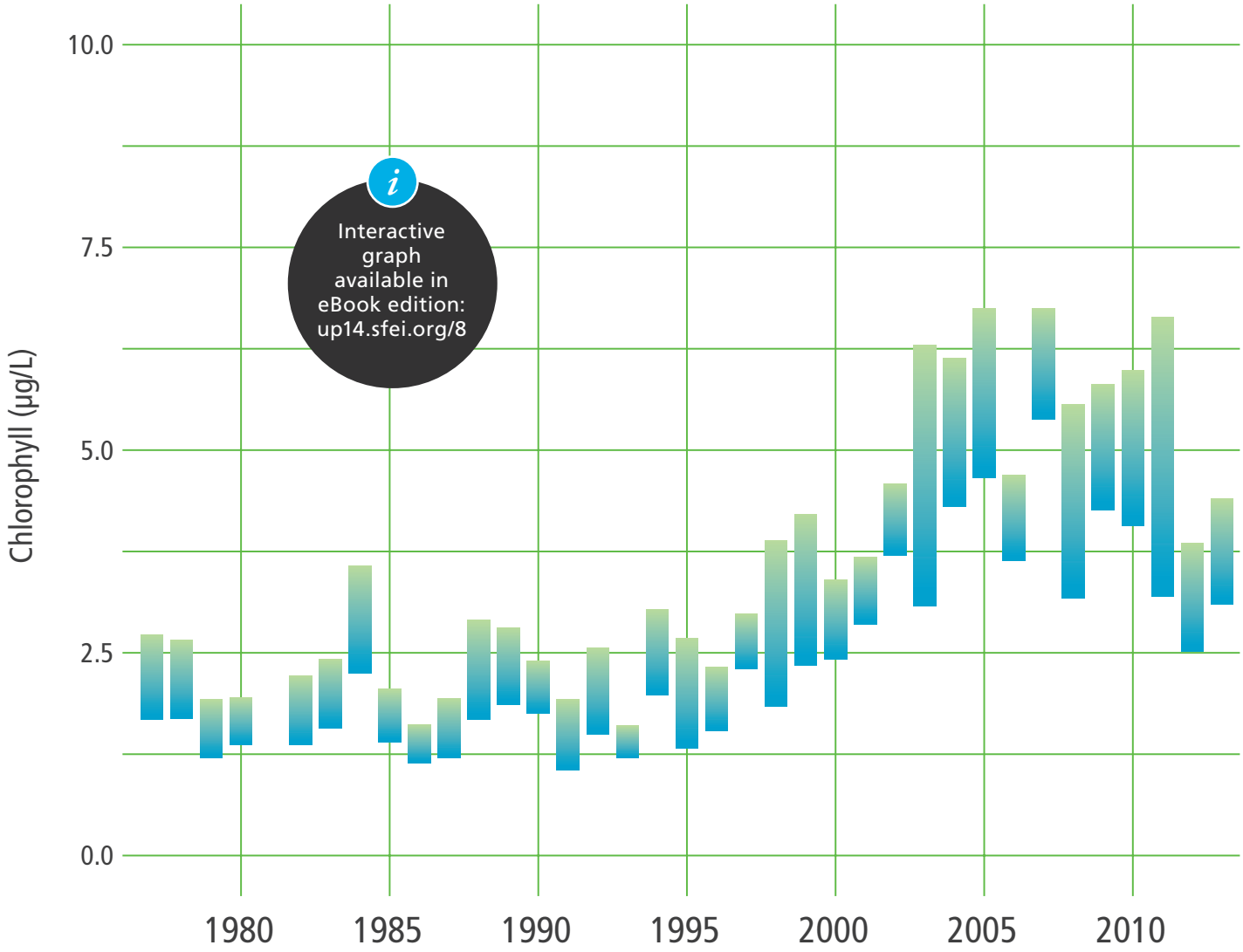
THE RMP TOP TEN: RECENT ACTIVITIES AND ACCOMPLISHMENTS

1 Asessing the State of Knowledge on Bay Nutrients

Nutrients have become one of the Bay's highest priority management issues over the past several years, as USGS monitoring data, funded in part by the RMP, signaled changes in the ecosystem's sensitivity to its high nutrient concentrations. The RMP, convened a team of regional and national experts to identify key science and data gaps related to nutrients and ecosystem response in the Bay. The resulting report presented a series of conceptual models extending from nutrient loads and cycling to ecosystem response; identified high priority science questions, based on current conditions and future scenarios; and put forward a set of recommendations for monitoring activities, special studies, and modeling work targeted to inform management decisions. SFEI staff also completed a RMP-funded study that estimates nutrient loads to the Bay's main subembayments. On a Bay-wide annual-average basis, nitrogen and phosphorus loads come from wastewater treatment plant effluent (65%), inflow from the Delta (20%), and stormwater (15%), respectively. The relative importance of these pathways varies substantially both seasonally and spatially.

2 Moored Sensors: A New Chapter in RMP Water Monitoring

While monitoring has occurred regularly in the Bay over the past 40 years, most of the data have been collected at weekly or monthly time intervals. Phytoplankton, nutrients, dissolved oxygen, and other parameters such as suspended sediment (which dictates the light available for phytoplankton



The middle range (between the 25th and 75th percentiles) of annual chlorophyll concentrations in the South Bay in late summer. The increase from 1995 to 2005 raised concern that the Bay's historic resilience to high nutrient concentrations may be weakening.

growth) vary strongly over much shorter time scales (e.g., on an hourly basis) due to the daily cycle of photosynthesis and respiration in phytoplankton, mixing, biogeochemical processes, and tides. To better assess the Bay's condition, and to collect high-frequency data to calibrate water quality models, the RMP is funding a moored sensor network. Beginning in summer 2013, sensors for chlorophyll, dissolved oxygen, turbidity, temperature, and other parameters were deployed at three stations in Lower South Bay and South Bay. In collaboration with the USGS sediment group, SFEI staff deployed sensors at locations where USGS has been performing sensor-based monitoring for 20 years. From the site at Dumbarton Bridge, data collected every 15 minutes are transmitted to SFEI, which allow for viewing data in near-real time. Activities in 2014 include data analysis and calibration, on-going maintenance, and expanding the effort by including additional parameters (e.g., nitrate) and potentially one new station.

3 Algal Toxins in the Bay

Algae species that form harmful algal blooms, or HABs, can produce potent toxins that substantially impact both aquatic life and humans. The RMP is funding work by USGS, UCSC, and SFEI to quantify algal toxins in the Bay. Although no full blooms have been noted in the Bay over the past few decades, potentially harmful species are commonly detected in low numbers. The common presence of seed organisms and the Bay's abundant nutrients mean that harmful algal blooms could develop when appropriate physical conditions occur (e.g., stratification, warm temperature), as evidenced by a fall 2004 red tide bloom in South Bay. Moreover, a 2011-2012 USGS-UCSC pilot study found that the toxins domoic acid and microcystin were commonly detected throughout the Bay. The RMP is contributing funds to continue that work, including monthly samples for 2013-2014. The analysis of samples from 2013 is complete and a report summarizing results for 2013-2014 is expected by December 2014.

4 Small Tributary Loading: Completion of One Five-Year Plan, On To the Next

In 2009, the Water Board issued the Municipal Regional Stormwater Permit (MRP). Stormwater management and monitoring activities prescribed by the first term of the MRP from 2009 to 2014 were supported by data and information generated by the RMP under the oversight of the Small Tributary Loading Strategy Team (STLST) and Sources Pathways and Loadings Workgroup (SPLWG), which augmented extensive non-RMP work performed by the counties included in the Permit. The RMP funded a reconnaissance study, which supported the initiation of six fixed station loading studies that were deemed priorities for obtaining baseline information for measuring trends in loading. In addition, the RMP funded the development of the Regional Watershed Spreadsheet Model as a tool for estimating loads at regional and sub-regional scales, along with work to better understand source areas in the watersheds (GIS layer development) and loading coefficients associated with each of the source areas. The SPLWG and STLST have been developing a strategic plan for RMP support of activities over the course of the next MRP five-year term. A synthesis report to document progress to date in answering priority questions relating to stormwater management will be a valuable step in this direction.

5 PCBs: Moving to the Margins

The RMP developed a PCB Strategy in 2009 that led to two studies to begin addressing priority management questions. The first was a small fish monitoring effort that revealed surprisingly high concentrations of PCBs in food webs in several areas on the Bay margins. The second study was a synthesis and conceptual model update that shifted focus from the open Bay to the contaminated areas on the margins where impairment is greatest, where load reductions are being pursued, and where reductions in impairment, in response to load reductions, would be most apparent. The Synthesis was the foundation for a 2014 update of the PCB Strategy that calls for a multi-year effort to identify margin areas that are high priorities for management and monitoring, develop site-specific conceptual models and sediment mass balances for margin areas downstream of watersheds where management actions will occur, and perform monitoring in these areas as a performance measure. A thorough and thoughtful effort is warranted given the large expenditures of resources that will be needed to implement management actions to reduce PCB loads from urban stormwater.

6 A Proactive Approach for Emerging Contaminants

In 2013, the RMP published a summary of the state of knowledge on emerging contaminants in the Bay, followed by a strategy for investigations over the next several years.

Tiered Framework for Managing and Monitoring CECs in San Francisco Bay

TIER ASSIGNMENTS	MANAGEMENT	MONITORING
No CECs currently in this tier	303(d) listing TMDL or alternative management plan. Aggressive control actions for all controllable sources	Studies to support TMDL or an alternative management plan

PFOS Fipronil Nonylphenol and nonylphenol ethoxylates PBDEs	Action plan or strategy Aggressive pollution prevention Low-cost control actions	Consider including in Status and Trends Monitoring Special studies of fate, effects, and sources, pathways, and loadings

HBCD Pyrethroids * Pharmaceuticals and personal care products PBDDs and PBDFs	Low-cost source identification and control Low-level pollution prevention Track product use and market trends	Discontinue screening, or periodically screen in water, sediment, or biota Periodic screening in wastewater effluent or urban runoff to track trends

Alternative flame retardants Pesticides Plasticizers Many, many others	Identify and prioritize contaminants of potential concern, track international efforts Develop targeted and non-targeted analytical methods	Screening in water, sediment, biota, wastewater effluent, urban runoff

* *Pyrethroids are of low concern in the Bay, but high concern in Bay Area urban creeks*

Both documents are rich resources useful to scientists and managers working locally and statewide to protect water quality.

The RMP's emerging contaminants strategy consists of three major elements. First, for contaminants known to occur in the Bay, the RMP evaluates relative risk using a tiered framework. This risk-based framework guides future monitoring and management for each of these contaminants.

The second element of the strategy involves review of scientific literature and other aquatic monitoring programs to identify new contaminants of potential concern for which no Bay data yet exist. Initial monitoring to establish the presence of these chemicals in the Bay is conducted to evaluate the risks they may pose.

The third element of the strategy consists of non-targeted monitoring. The RMP has launched two non-targeted monitoring projects: a) broadscan analyses of Bay biota to detect previously unidentified contaminants; and b) development of bioanalytical tools that detect estrogenic chemicals.

7 PBDEs: RMP Data Show that Phase-outs and Bans Lead to a Cleaner Bay

California has unique consumer product flammability standards. Polybrominated diphenyl ether (PBDE) flame retardants were once widely incorporated into products to meet these standards, but concerns over toxicity and accumulation in human and wildlife led to nationwide phase-outs and state bans.

A decade of PBDE monitoring by the RMP has resulted in a dataset covering periods during and after peak PBDE use, and consisting of hundreds of measurements of water, sediment, and aquatic organisms. PBDE levels in aquatic organisms have declined dramatically. In sediment, concentrations of BDE-47 have also dropped, but the dominant PBDE compound in sediment, BDE-209, has shown no sign of decline. U.S. production of BDE-209 ended in 2013; future monitoring may reveal declines.

Overall, RMP data indicate that reduced PBDE production resulted in relatively rapid declines in concentrations of these contaminants. These findings were published as a RMP technical report and submitted for publication in Environmental Science and Technology, a leading scientific journal.

8 Alternatives to PBDEs: Tracking Flame Retardants Still In Use

Following PBDE phase-outs and bans, manufacturers began to substitute alternative flame retardants in their products to meet California's unusual flammability standards. Little is known about many of the bromine-, chlorine-, and phosphate-containing compounds that have replaced PBDEs. Some of these chemicals have been in use for decades, while others are new. Some exhibit significant aquatic toxicity or endocrine-disrupting properties.

In 2013 and 2014, RMP scientists collected samples of Bay water and sediment, stormwater, treated wastewater, harbor seal blubber, and bivalves for analysis of an array of alternative flame retardants. Levels will be compared to effects thresholds that exist for a few of these compounds. However, for most of these chemicals, the risks are unknown. Earlier RMP pilot studies have detected some of these contaminants in Bay water, sediment, and biota.

Starting in 2014, changes to California's flammability standards may lessen the use of flame retardants in some consumer goods, and therefore possibly reduce contamination in the Bay.

9 Science Forum to Support Management of Methylmercury in Restored Tidal Marshes

The RMP sponsored a forum in December 2013 to review available information and data gaps relating to managing methylmercury in restored tidal marshes in the Bay. A primary goal was to promote consensus on the best approaches for monitoring methylmercury and for using monitoring data in decision-making. The following are some of the key conclusions of the forum.

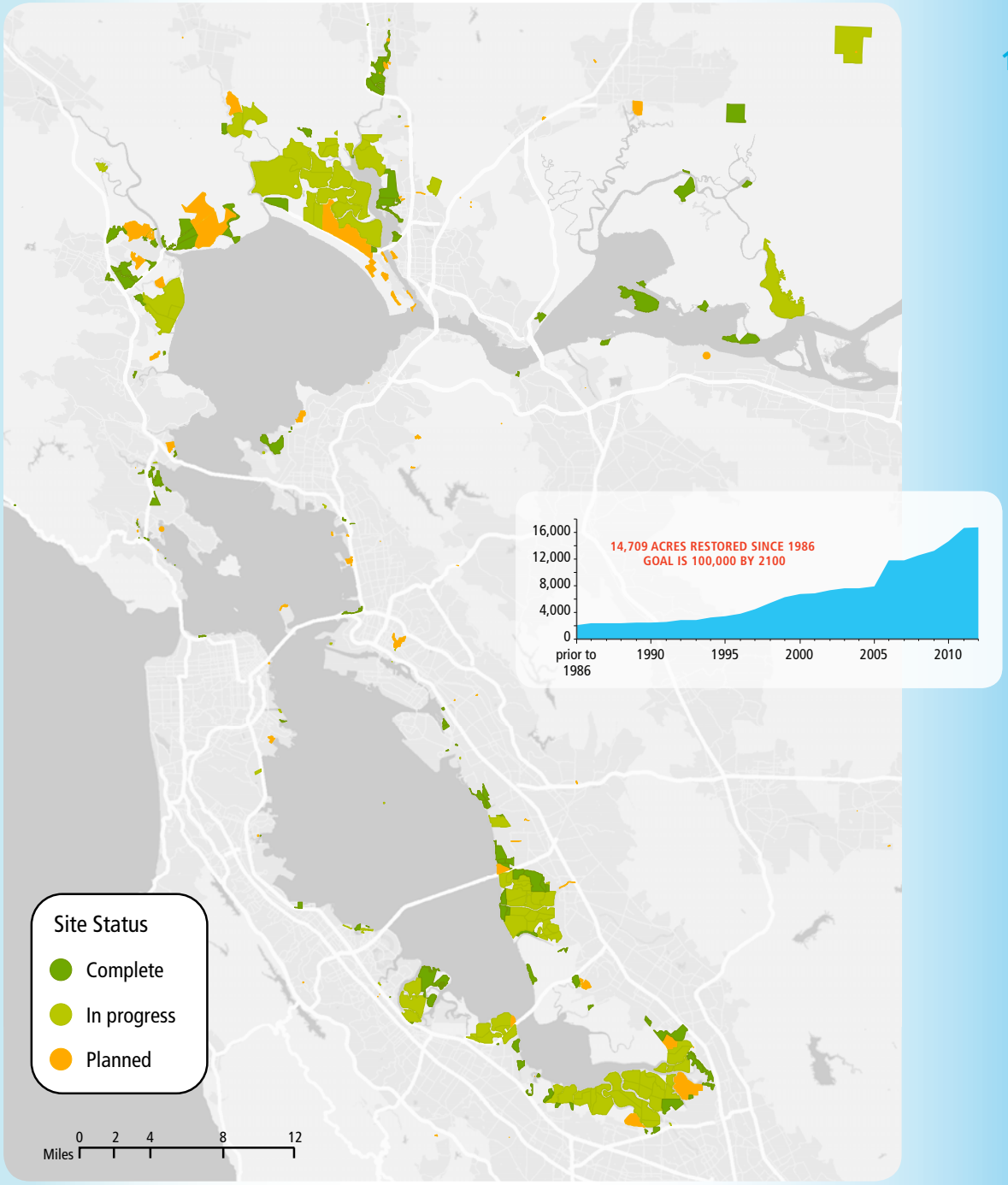
- Increases in methylmercury are most likely in the year or two following restoration. Additional longer-term monitoring is needed to assess the potential for elevated methylmercury at later stages of restoration.
- On a regional-scale, methymercury increases in bay biota are far less likely to be detectable than increases that could occur within an individual restoration site. However, the potential regional-scale effect of existing and planned projects in aggregate is a concern.
- There was support for a regional approach to monitoring, with some sites selected for detailed investigation. Biosentinel monitoring should be used to track status and trends and generate

hypotheses, and process studies should be used to test hypotheses and gain mechanistic understanding.

- Continued research and pilot studies may identify design features for some sites that minimize methylmercury accumulation in the food web.

10 Optimizing Status and Trends Monitoring

A continuing challenge for the RMP is determining how to make optimal use of the funds that participants provide to the Program. High priority topics continue to emerge (e.g., nutrients and selenium), and information needs continue to grow. Status and trends monitoring of open Bay waters is a cornerstone of the Program, but after 20 years of repeated sampling the information yield has gradually diminished. Starting in 2014, monitoring to evaluate open Bay status and trends will be conducted at a reduced frequency of sampling for selected parameters in the various matrices sampled (water, sediment, mussels, fish, and bird eggs) where it is warranted. As one example, PCBs in water, an expensive parameter to analyze, will now be analyzed once every 10 years - commensurate with the value of additional water PCB data in promoting understanding and supporting decision-making. Other matrices that are more crucial for PCBs, such as sport fish, bird eggs, and sediment, will continue to be monitored at a higher frequency. This belt-tightening will free up resources that can be applied to higher priority information needs, such as sampling of water and sediment on the shallow margins of the Bay, which have historically not been included in status and trends monitoring.



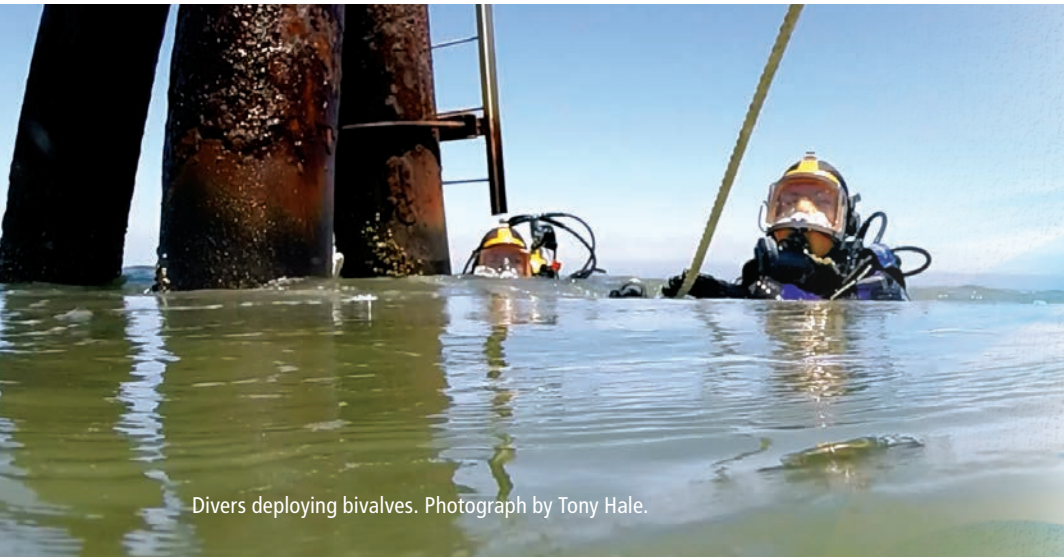
San Francisco Bay Tidal Marsh Restoration. Marsh restoration may cause local or regional increases in methylmercury in the food web. From the EcoAtlas (www.ecoatlas.org).

COMING ATTRACTIONS

1 Nutrient Model
The RMP convened experts in 2013 and 2014 to advise on developing the region's approach to nutrient modeling. Modeling work will commence in Fall 2014.

2 Nutrient Monitoring Program Design
The recent focus on nutrients in the Bay has identified important data gaps, and efforts are underway to develop an optimized nutrient monitoring program to address those gaps. (2015)

3 Alternative Flame Retardants
Monitoring dozens of members of this diverse group of chemicals in Bay water and sediment, stormwater, and treated wastewater, as well as mussels and harbor seals. (2015)



Divers deploying bivalves. Photograph by Tony Hale.

4 Bioanalytical Tools Report
This project is examining links between endocrine-disrupting activity in cell-based assays and reproductive effects in assays with fish. The ultimate goal is to develop a tool for screening for a class of endocrine-disrupting compounds that share a common mode of toxic action. (2015)

5 PFOS in Bay Fish and Wildlife
A summary of RMP monitoring of this emerging contaminant that may pose a risk for Bay birds and seals. PFOS continues to be detected in cormorant eggs and harbor seals, particularly in the South Bay. (2014)

6 Small Tributary Loading Synthesis Report
A report documenting progress from small tributary studies over the past five years and synthesizing available information to support monitoring needs in WY 2016 and beyond. (2015)

7 Sport Fish Survey and Sturgeon Monitoring
The RMP measures contaminants in Bay sport fish on a five year cycle. A special study in 2014 will pilot a nonlethal method of sampling that promises to greatly increase the dataset on selenium in sturgeon. A report on the sampling conducted in 2014 will be completed in early 2016.

8 Further Evaluation of Effects of Copper on Salmon
The RMP, in partnership with the Copper Development Association, has funded studies evaluating the effect of copper on the olfactory response of juvenile salmon. (2015)

9 Upgraded RMP Contaminant Data Display and Download (CD3)
An improved user interface for accessing RMP data is in development, providing more options for obtaining statistics, maps of contaminant distributions, and data files. (2014)

10 Bay Margins Monitoring
RMP sediment sampling to date has been conducted on vessels that cannot access waters less then 1 meter in depth at mean lower low water, excluding a large and ecologically important area. A sampling plan to address this information gap is in development. (2014)

RECENT PUBLICATIONS

Journal Publications

Reducing methylmercury accumulation in the food webs of San Francisco Bay and its local watersheds. Davis. 2012. Environmental Research. http://www.sfei.org/documents/reducing-methylmercury-accumulation-food-webs-san-francisco-bay-and-its-local-watersheds

Benthic macrofaunal assemblages of the San Francisco Estuary and Delta, USA. Thompson. 2012. Environmental Monitoring Assessment. http://www.sfei.org/documents/benthic-macrofaunal-assemblages-san-francisco-estuary-and-delta-usa

Adjustment of the San Francisco estuary and watershed to decreasing sediment supply in the 20th century. Schoellhamer. 2013. Marine Geology. http://www.sfei.org/documents/adjustment-san-francisco-estuary-and-watershed-decreasing-sediment-supply-20th-century

Comparative embryotoxicity of a pentabrominated diphenyl ether mixture to common terns (Sterna hirundo) and American kestrels (Falco sparverius). Rattner. 2013. Chemosphere. http://www.sfei.org/documents/comparative-embryotoxicity-pentabrominated-diphenyl-ether-mixture-common-terns-sterna-hiru

Comparison of sediment supply to San Francisco Bay from watersheds draining the Bay Area and the Central Valley of California. McKee. 2013. Marine Geology. http://www.sfei.org/documents/comparison-sediment-supply-san-francisco-bay-watersheds-draining-bay-area-and-central-vall

Method validation and reconnaissance of pharmaceuticals, personal care products, and alkylphenols in surface waters, sediments, and mussels in an urban estuary. Klosterhaus. 2013. Environment International. http://www.sfei.org/documents/method-validation-and-reconnaissance-pharmaceuticals-personal-care-products-and-alkylpheno

Predictors of Mercury Spatial Patterns in San Francisco Bay Forage Fish. Greenfield. 2013. Environmental Toxicology and Chemistry. http://www.sfei.org/documents/predictors-mercury-spatial-patterns-san-francisco-bay-forage-fish

Seasonal and annual trends in forage fish mercury concentrations, San Francisco Bay. Greenfield. 2013. Science of the Total Environment. http://www.sfei.org/documents/seasonal-and-annual-trends-forage-fish-mercury-concentrations-san-francisco-bay

Seasonal variations in suspended-sediment dynamics in the tidal reach of an estuarine tributary. Downing-Kunz. 2013. Marine Geology. http://www.sfei.org/documents/seasonal-variations-suspended-sediment-dynamics-tidal-reach-estuarine-tributary

A sediment budget for the southern reach in San Francisco Bay, CA: Implications for habitat restoration. Shellenbarger. 2013. Marine Geology. http://www.sfei.org/documents/sediment-budget-southern-reach-san-francisco-bay-ca-implications-habitat-restoration

Sediment transport in the San Francisco Bay Coastal System: An overview. Barnard. 2013. Marine Geology. http://www.sfei.org/documents/sediment-transport-san-francisco-bay-coastal-system-overview

The use of modeling and suspended sediment concentration measurements for quantifying net suspended sediment transport through a large tidally dominated inlet. Erikson. 2013. Marine Geology. http://www.sfei.org/documents/use-modeling-and-suspended-sediment-concentration-measurements-quantifying-net-suspended-s

Polychlorinated biphenyls in the exterior caulk of San Francisco Bay Area buildings, California, USA. Klosterhaus. 2014. Environment International. http://www.sfei.org/documents/polychlorinated-biphenyls-exterior-caulk-san-francisco-bay-area-buildings-california-usa

RMP Technical Reports

CECs in the San Francisco Estuary: Alkylphenol Ethoxylates. Klosterhaus. 2012. http://www.sfei.org/documents/contaminants-emerging-concern-san-francisco-estuary-alkylphenol-ethoxylates

Pollutants of Concern (POC) Loads Monitoring Data, Water Year (WY) 2011. McKee. 2012. http://www.sfei.org/documents/pollutants-concern-poc-loads-monitoring-data-water-year-wy-2011

Pollutant Monitoring in the North Richmond Pump Station: A Pilot Study for Potential Dry Flow and Seasonal First Flush Diversion for Wastewater Treatment. Hunt. 2012. http://www.sfei.org/documents/pollutant-monitoring-north-richmond-pump-station-pilot-study-potential-dry-flow-and-season

Estimation of Loads of Mercury, Selenium, PCBs, PAHs, PBDEs, Dioxins, and Organochlorine Pesticides from the Sacramento-San Joaquin River Delta to San Francisco Bay. David. 2012. http://www.sfei.org/documents/estimation-loads-mercury-selenium-pcbs-pahs-pbdes-dioxins-and-organochlorine-pesticides-sa

Conceptual Foundations for Modeling Bioaccumulation in San Francisco Bay. Melwani. 2012. http://www.sfei.org/documents/conceptual-modeling-bioaccumulation-sf-bay

Contaminants of Emerging Concern in the San Francisco Estuary: Carbamazepine. Allen. 2012. http://www.sfei.org/documents/contaminants-emerging-concern-san-francisco-estuary-carbamazepine

Applying Sediment Quality Objective Assessments to San Francisco Bay Samples from 2008-2012. Willis-Norton. 2013. http://www.sfei.org/documents/applying-sediment-quality-objective-assessments-san-francisco-bay-samples-2008-2012-0

Pollutants of Concern (POC) Loads Monitoring Data Progress Report: Water Years (WYs) 2012 and 2013. McKee. 2014. http://www.sfei.org/documents/poc-loads-monitoring-wys-2012-and-2013

Suisun Bay Ammonium Synthesis. Senn. 2014. http://www.sfei.org/documents/suisun-bay-ammonium-synthesis

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PBDEs in San Francisco Bay: A Summary of Occurrence and Trends. Sutton. 2014. http://www.sfei.org/documents/polybrominated-diphenyl-ethers-pbdes-san-francisco-bay-summary-occurrence-and-trends

Model Development Plan to Support Nutrient Management Decisions in San Francisco Bay. Senn. 2014. http://www.sfei.org/documents/model-development-plan-support-nutrient-management-decisions-san-francisco-bay

External Nutrient Loads to San Francisco Bay. Novick. 2014. http://www.sfei.org/documents/external-nutrient-loads-san-francisco-bay

RMP GOAL AND MANAGEMENT QUESTIONS

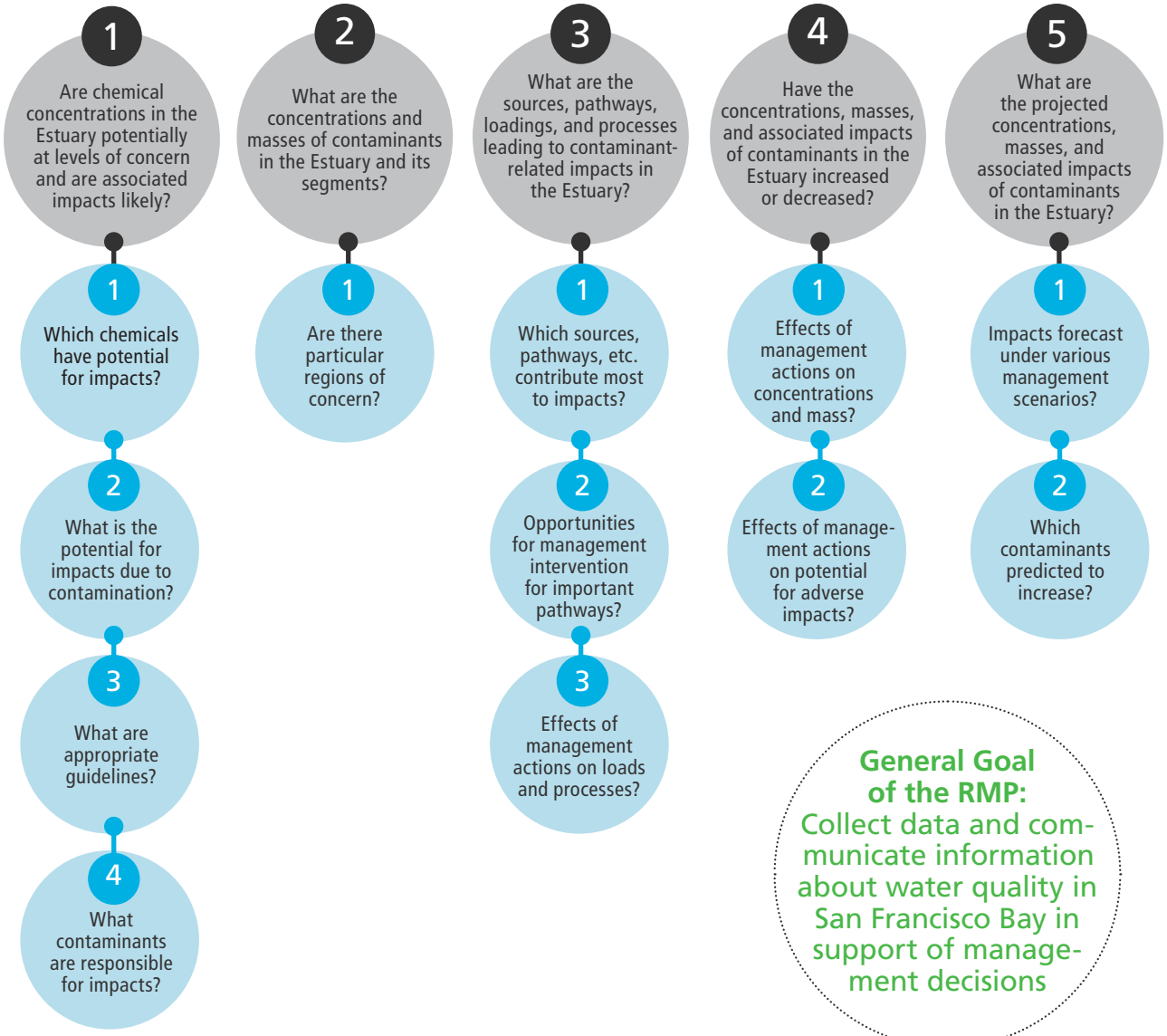
RMP stakeholders have articulated an overarching goal and a tiered framework of management questions that organize and guide RMP studies. The management questions are closely linked to existing and planned regulations.

Level 1

(Core) Management Questions

Level 2

Questions



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

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

- Addresses relevant NPDES permit requirements
- Supports policies and adaptive implementation
- Addresses scientific information needs

General Goal of the RMP: Collect data and communicate information about water quality in San Francisco Bay in support of management decisions

CURRENT AND ANTICIPATED MANAGEMENT DECISIONS, POLICIES, AND ACTIONS

The RMP contributes to effective management by providing scientific support for current policies and by anticipating and addressing information needs related to future policies and actions

DETERMINATION OF PERMIT LIMITS

LONG-TERM MANAGEMENT STRATEGY FOR PLACEMENT OF DREDGED MATERIAL/ DREDGED MATERIAL MANAGEMENT OFFICE

Regional Sediment Management Strategy

DREDGING PERMITS

Bioaccumulation testing triggers and in-Bay disposal levels

303(D) LIST AND 305(B) REPORT

COPPER

Evaluation of the site-specific objectives

Compare levels to triggers

CYANIDE

Compare levels to site specific objectives trigger

Evaluation of the site-specific objectives

SELENIUM

North Bay Selenium TMDL

South Bay Selenium TMDL

DIOXINS

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

MERCURY

Review existing TMDL and establish plan to revise

PCBS

Review existing TMDL and establish plan to revise

NUTRIENTS

Nutrient Management Strategy

Nutrient Water Quality Objectives

PATHOGENS

Review Bay beaches 303(d) listings and establish TMDL development plan

SEDIMENT HOT SPOTS

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

CONTAMINANTS OF EMERGING CONCERN

Review of RMP strategy

TOXICITY

New state plan on effluent and receiving water toxicity

SEDIMENT QUALITY OBJECTIVES

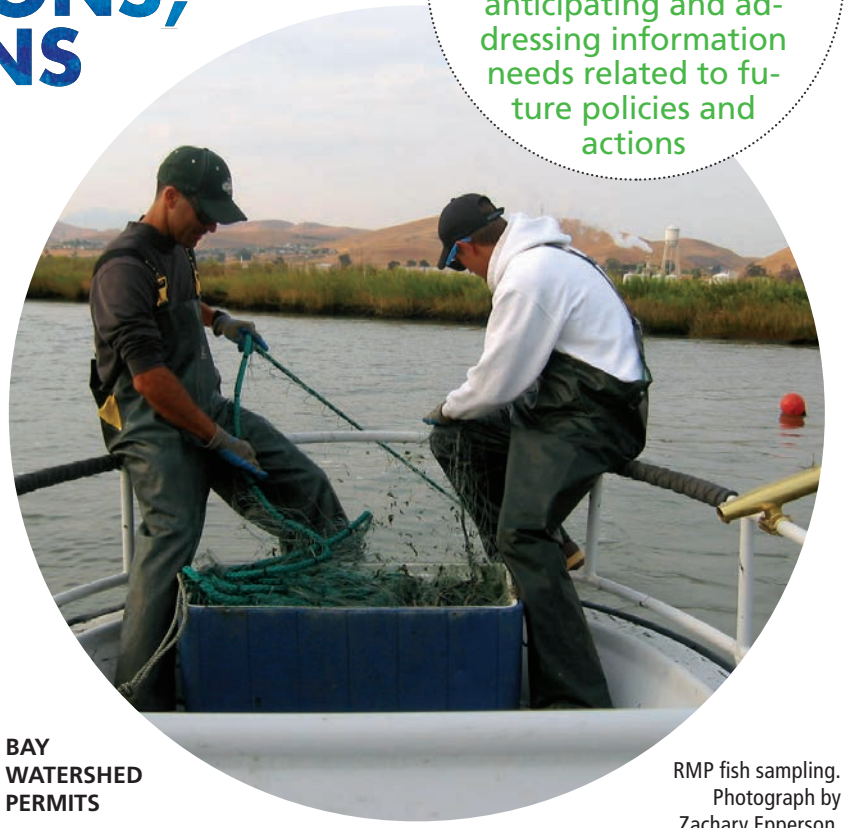
303(d) listings

Determination of reasonable potential and permit requirements

BAY WATERSHED PERMITS

Municipal Regional Stormwater Permit

Mercury and PCBs Watershed Permit for Municipal and Industrial Wastewater



RMP fish sampling. Photograph by Zachary Epperson.

THE 303(D) LIST

Section 303(d) of the 1972 Federal Clean Water Act requires that states develop a list of water bodies that do not meet water quality standards, establish priority rankings for waters on the list, and develop action plans, called Total Maximum Daily Loads (TMDLs), to improve water quality.

The list of impaired water bodies is revised every six years, with the next revision scheduled for 2016. The RMP is one of many entities that provide data to the State Water Board to compile the 303(d) List and to develop TMDLs. The process for developing the 303(d) List for the Bay includes the following steps:

- development of a draft List by the San Francisco Bay Regional Water Board;
- adoption by the State Water Board; and
- approval by USEPA.

In August 2010, the State Water Board adopted the 2010 303(d) List. The 2010 List was approved by USEPA.

The primary pollutants/stressors for the Estuary and its major tributaries on the 2010 303(d) List include:

Trace elements
Mercury and Selenium

Pesticides
Dieldrin, Chlordane, and DDT

Other chlorinated compounds
PCBs, Dioxin and Furan Compounds

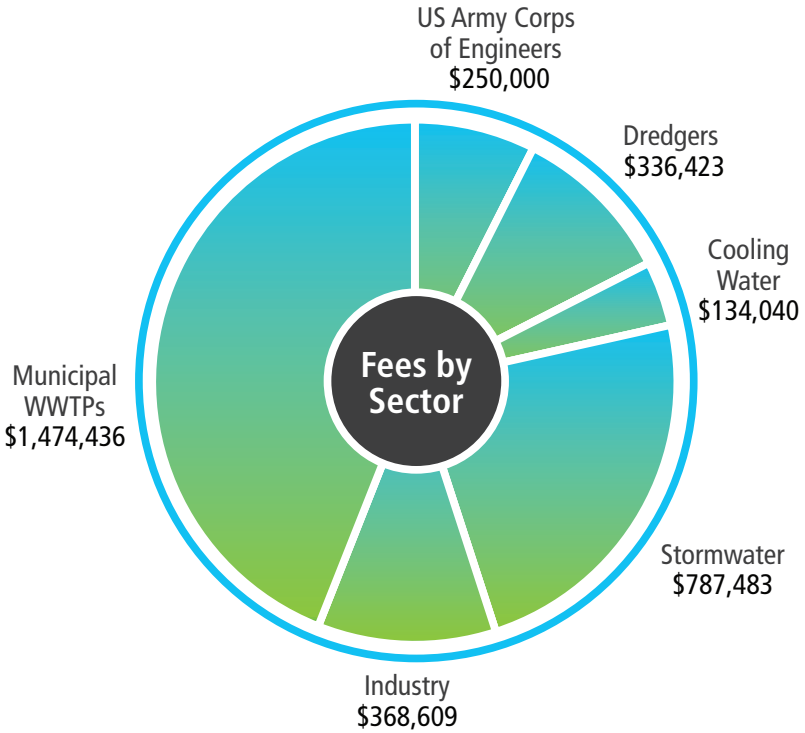
Others
Exotic Species, Trash, and Polycyclic Aromatic Hydrocarbons (PAHs)

REGULATORY STATUS OF POLLUTANTS OF CONCERN

Pollutant	Status
Copper	Site-specific objectives approved for entire Bay San Francisco Bay removed from 303(d) List in 2002
Dioxins / Furans	TMDL in early development stage
Legacy Pesticides (Chlordane, Dieldrin, and DDT)	Under consideration for delisting
Mercury	Bay TMDL and site-specific objectives approved in 2008 Guadalupe River Watershed TMDL approved in 2010
Pathogens	Richardson Bay TMDL adopted in 2008 Bay beaches (multiple listings); TMDL in early development stage
PCBs	TMDL approved in 2009
Selenium	TMDL in development for North Bay – completion projected for 2014/2015
Trash	Central and South Bay shorelines added to the 2010 303(d) List

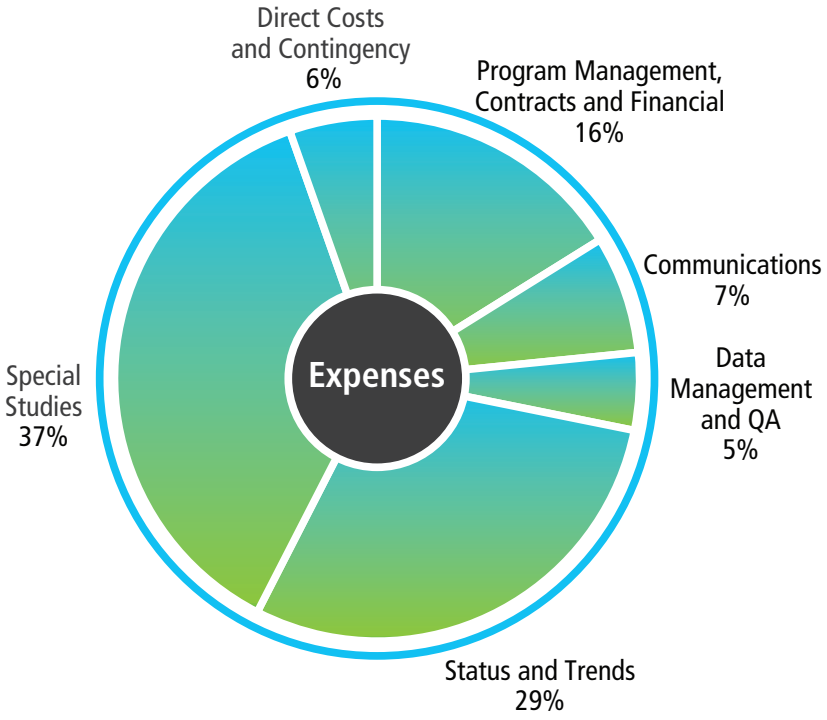
PROGRAM MANAGEMENT

RMP Fees by Sector: 2014



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

RMP Expenses: 2014



Special studies became the largest component of the RMP in 2012 due to efficiencies identified in the Status and Trends element.

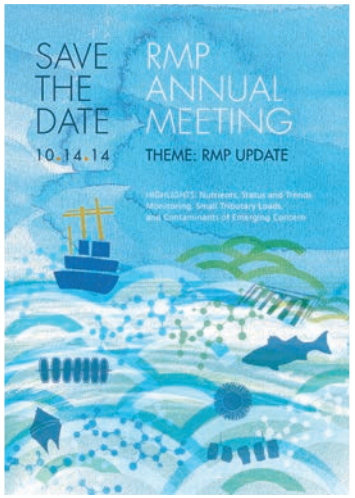
PROGRAM MANAGEMENT

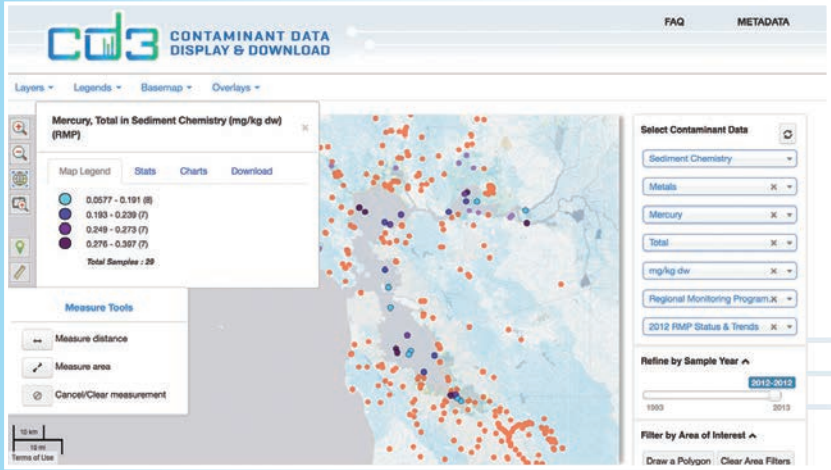
Communications

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

Program Management

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

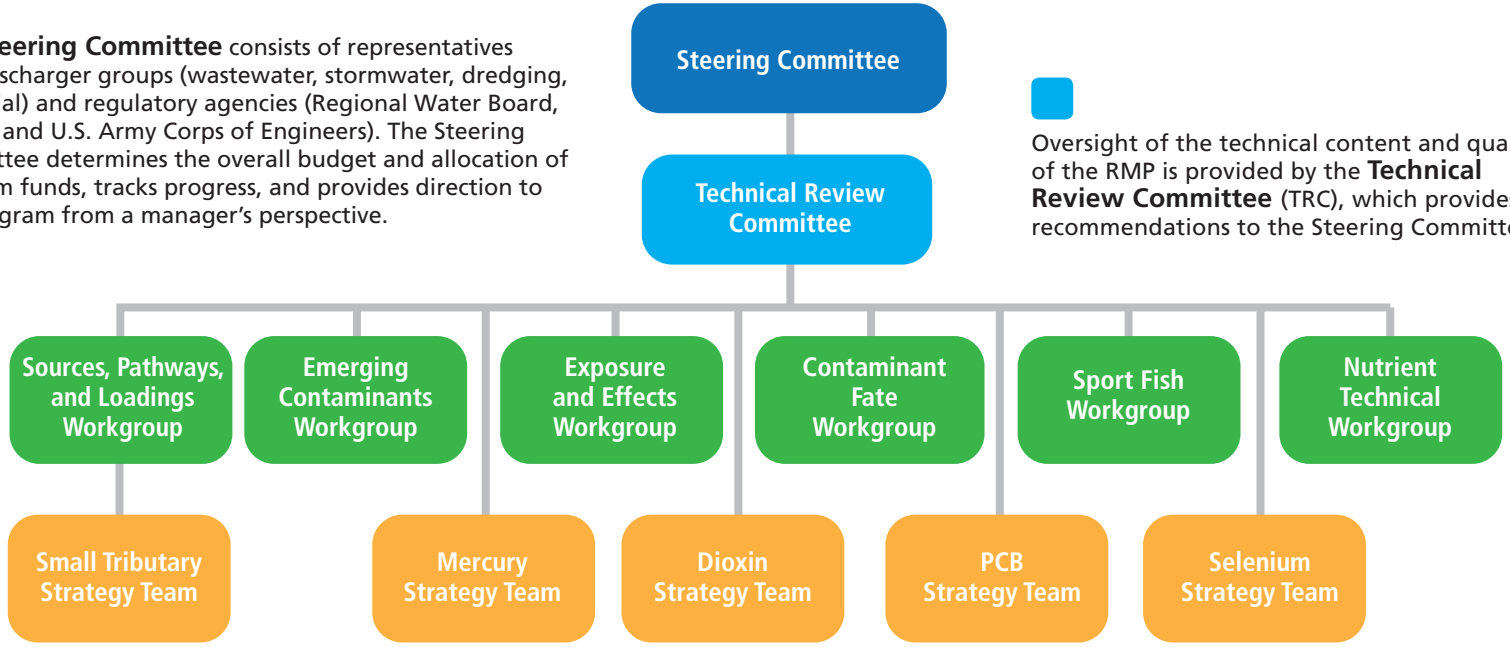
The RMP database contains approximately 1.1 million records generated since the Program began in 1993. Web-based data access tools include user-defined queries, data download and printing functionality, maps of sampling locations, and visualization tools.

CONTAMINANT DATA DISPLAY & DOWNLOAD

PROGRAM OVERSIGHT

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

The Steering Committee consists of representatives from discharger groups (wastewater, stormwater, dredging, industrial) and regulatory agencies (Regional Water Board, USEPA, and U.S. Army Corps of Engineers). The Steering Committee determines the overall budget and allocation of program funds, tracks progress, and provides direction to the Program from a manager's perspective.



Oversight of the technical content and quality of the RMP is provided by the **Technical Review Committee** (TRC), which provides recommendations to the Steering Committee.

Six **workgroups** report to the TRC and address the main technical subject areas covered by the RMP: sources, pathways, and loadings; contaminant fate; exposure and effects; emerging contaminants; sport fish contamination, and nutrients. The Nutrient Technical Workgroup was established as part of the committee structure of a separate effort - the Nutrient Science 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. Topics addressed to date include mercury, PCBs, dioxins, small tributary loads, and selenium.

PROGRAM AREA UPDATES

SMALL TRIBUTARY LOADING

Relevant Management Policies and Decisions

- Refining pollutant loading estimates for future TMDLs and management decisions, including TMDL updates.
- 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 the best management actions for reducing concentrations and loads.

Water quality sampling device in the North Richmond Pump Station. Photograph by Lester McKee.

Recent Noteworthy Findings

- Small tributaries are the dominant loading pathway for suspended sediment, PCBs, and mercury.
- PCB and mercury loads in stormwater are primarily associated with large storms and transport of suspended sediment particles.
- Greater PCB and mercury concentrations are associated with older urban and industrial land uses.
- PCB concentrations vary more widely in stormwater and soils relative to mercury because PCB uses were historically more localized and mercury more readily cycles to and from the atmosphere.
- Based on data collected at 24 locations so far, primarily using RMP funding, PCB concentrations on particles in stormwater are greatest in the watersheds of Pulgas Creek Pump Station (North and South), Santa Fe Channel and Ettie Street Pump Station. In addition, several samples indicate sources in the Sunnyvale East Channel watershed. This dataset is being collected as a primary indicator of pollution sources and will continue to grow each year.
- Stormwater agencies are pursuing PCB mitigation efforts in five pilot drainage areas in the cities of Richmond (Lauritzen and Parr Channels), Oakland (Ettie Street Pump Station), San Jose (Leo Avenue), and San Carlos (Pulgas Creek).
- The next MRP will continue to focus on reducing PCB loads in urban stormwater.

Note:
"Small tributary" refers to the rivers, creeks, and storm drains that enter the Bay

Priority Questions for the Next Five Years

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

SMALL TRIBUTARY LOADING

Workplan Highlights

- Monitoring of contaminant loads from representative watersheds (San Leandro Creek, Sunnyvale East Channel, Guadalupe River, Lower Marsh Creek, and Richmond and Pulgas Pump stations) was completed in April 2014 with a report due in fall 2014
- Ongoing regional-scale stormwater load estimation using the regional watershed spreadsheet model
- A synthesis report summarizing over 10 years of loading studies will support decisions associated with the next regional stormwater permit
- A characterization study is planned for the winter of 2014-15 to support identification of additional watersheds for management consideration, with a design that includes sampling of fine sediments using special settling chambers
- Development of a trend monitoring strategy in 2015

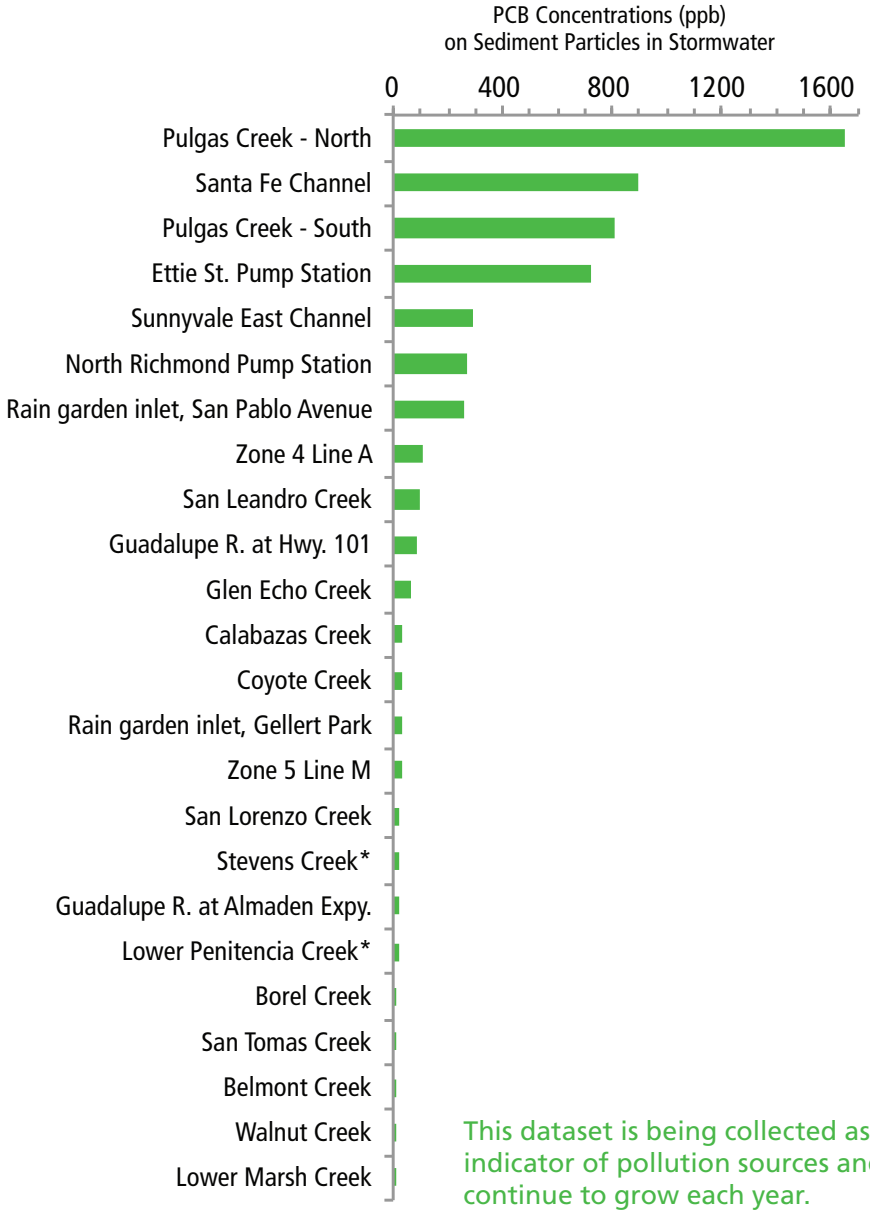
Partners and Coordination

This work is being closely coordinated with monitoring performed by:

- Bay Area Stormwater Management Agencies Association (representing the 76 cities, counties, and flood management districts covered by the Municipal Regional Permit)
- Santa Clara Valley Water District

Relation to Permit Requirements

The RMP-funded work partially satisfies monitoring requirements specified in the Municipal Regional Stormwater Permit



This dataset is being collected as a primary indicator of pollution sources and will continue to grow each year.

NUTRIENTS

Relevant Management Policies and Decisions

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

Recent Noteworthy Findings

- Several lines of evidence suggest that San Francisco Bay's resistance to the harmful effects of nutrient enrichment is weakening.
- Since the late 1990s, regions of the Bay have experienced significant increases in phytoplankton biomass (30-105% from Suisun to South Bay). Data from the last 3-4 years suggest biomass levels may be leveling off in South Bay.
- Observed biomass increases could be related to one or more factors, including: higher light levels from declining suspended sediments in the Bay and decreases in benthic grazers.
- Continuous sensor measurements at Dumbarton Bridge showed that DO concentration varies substantially with tides, with minimum DO occurring at lowest tide. During some periods, chlorophyll also showed strong tidal variations, with peaks at low tide.
- While DO in deep subtidal areas is typically above 5 mg/L, analysis of data in sloughs and creeks south of Dumbarton Bridge suggest that DO < 5 mg/L is a common occurrence at some sites.
- Although treated wastewater effluent is the greatest source of nitrogen and phosphorus south of the Bay Bridge, effluent loads to Suisun Bay are smaller than Delta loads to Suisun Bay.
- The phycotoxins (toxins produced by phytoplankton) domoic acid and microcystin are detected throughout the Bay.
  - Recent reports confirm a continued need for long-term status and trends monitoring of nutrients, and the need for greater effort directed toward phytoplankton composition, phycotoxins, high frequency measurements, and monitoring in Bay margins and sloughs.

i Video available in eBook edition: up14.sfei.org/26

Inspecting the continuous monitoring probe in Alviso Slough. Photograph by April Robinson.

Priority Questions for the Next Five Years

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

NUTRIENTS

Workplan Highlights

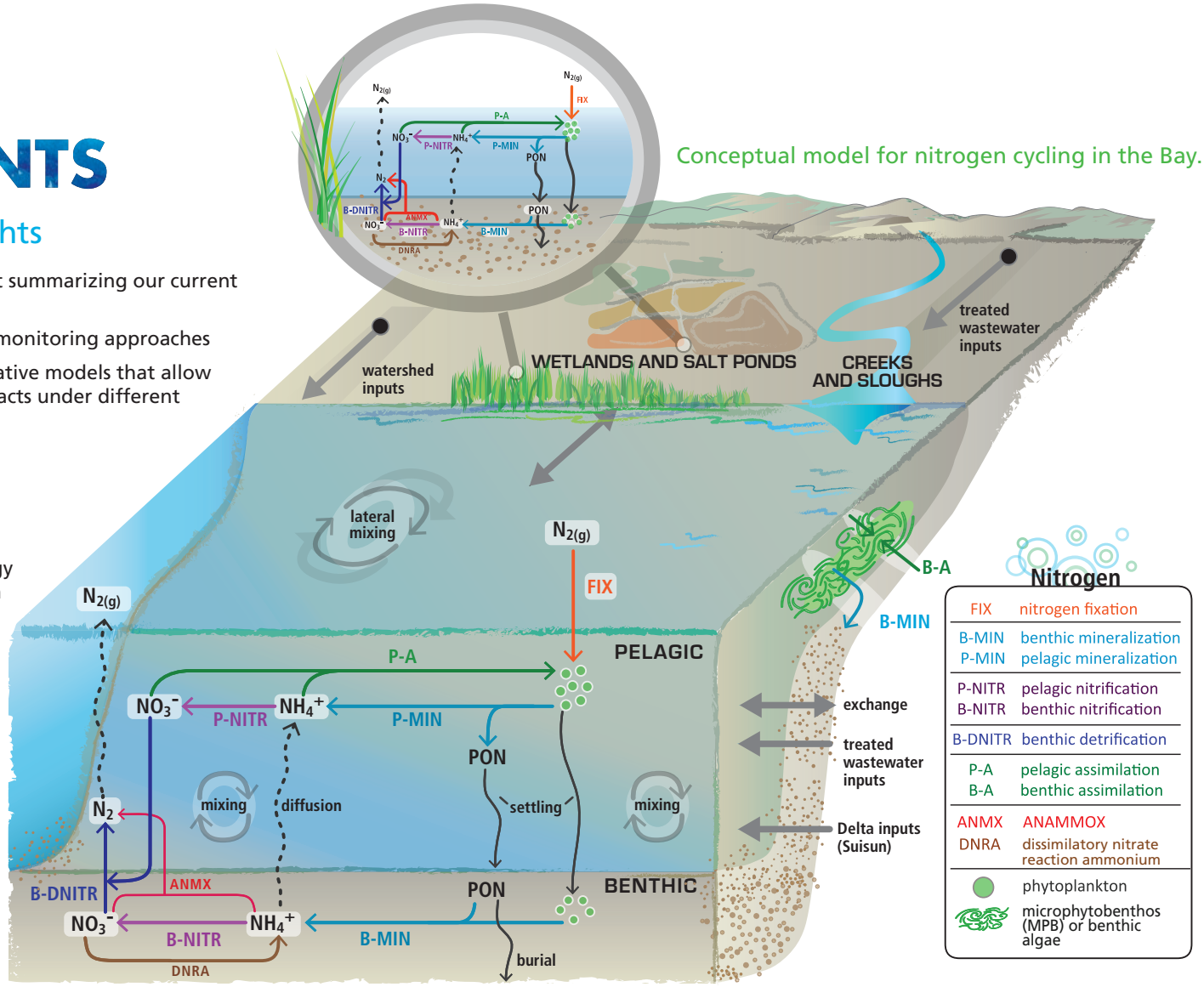
- Conceptual model report summarizing our current state of knowledge
- Pilot studies of nutrient monitoring approaches
- Development of quantitative models that allow forecasting nutrient impacts under different management scenarios

Partners and Coordination

The Nutrient Science Strategy is a collaborative effort with major contributions from:

- RMP
- US Geological Survey
- State Water Board
- San Francisco Bay Regional Water Board
- Bay Area Clean Water Agencies
- Southern California Coastal Water Research Project

Conceptual model for nitrogen cycling in the Bay.



Relation to Permit Requirements

- Developing underlying scientific basis for future permit decisions
- Closely coordinated with permit requirements for Central Contra Costa Sanitation District to evaluate nutrient concerns in Suisun Bay

Five-Year Goals for Nutrient Strategy

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

EMERGING CONTAMINANTS

Video available in eBook edition: up14.sfei.org/28

Harbor seal sampling. Conducted under NOAA-NMFS permit number 16991. Photograph by Linda Wanczyk.

Relevant Management Policies and Decisions

- Support for early management intervention, including recommendations for green chemistry and pollution prevention
- Narrative water quality objectives for toxicity, bioaccumulation, and aquatic organisms population and community ecology

Recent Noteworthy Findings

- In 2013, the RMP published both a summary of the current state of knowledge on emerging contaminants in the Bay and a strategy for future investigations.
- Synthesis of a decade of Bay PBDE monitoring data indicates levels have declined in biota and sediment following nationwide phase-outs and state bans of these toxic and persistent flame retardant chemicals.
- A study to screen Bay wildlife for emerging contaminants with an analytical technique that allows detection of a broad spectrum of contaminants, rather than just those that are on a pre-defined list of target chemicals, detected seven chemicals of potential interest. Levels of these newly identified contaminants were significantly lower than those for legacy contaminants of concern, such as PCBs.
- Special studies of perfluorochemicals (PFCs), including toxic compounds once used in the manufacture of Scotchgard, Teflon, and other surface coatings, revealed new details about these contaminants. Bay harbor seals have unusually high levels of perfluorooctane sulfonate (PFOS), despite a nationwide phase-out in 2002. Cormorant egg PFOS levels measured in 2012 were one-third lower than levels measured in 2006 and 2009. New toxicity data suggest that these levels may still be harmful to birds. Analyses of treated wastewater and Bay sediment have uncovered the presence of many different PFCs, including so-called "precursor" chemicals that may degrade to form PFOS or other potentially toxic and persistent PFCs.
- Fipronil, a broad-spectrum insecticide of particular concern due in part to growing urban uses, has been detected in Bay stormwater and sediment. Observed concentrations of fipronil and its degradation products in sediment have exceeded effect thresholds on occasion, suggesting these compounds may pose risks to Bay aquatic life. In 2013, fipronil and its degradation products were not detected in Bay ambient water samples.
- Siloxanes, found in cleaning solvents and personal care products, were detected at low levels in bivalves from all 11 Bay sites sampled. Concentrations were highest in Central Bay samples. Siloxane levels are unlikely to be a concern for humans consuming Bay shellfish

Priority Questions for the Next Five Years

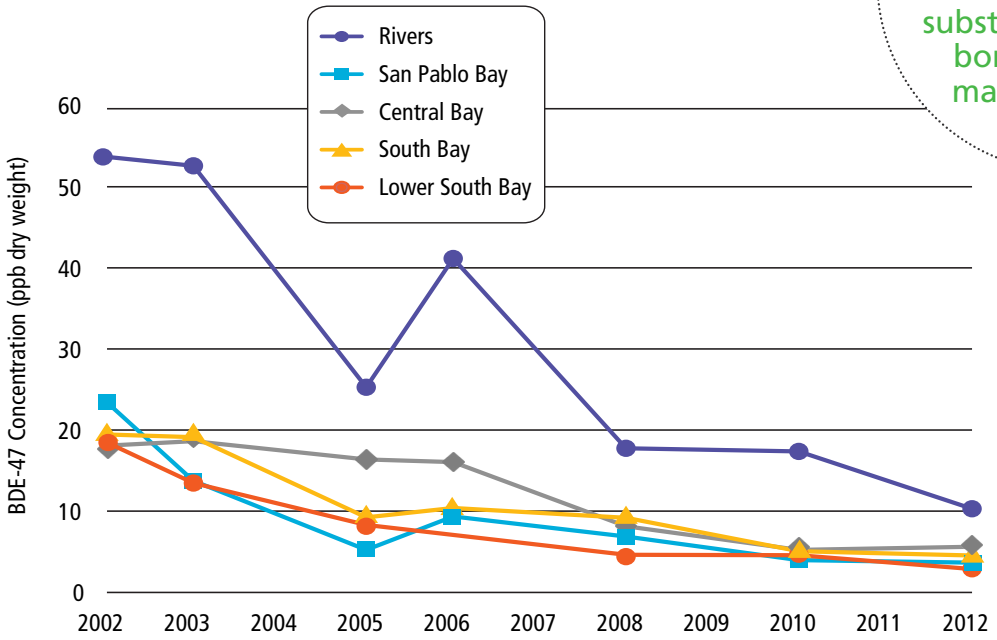
1. What emerging contaminants have the potential to adversely impact beneficial uses of the Bay?

EMERGING CONTAMINANTS

Emerging contaminant studies in the RMP have been augmented substantially by pro bono work and matching funds

Workplan Highlights

- Report on alternative flame retardants in the Bay
- Study of perfluorochemicals (PFCs or Teflon chemicals) and the pesticide fipronil in treated wastewater discharged to the Bay
- Results of analysis of microplastic pollution in Bay water and sediment
- Pilot projects to examine quaternary ammonium compounds (common components of cleaning products and fabric softeners) in Bay sediment and hindered phenols (plastics additives) in Bay water and sediment



PBDE concentrations in bivalves have declined at five stations since RMP measurements began in 2002.

Bivalve samples to be analyzed for emerging contaminants. Photograph by Amy Franz.

Partners and Coordination

Partnerships with many organizations have substantially augmented RMP efforts on emerging contaminants:

- National Oceanic and Atmospheric Administration
- State Water Board
- Southern California Coastal Water Research Project
- National Institute of Standards and Technology
- AXYS Analytical
- Canada Department of Fisheries and Oceans
- Environment Canada
- The Marine Mammal Center
- US Environmental Protection Agency
- Duke University
- Cal Poly San Luis Obispo
- San Diego State University
- University of Minnesota
- Southern Illinois University
- SUNY Fredonia
- Stony Brook University
- TDC Environmental
- University of Florida

PCBS

Relevant Management Policies and Decisions

- PCBs TMDL and potential update
- Selecting management actions for reducing PCB impairment

Recent Noteworthy Findings

- Shiner surfperch have concentrations 12 times higher than the TMDL target, and these have resulted in an advisory from OEHHA recommending no consumption for all surfperch in the Bay. Concentrations in shiner surfperch and white croaker show no clear sign of decline.
- Small fish on the Bay margins accumulate high concentrations of PCBs that correlate with concentrations in sediment and represent a pathway for impact on piscivorous wildlife.
- For birds, seals, and fish there is evidence of PCB exposure to a degree in certain locations that may be reducing health and survival.
- Average concentrations in Suisun Bay sediments are lower than in the other Bay segments.
- Wetland sediment cores provide evidence of dramatic declines from the 1960s to the present.
- Patterns of PCB bioaccumulation suggest that there are two broad habitat categories that appear to have food webs that are largely distinct: the margins and the open Bay. Impairment is far more severe in contaminated margin locations.
- Monitoring, forecasting, and management should treat these margin locations as discrete local-scale units. Local-scale actions within a margin area, or in upstream watersheds, will be needed to reduce exposure within that area.
- 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.
- Recent fish monitoring data point to several contaminated margin sites that are high priorities for management, including: Hunters Point, Stege Marsh, Oakland Inner Harbor, Richmond Inner Harbor, San Leandro Harbor, San Leandro Bay, and Coyote Point.
- Stormwater management actions are being developed and tested.
- Recent estimates of total loads for POTWs and industrial facilities were well below the waste-load allocations in the TMDL.
- The RMP list of 40 congeners is the most appropriate PCB index for monitoring in support of the PCB TMDL.

Priority Questions for the Next Five Years

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? (newly added question)

Collecting small fish with a beach seine. Photograph by Ben Greenfield.

PCBS

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
- Development of a multi-year plan for PCBs to support revision of the PCBs TMDL

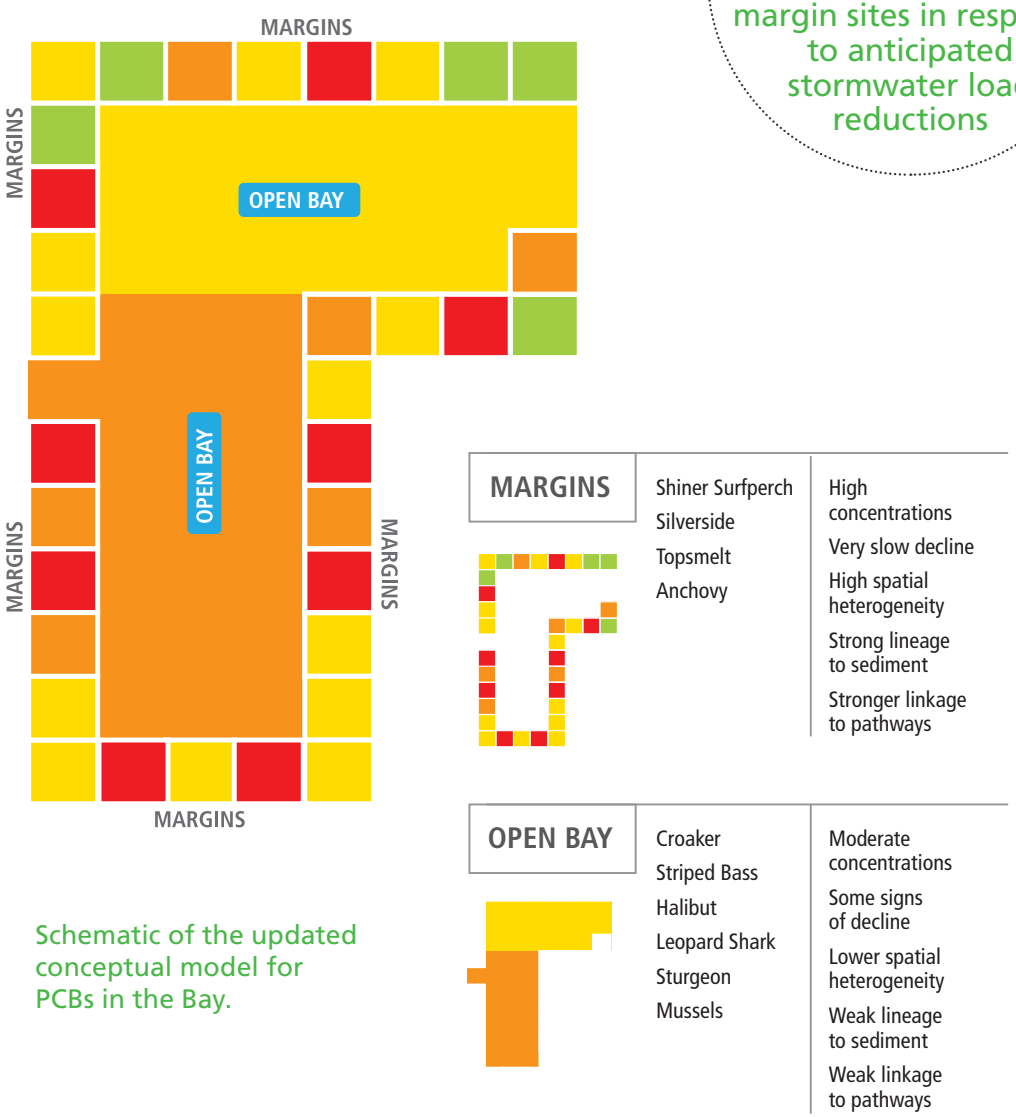
Relation to Permit Requirements

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

Partners and Coordination

- Bay Area Stormwater Management Agencies Association (representing the 76 cities, counties, and flood management districts covered by the Municipal Regional Permit)

The multi-year workplan for PCBs is focusing on preparing to detect improvements in Bay margin sites in response to anticipated stormwater load reductions



Schematic of the updated conceptual model for PCBs in the Bay.

SELENIUM

Relevant Management Policies and Decisions

- North Bay TMDL – Board consideration 2015
- South Bay TMDL or other control plan – After 2016

Recent Noteworthy Findings

- Sturgeon, a benthic species, is recognized as a key indicator of selenium impairment in the North Bay due to its susceptibility to selenium bioaccumulation.
- No trend is apparent in sturgeon concentrations in monitoring going back to 1987.
- The Lower South Bay has much 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.
- Selenium concentrations in bird eggs are usually well below a target developed to protect birds in Newport Bay.
- Concentrations in cormorant eggs were unusually high in 2009, but were back down to more typical concentrations in 2012.

Priority Questions for the Next Five Years

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?

Workplan Highlights

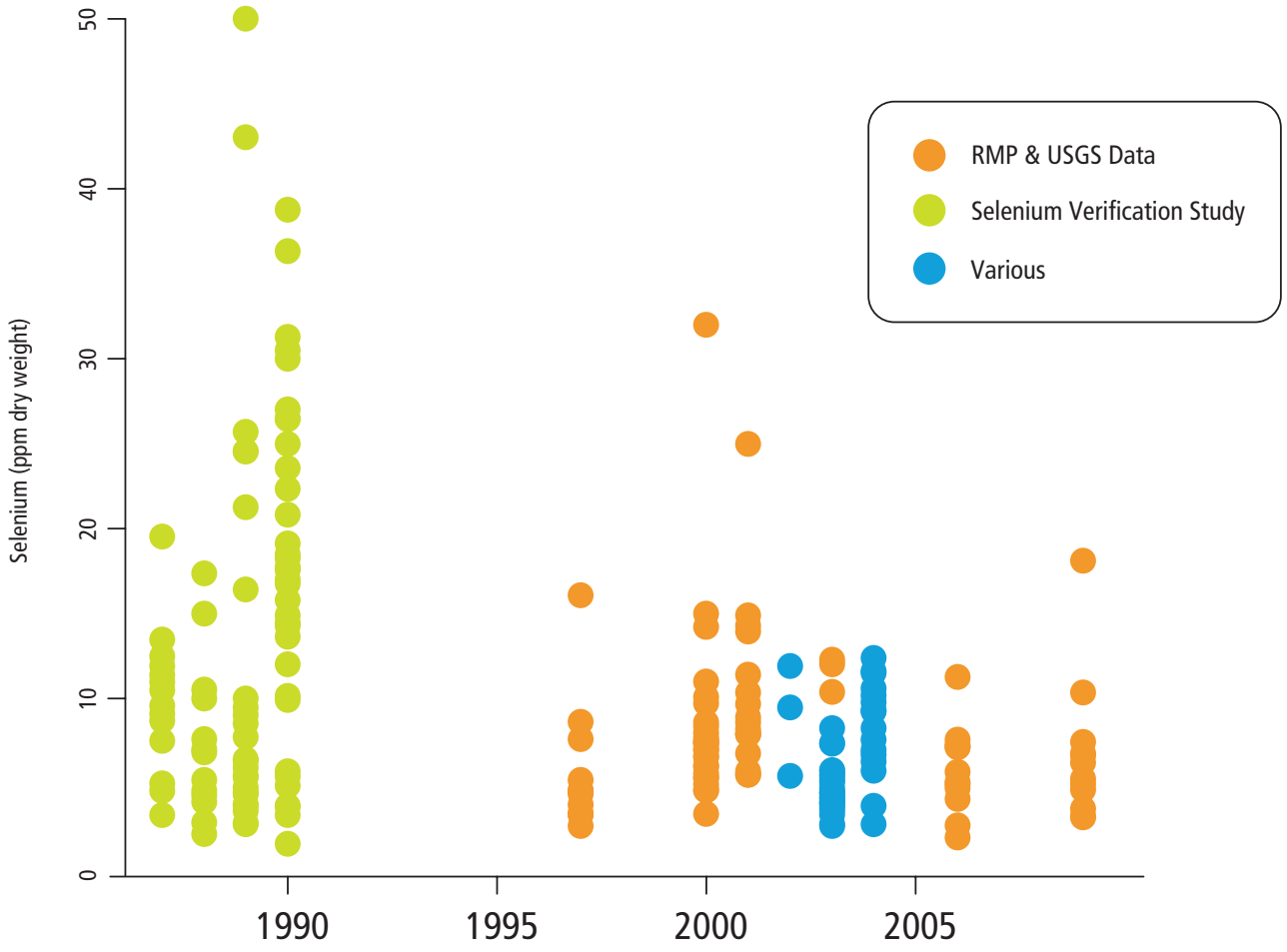
- Monitoring of selenium in plugs of muscle tissue obtained non-lethally

Partners and Coordination

- California Department of Fish and Wildlife
- US Fish and Wildlife Service
- US Geological Survey

White sturgeon collected in RMP fish sampling. Photograph by Zachary Epperson.

SELENIUM



Selenium concentrations in white sturgeon muscle in recent years have mostly been below 10 ppm dry weight.

DIOXINS

Relevant Management Policies and Decisions

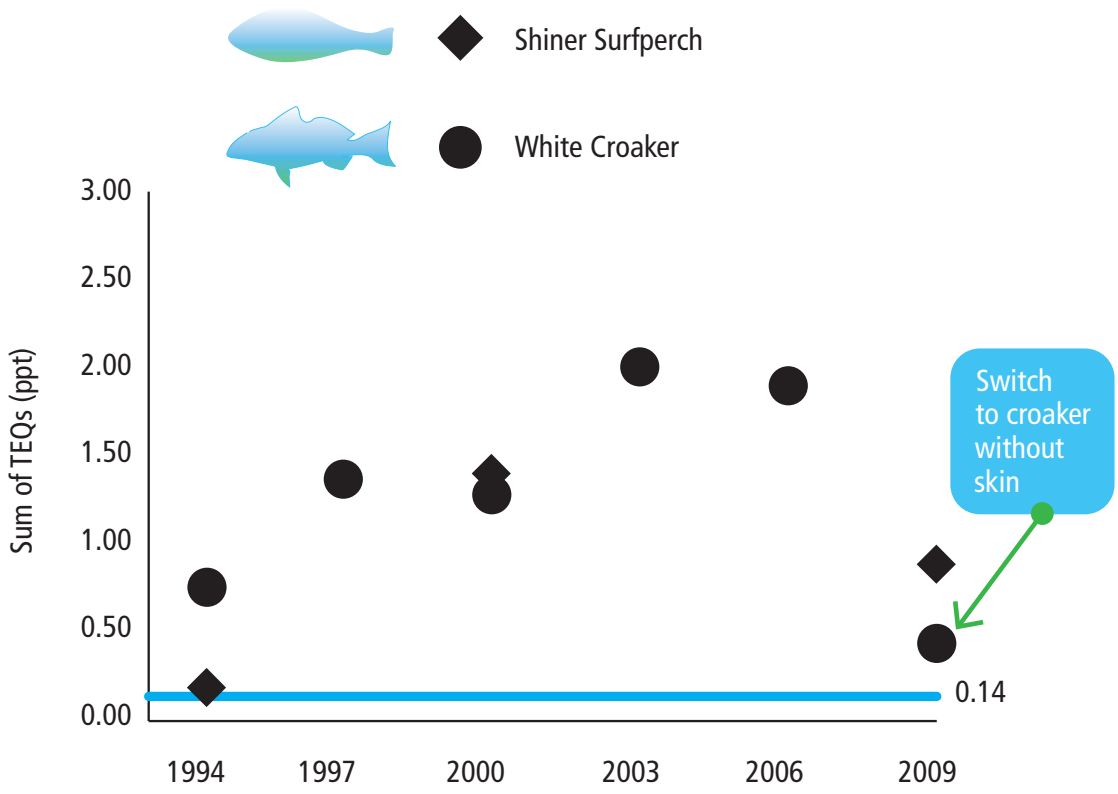
- Review 303(d) listings and establish TMDL development plan or alternative

Recent Noteworthy Findings

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

Priority Questions for the Next Five Years

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



Baywide average dioxin and furan TEQ concentrations (ppt) in white croaker (circles) and shiner surfperch (diamonds). Blue line indicates screening value.

DIOXINS

Workplan Highlights

- Monitoring stormwater, sediment, sport fish, and bird eggs.

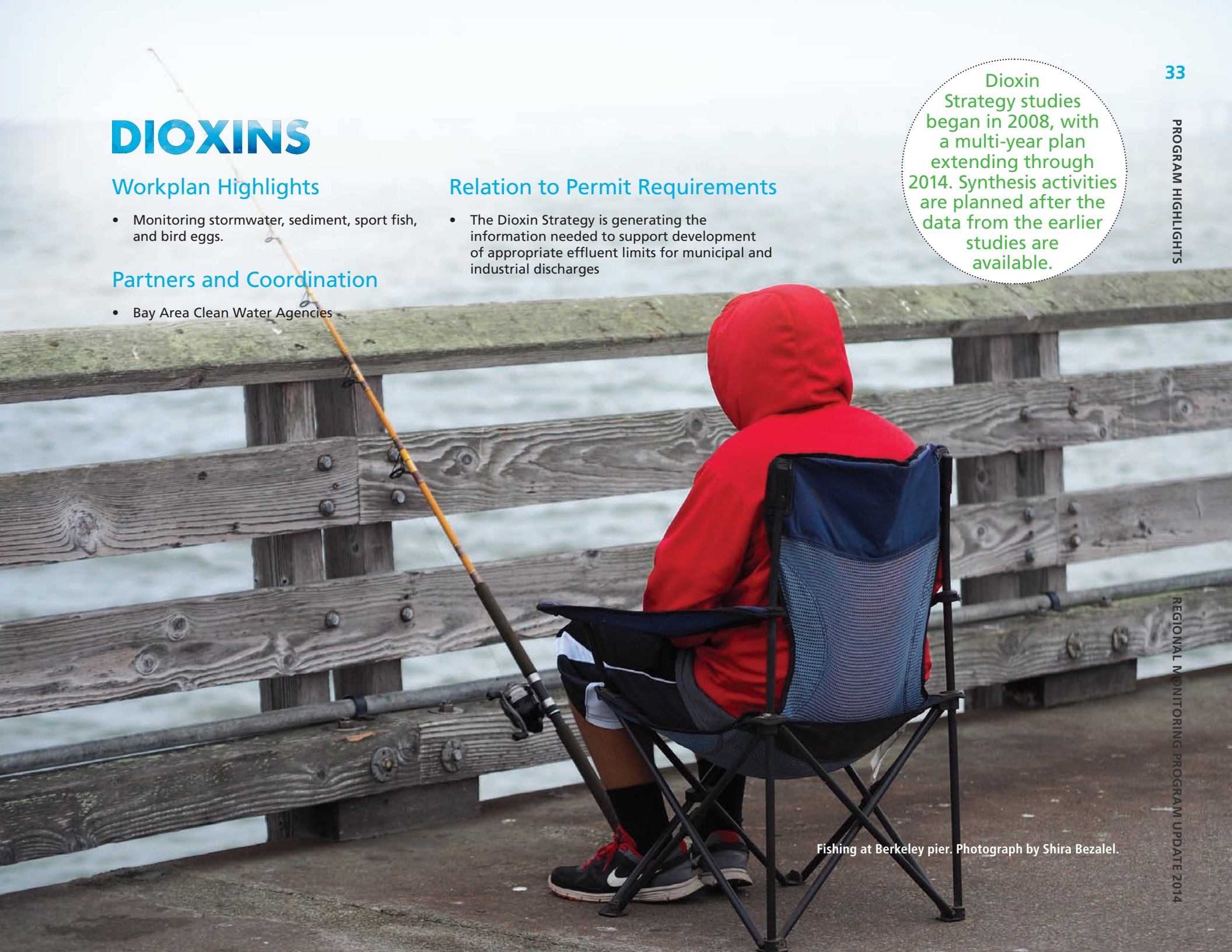
Partners and Coordination

- Bay Area Clean Water Agencies

Relation to Permit Requirements

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

Dioxin Strategy studies began in 2008, with a multi-year plan extending through 2014. Synthesis activities are planned after the data from the earlier studies are available.



Fishing at Berkeley pier. Photograph by Shira Bezalel.

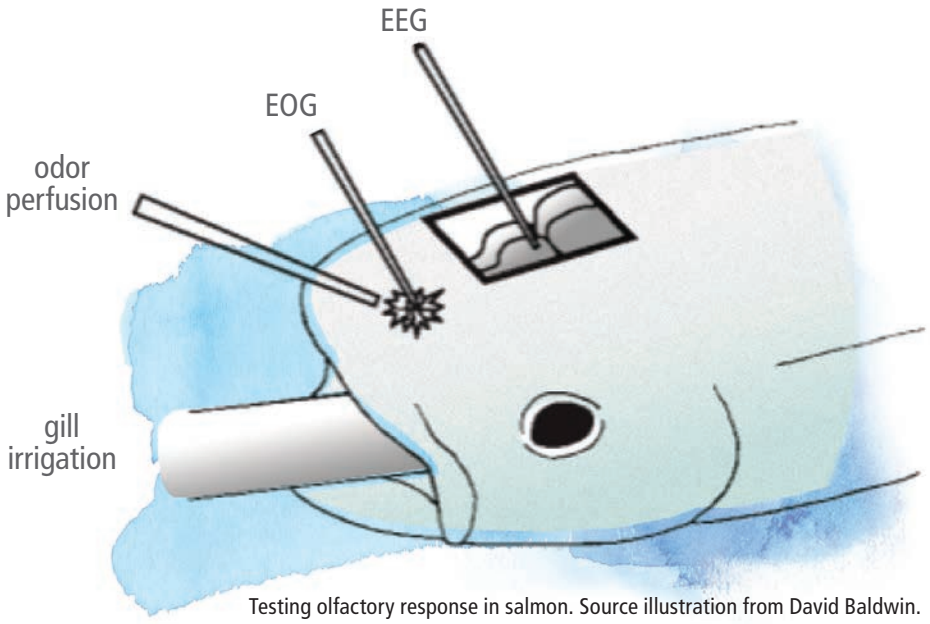
EXPOSURE AND EFFECTS

Relevant Management Policies and Decisions

- Implementation of sediment quality objectives
- Permitting decisions regarding dredging projects
- Implementation of narrative water quality objectives for toxicity, bioaccumulation, and aquatic organisms population and community ecology
- Review contaminated sediment 303(d) listing and potential to delist
- Copper control plan, especially with regard to risks to salmon

Recent Noteworthy Findings

- Sediment quality objective (SQO) 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.
- Recent studies by NOAA indicate that even at very high concentrations of copper in seawater (> 100 µg /L), Chinook salmon's sense of smell is not impaired.
- 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.



Testing olfactory response in salmon. Source illustration from David Baldwin.

Priority Questions for the Next Five Years

Effects on Benthos

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

Effects on Fish

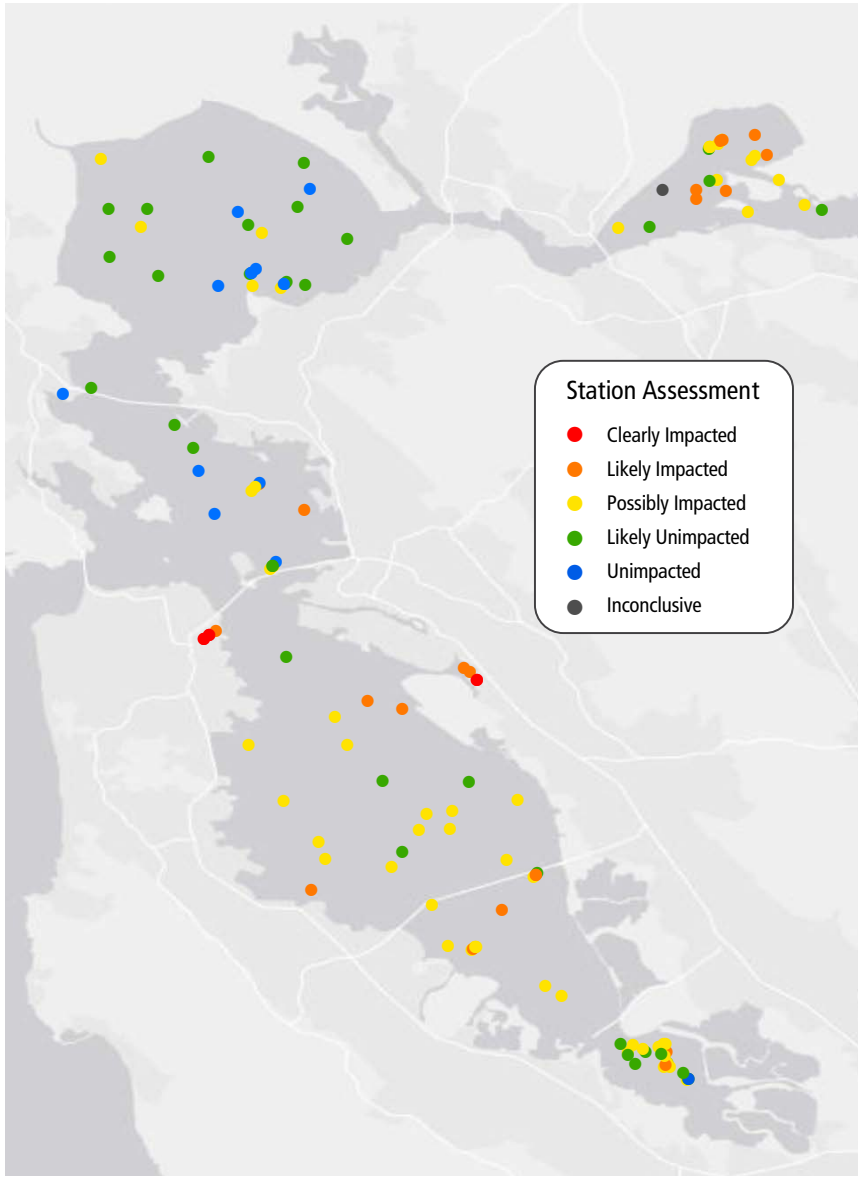
4. Are pollutants, individually or in combination, reducing the reproductive ability, growth, and health of sensitive fish populations?
5. What are appropriate thresholds of concern for contaminant concentrations for Bay species?
6. What are cost-effective indicators for monitoring effects of contaminants?

Effects on Birds

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

EXPOSURE AND EFFECTS

Exposure and effects effort is focused on identifying causes of sediment toxicity and evaluating the effects of copper on fish. For birds, significant progress has been made in answering the priority questions, and further work is not needed at this time.



Sediment quality objective station assessments for 2008-2012.

Workplan Highlights

- Report on effects of PAHs in flatfish
- Report on effects of copper on olfaction in salmonids
- Report on sediment quality at Bay hotspots

Partners and Coordination

- National Oceanic and Atmospheric Administration
- Copper Development Association
- Southern California Coastal Water Research Project
- UC Davis – Granite Canyon
- State Water Board
- US Geological Survey Western Ecological Research Center

Relation to Permit Requirements

- Addresses technical uncertainties identified in the Basin Plan's implementation program for copper site-specific objectives, to be addressed by municipal and industrial wastewater dischargers and stormwater management agencies
- Thresholds for bioaccumulation testing of dredged material based on ambient sediment conditions

STATUS AND TRENDS

Relevant Management Decisions

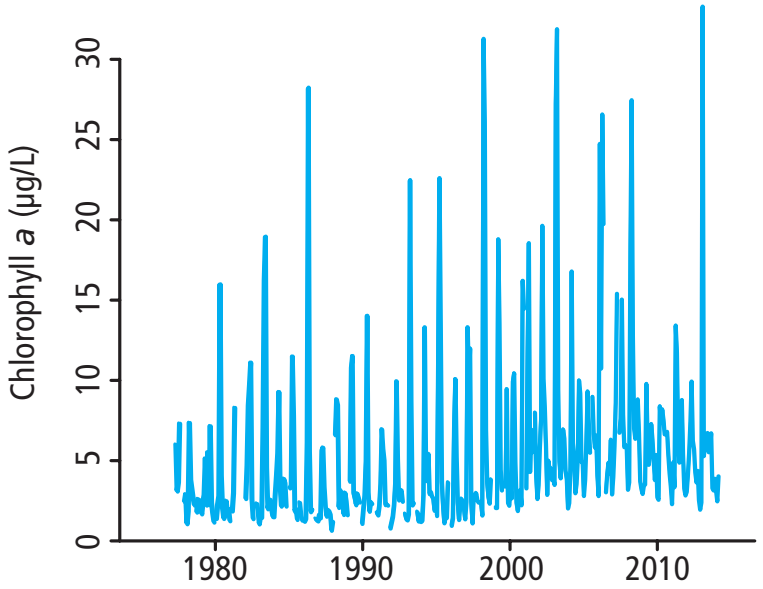
- Development of Se TMDL for North Bay and possibly for South Bay
- Copper site-specific objective and cyanide anti-degradation policies
- Evaluation of sediment and water quality objectives
- Water Quality Assessment - 303(d) impairment listings or de-listings
- Determination of whether there is reasonable potential that a NPDES permitted discharge may cause violation of a water quality standard
- Dredged material management
- Defining ambient conditions in Bay
- Development and evaluation of a Nutrient Assessment Framework (i.e., development of water quality objectives)

Recent Noteworthy Findings

- Annual sampling of water and sediment chemistry has documented a general lack of trend in persistent pollutants and spatial patterns that vary by pollutant but are consistent from year to year.
- A sudden decrease in suspended-sediment concentrations occurred in 1999 and has persisted since that time.
- Increasing chlorophyll concentrations have been observed in the Bay and are attributed to a variety of possible drivers (e.g., decrease in suspended-sediment concentrations and an increase in bivalve predators.
- 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.
- Average PAH concentrations in sediment have been highest along the southwestern shoreline of Central Bay.

Priority Questions for the Next Five Years

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



Monthly average chlorophyll concentrations in South Bay have increased in recent years relative to the 1980s and 1990s.

STATUS AND TRENDS

Workplan Highlights

- Biennial monitoring of water and bivalves, and sediment once every four years
- Triennial monitoring of bird eggs and analysis of sport fish every five years
- Pilot work to sample sediment in shallow water on the Bay margins

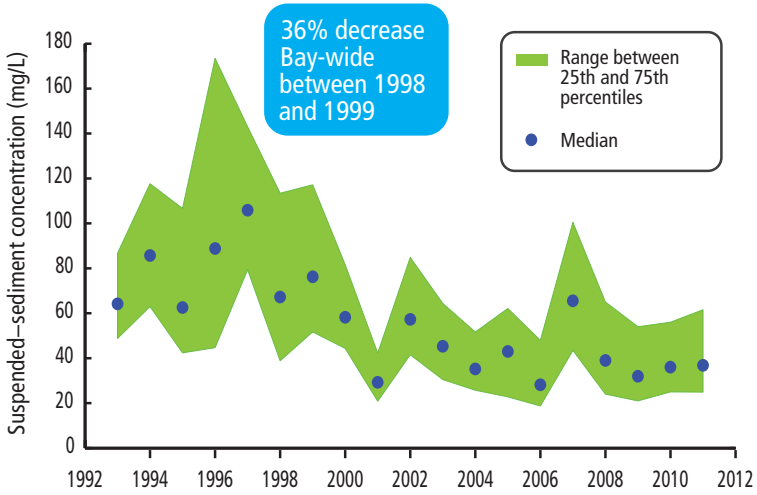
Partners and Coordination

- Applied Marine Sciences
- AXYS Analytical
- EBMUD
- City and County of San Francisco
- US Geological Survey
- Marine Pollution Studies Laboratory
- California Department of Fish and Wildife
- City of San Jose
- Brooks Rand Analytical
- Columbia Analytical Services
- Moss Landing Marine Laboratory

Relation to Permit Requirements

- Satisfies requirement for receiving water compliance monitoring for NPDES discharge permit holders

Status and Trends sampling was scaled back significantly in 2014, freeing up resources for special studies and other topics

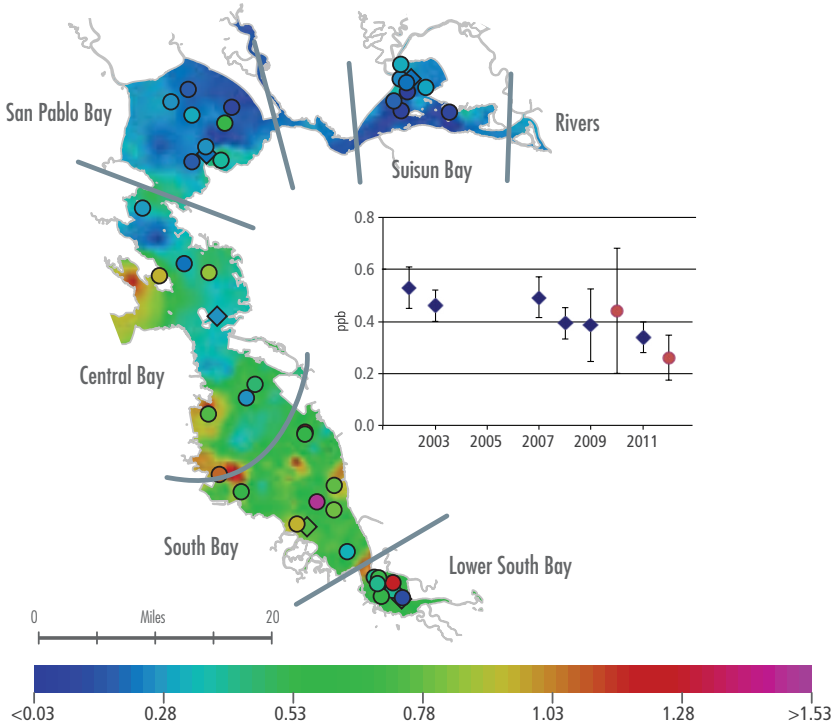


Suspended-sediment concentrations declined abruptly after 1999, as seen at this representative station.

Gathering flow data. Photograph by Tony Hale.

STATUS AND TRENDS

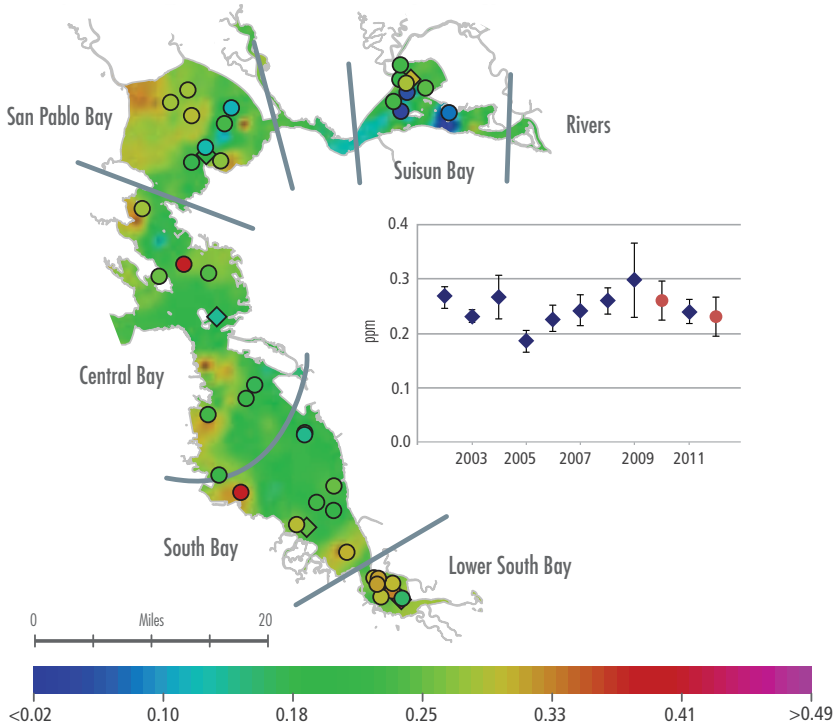
Methylmercury in Sediment (ppb)



Concentrations of methylmercury in sediment south of the Bay Bridge have been consistently higher than those in the northern Estuary. Methylmercury production can vary tremendously over small distances and over short time periods, so the colored contours shown should be viewed as the result of several "snapshots" of Bay conditions at the time of the surveys in the summers of 2002-2011 (except for 2010, when sampling occurred during the wet season - these data are excluded from the map and the statistics that follow). Long-term (2002-2011) average concentrations have been highest in South Bay and Lower South Bay (0.72 and 0.68 ppb, respectively), and lowest in Suisun Bay (0.20 ppb) and San Pablo Bay (0.27 ppb).

Footnote: Contour plot based on 425 RMP data points over nine rounds of dry season sampling from 2002-2011 (data from a wet season sampling in 2010 are excluded). The maximum concentration was 6.1 ppb at a site in Central Bay in 2009. Colored symbols on map show results for samples collected in 2011. Circles represent random sites. Diamonds represent historic fixed stations. Trend plot shows annual Bay-wide averages. Red circle on trend plot indicates a wet season sample; other samples were dry season. Concentrations presented on a dry weight basis.

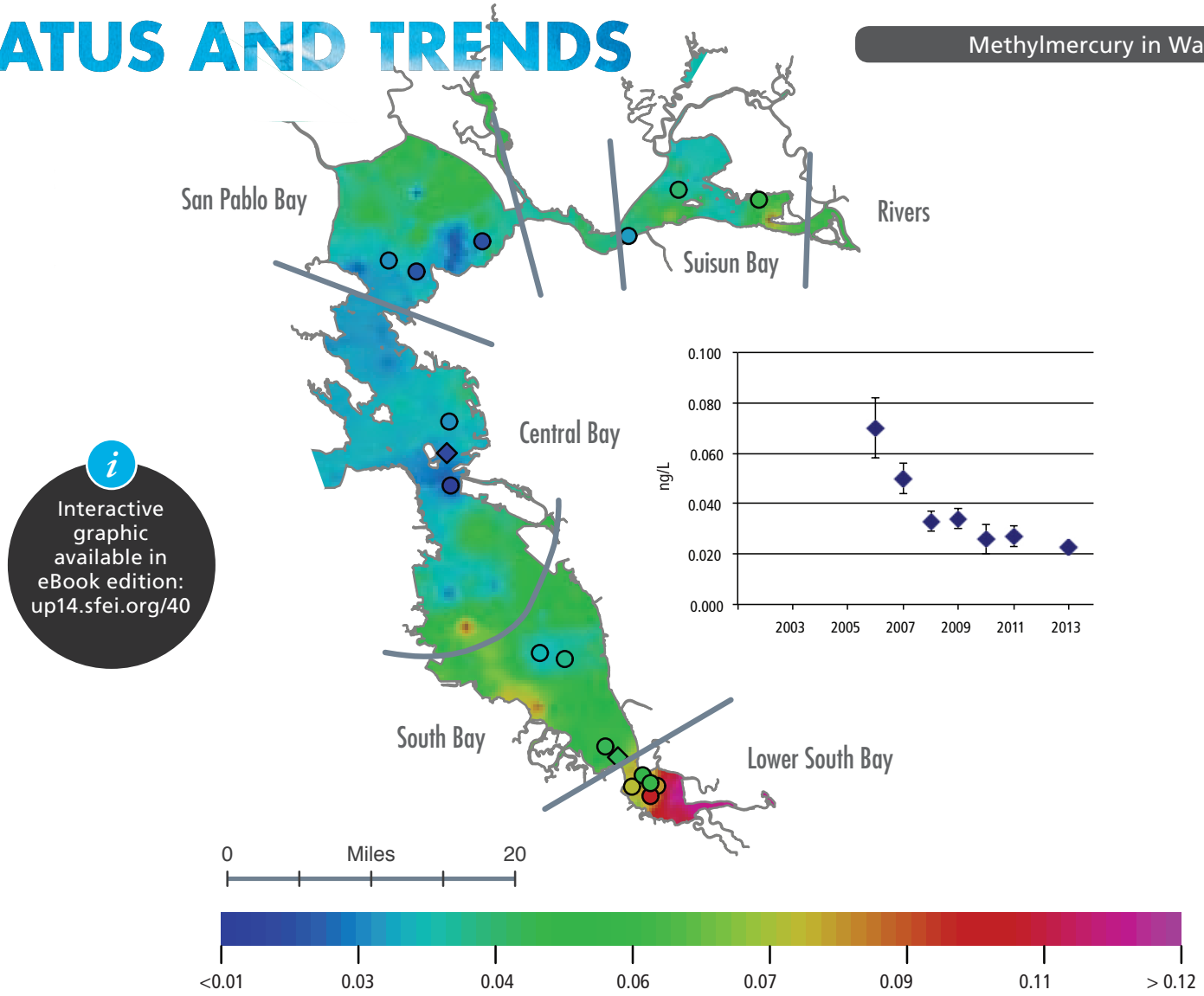
Mercury in Sediment (ppm)



In contrast to methylmercury, long-term average total mercury concentrations in sediment during the dry season have been highest in San Pablo Bay (0.27 ppm). Average concentrations have been slightly lower in Lower South Bay and Central Bay (both 0.26 ppm) and South Bay (0.22 ppm), and lowest in Suisun Bay (0.17 ppm). The Bay-wide average for the eight-year period was 0.25 ppm. Also in contrast to methylmercury, Bay-wide average concentrations of total mercury in sediment have shown relatively little variability over this period, ranging from a low of 0.19 ppm in 2005 to a high of 0.30 ppm in 2009. No regulatory guideline exists for total mercury in sediment.

Footnote: Contour plot based on 425 RMP data points over nine rounds of dry season sampling from 2002-2011 (data from a wet season sampling in 2010 are excluded). The maximum dry season concentration was 0.94 ppm in Central Bay in 2009. Colored symbols on map show results for samples collected in 2011. Circles represent random sites. Diamonds represent historic fixed stations. Trend plot shows annual Bay-wide averages. Red circle on trend plot indicates a wet season sample; other samples were dry season. Concentrations presented on a dry weight basis.

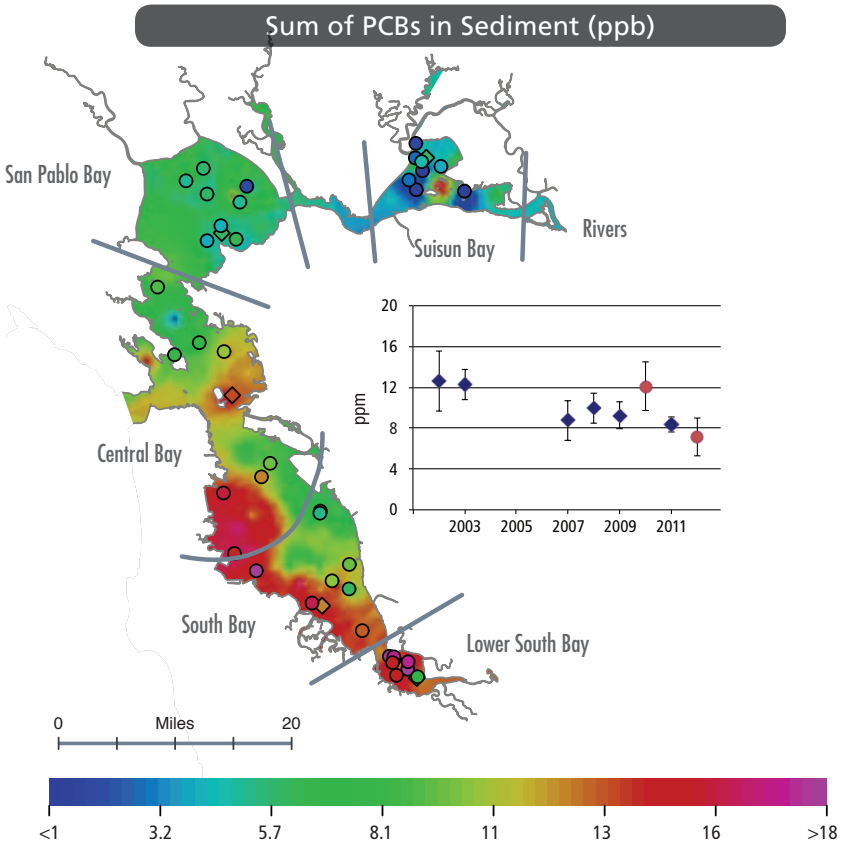
STATUS AND TRENDS

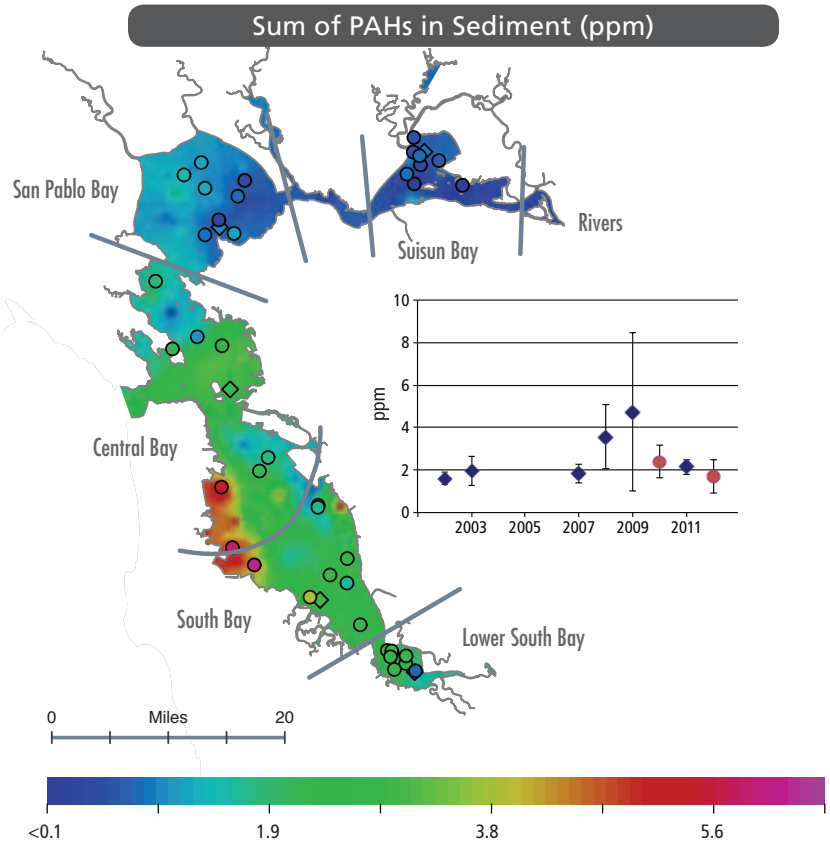


Water from Lower South Bay had the highest average concentration of methylmercury by far (0.109 ng/L) of any segment from 2006 to 2013. South Bay had the next highest average (0.054 ng/L). Methylmercury typically represents only about 1% of the total of all forms of mercury in water or sediment, but it is the form that is readily accumulated in the food web and poses a toxicological threat to highly exposed species. Methylmercury has a complex cycle, influenced by many processes that vary in space and time. No regulatory guideline exists for methylmercury in water. The Bay-wide average in 2013 was 0.023 ng/L. The Bay-wide average for the eight-year period was 0.042 ng/L. The Bay-wide averages for 2008-2011 were lower than those observed in 2006 and 2007.

Footnote: Water is sampled only in the dry season, and was not sampled in 2012. Earlier years not included because a less sensitive method was employed. Contour plot based on 127 RMP data points from 2006-2013. Colored symbols on map show results for samples collected in 2013: circles represent random sites; diamonds represent historic fixed stations. Trend plot shows annual Bay-wide random station means with error bars indicating the 95% confidence intervals of the means. The maximum concentration at a random station was 0.28 ng/L in Lower South Bay in 2011. Data are for total methylmercury.

STATUS AND TRENDS





Long-term average dry season PCB concentrations in Bay sediment have been highest in the southern reach of the Bay: Lower South Bay (14.2 ppb), South Bay (11.7 ppb), and Central Bay (12.9 ppb), and lower in San Pablo Bay (6.2 ppb) and Suisun Bay (4.5 ppb). The Bay-wide average for the wet season sampling in 2012 was 7.1 ppb - the lowest annual average observed over the period of record. Concentrations observed in 2007-2012 were lower than those in 2002-2003 - additional sampling will be needed to determine whether this is indicative of a long-term decline. Models suggest that sediment PCB concentrations must decline to about 1 ppb for concentrations in sport fish to fall below the threshold of concern. Suisun Bay has been closest to this level, with a minimum annual average of 2.0 ppb in 2011.

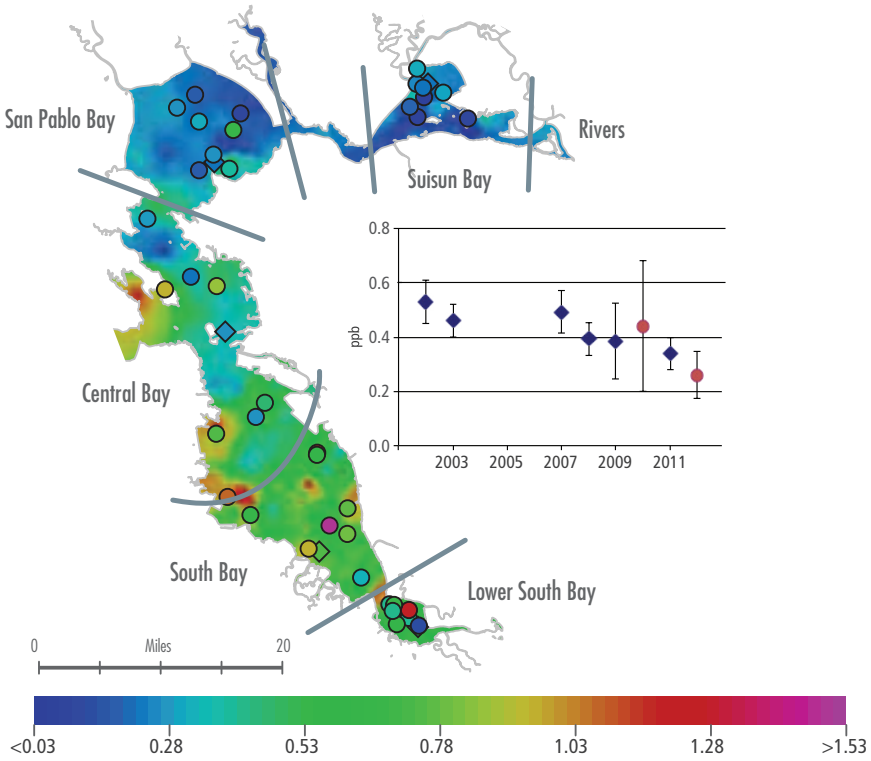
Footnote: Data from 2004-2006 are excluded due to analytical problems. Contour plot based on 236 RMP data points over six rounds of dry season sampling (2002, 2003, 2007-2009, and 2011). Colored symbols on map show results for wet season samples collected in 2012. Circles represent random sites. Diamonds represent historic fixed stations. Trend plot shows annual Bay-wide random station means with error bars indicating the 95% confidence intervals of the means. Red circles on trend plot indicate wet season samples; other samples were dry season. The maximum at a random station was 41 ppb in Suisun Bay in 2002. Concentrations presented as sum of 40 congeners on a dry weight basis.

Average dry season PAH concentrations in sediment have been highest along the southwestern shoreline of Central Bay. Central Bay has had the highest average dry season concentration (4.1 ppm) of any Bay segment. South Bay had the next highest average concentration (2.6 ppm), followed by Lower South Bay (2.1 ppm), San Pablo Bay (1.1 ppm), and Suisun Bay (0.6 ppm). The Bay-wide average in 2012 (wet season) was 1.7 ppm - the second lowest annual average observed over the period of record. The high annual average dry season concentrations observed in 2008 and 2009 were largely driven by a few unusually contaminated sites sampled in those years, including the maximum concentration of 43 ppm at a site on the southwestern Central Bay shoreline in 2009.

Footnote: Data from 2004-2006 are excluded due to analytical problems. Contour plot based on 236 RMP data points over six rounds of dry season sampling (2002, 2003, 2007-2009, and 2011). Colored symbols on map show results for wet season samples collected in 2012. Circles represent random sites. Diamonds represent historic fixed stations. Trend plot shows annual Bay-wide random station means with error bars indicating the 95% confidence intervals of the means. Red circles on trend plot indicate wet season samples; other samples were dry season. The maximum concentration at a random station was 43 ppm in Central Bay in 2009. Concentrations presented on a dry weight basis.

STATUS AND TRENDS

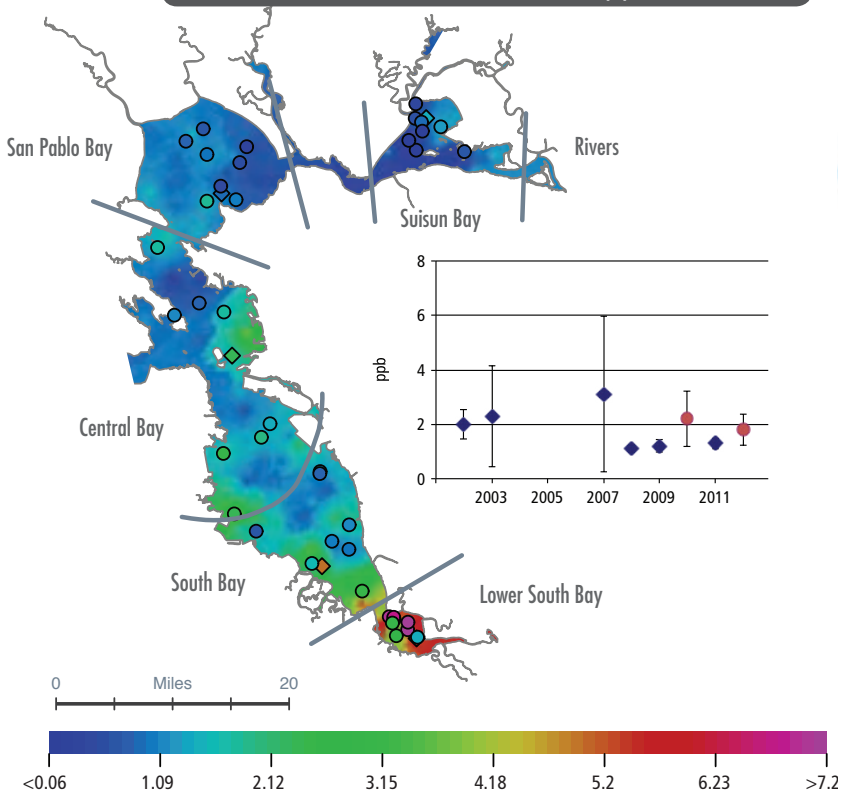
PBDE 47 in Sediment (ppb)



Concentrations of BDE-47 in sediment, consistent with the data for water and biota, appear to be on the decline. The Bay-wide average for 2012 (0.26 ppb, a wet season value) was the lowest observed during the period of record, and 50% lower than the average observed in 2002. In contrast to the results obtained from water monitoring, long-term average dry season concentrations of BDE-47 in sediment have been highest, by far, in Lower South Bay (0.65 ppb). Average concentrations in the other segments ranged from 0.35 ppb in South Bay to 0.46 ppb in Central Bay.

Footnote: BDE-47 is one of the most abundant PBDEs and was consistently quantified by the lab. Data from 2004-2006 are excluded due to analytical problems. Contour plot based on 239 RMP data points over six rounds of dry season sampling (2002, 2003, 2007-2009, and 2011). Colored symbols on map show results for wet season samples collected in 2012. Circles represent random sites. Diamonds represent historic fixed stations. Trend plot shows annual Bay-wide random station means with error bars indicating the 95% confidence intervals of the means. Red circles on trend plot indicate wet season samples; other samples were dry season. The maximum concentration at a random station was 1.7 ppb in Central Bay in 2009. Concentrations presented on a dry weight basis.

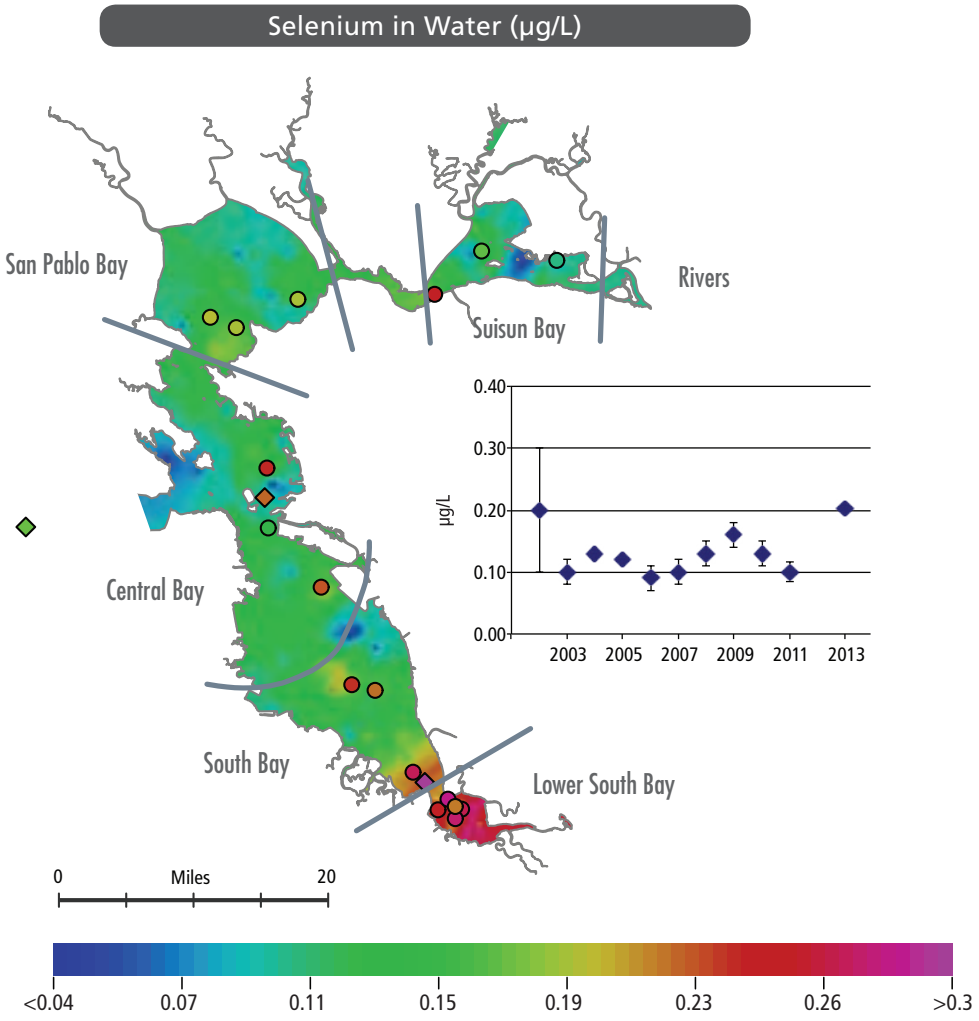
PBDE 209 in Sediment (ppb)



BDE-209 (also known as decabromodiphenyl ether) represents the last PBDE mixture ("DecaBDE") to be phased out of production in the US. In contrast to BDE-47, Bay-wide average concentrations of BDE-209 in sediment do not appear to be declining. The average concentration in the wet season sampling of 2012 (1.8 ppb) was equal to the long-term dry season average. Similar to BDE-47 in sediment, long-term average dry season concentrations of BDE-209 from 2004-2009 were highest in Lower South Bay (5.2 ppb), followed by San Pablo Bay (2.1 ppb), Central Bay (1.9 ppb), South Bay (1.7 ppb), and Suisun Bay (0.8 ppb).

Footnote: BDE-209 shown as an index of the DecaBDE mixture. Data from 2004-2006 are excluded due to analytical problems. Contour plot based on 236 RMP data points over six rounds of dry season sampling (2002, 2003, 2007-2009, and 2011). Colored symbols on map show results for wet season samples collected in 2012. Circles represent random sites. Diamonds represent historic fixed stations. Trend plot shows annual Bay-wide random station means with error bars indicating the 95% confidence intervals of the means. Red circles on trend plot indicate wet season samples; other samples were dry season. The maximum concentration at a random station was 52 ppb in San Pablo Bay in 2007. Concentrations presented on a dry weight basis.

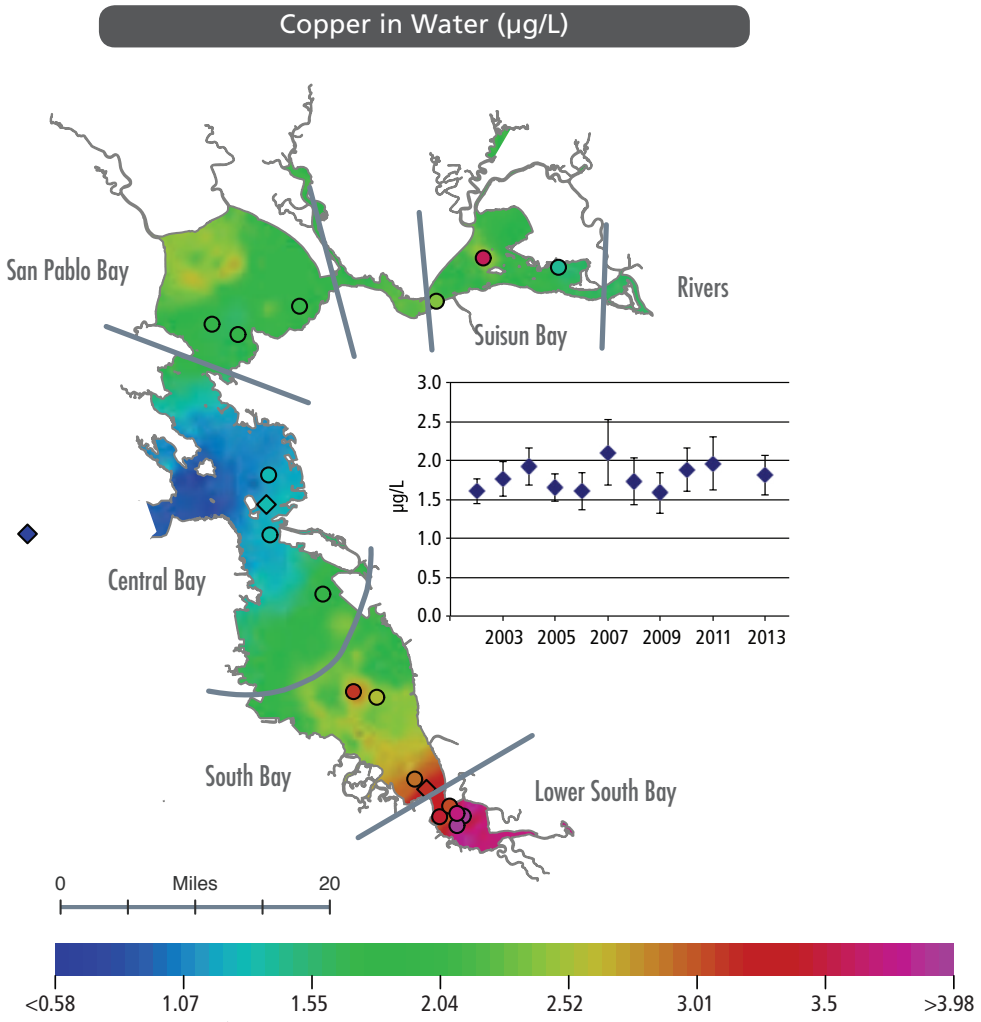
STATUS AND TRENDS



Selenium concentrations in water are well below the water quality objective established by the California Toxics Rule (5 µg/L), but concerns still exist for wildlife exposure as indicated by studies on early life-stages of fish. The highest concentration observed in water at random stations from 2002 to 2013 was 0.63 µg/L (in Central Bay in 2002), much lower than the Toxics Rule objective. The Lower South Bay had a higher average concentration over this period (0.25 µg/L) than the other Bay segments, which had very consistent average concentrations (all other averages were between 0.13 and 0.15 µg/L). The Bay-wide average concentration in 2013 (0.20 µg/L) was much higher than the long-term Bay-wide average (0.14 µg/L). Measured selenium concentrations are not much higher than the typical analytical detection limit (0.05 µg/L)- this is likely contributing to the observed interannual fluctuations in the dataset.

Footnote: Water is sampled only in the dry season, and was not sampled in 2012. Contour plot based on 226 RMP random station data points from 2002-2013. Colored symbols on map show results for samples collected in 2013: circles represent random sites; diamonds represent historic fixed stations. Trend plot shows annual Bay-wide random station means with error bars indicating the 95% confidence intervals of the means. The maximum concentration at a random station was 0.63 µg/L in Central Bay in 2002. Data are for total selenium (dissolved plus particulate).

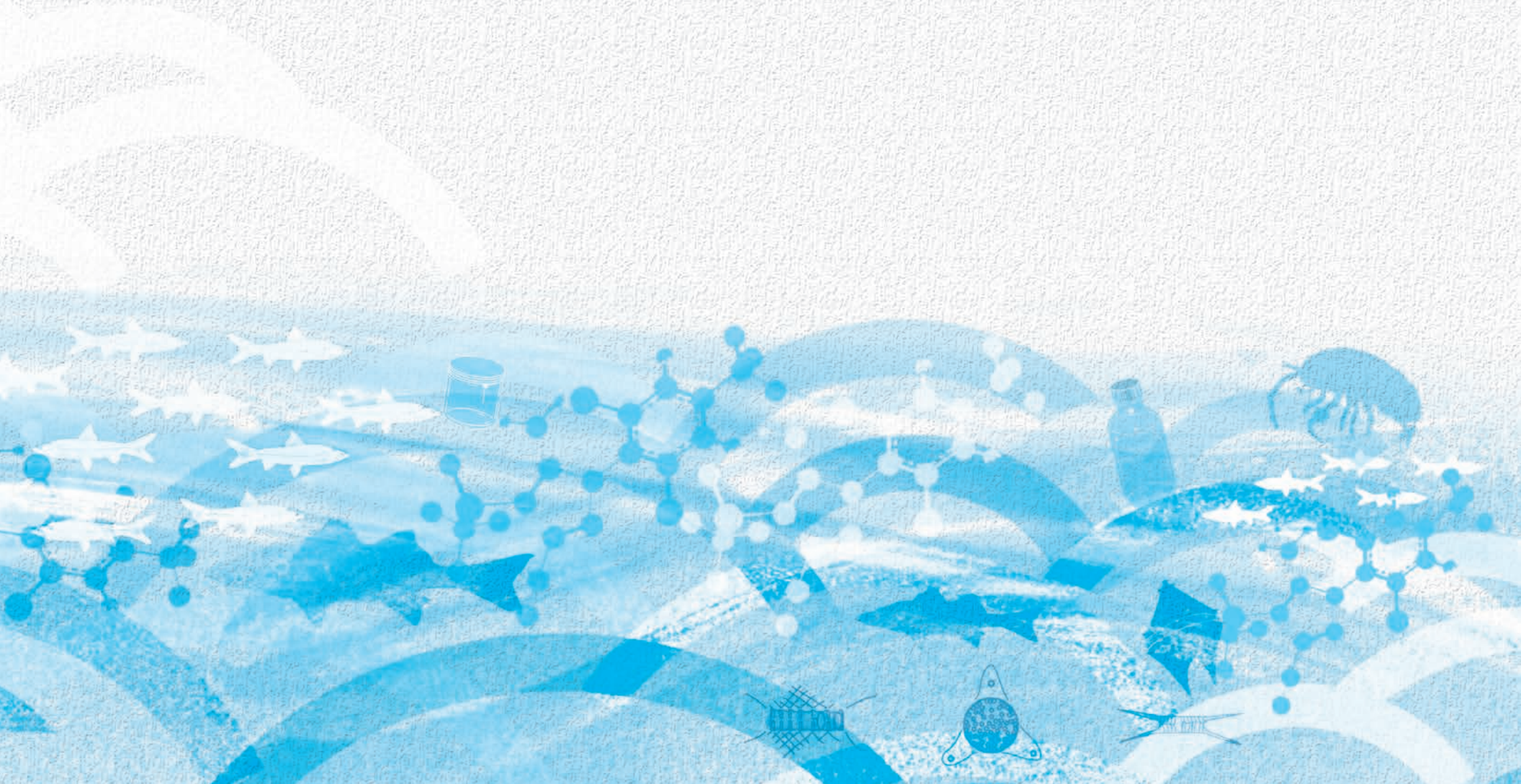
STATUS AND TRENDS



Only one of the 234 water samples analyzed from 2002-2013 had a dissolved copper concentration above site-specific objectives for the Bay. Bay-wide average copper concentrations have been relatively constant, with a long-term average for random stations for the period of record of 1.8 µg/L. The Bay-wide average for random stations in 2013 was also 1.8 µg/L. The Water Board has established site-specific objectives of 6.9 µg/L for the South Bay and Lower South Bay, and 6.0 µg/L for Central Bay, San Pablo Bay, and Suisun Bay. The highest concentration observed was 8.0 µg/L in Lower South Bay in 2011. None of the other samples approached the objectives. The Lower South Bay had the highest average concentration (3.7 µg/L), followed by South Bay (2.4 µg/L), San Pablo Bay (2.0 µg/L), Suisun Bay (2.0 µg/L), and Central Bay (1.4 µg/L).

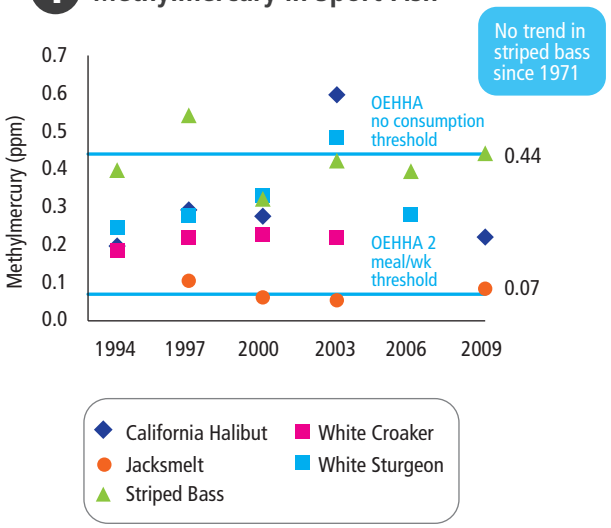
Footnote: Water is sampled only in the dry season, and was not sampled in 2012. Contour plot based on 234 RMP random station data points from 2002-2013. Colored symbols on map show results for samples collected in 2013: circles represent random sites; diamonds represent historic fixed stations. Trend plot shows annual Bay-wide random station means with error bars indicating the 95% confidence intervals of the means. Data are for dissolved copper.

TRENDS AT A GLANCE

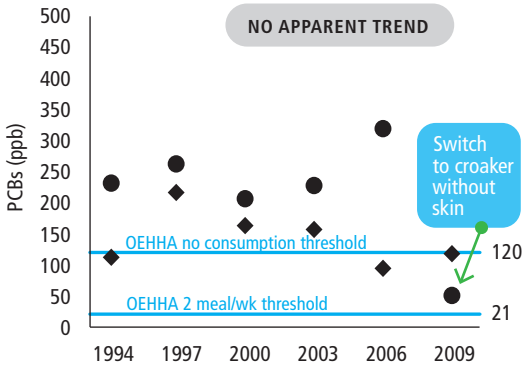


TOXICS AND BACTERIA

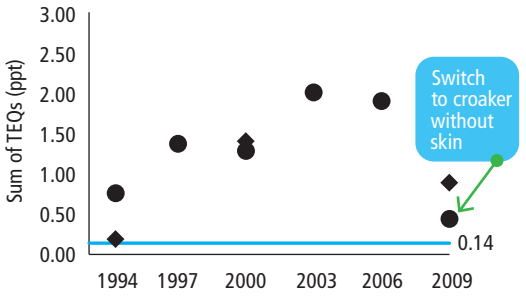
1 Methylmercury in Sport Fish



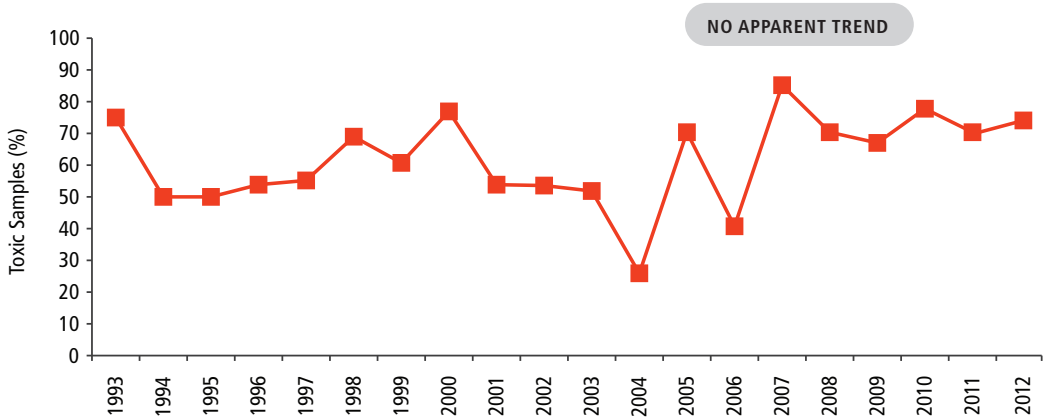
2 PCBs in Sport Fish



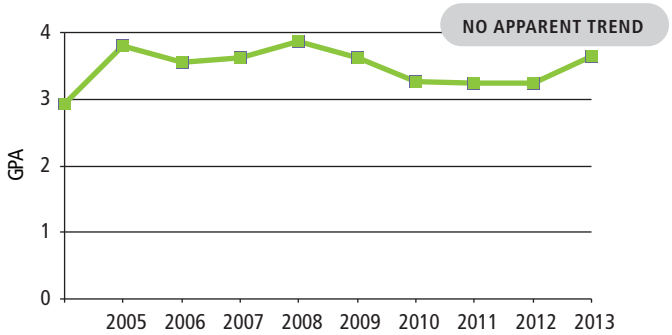
3 Dioxins in Sport Fish



4 Percent Toxic Sediment Samples



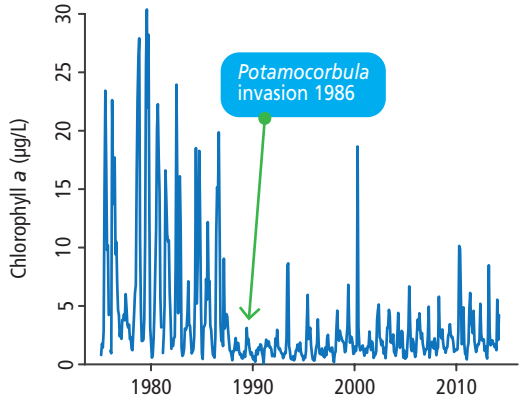
5 Beach Report Card Grades



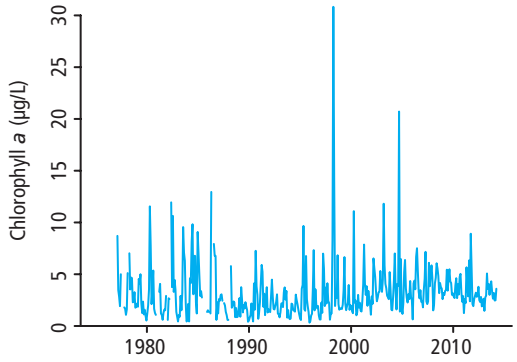
See page 53 for Graph Details

CHLOROPHYLL AND DISSOLVED OXYGEN

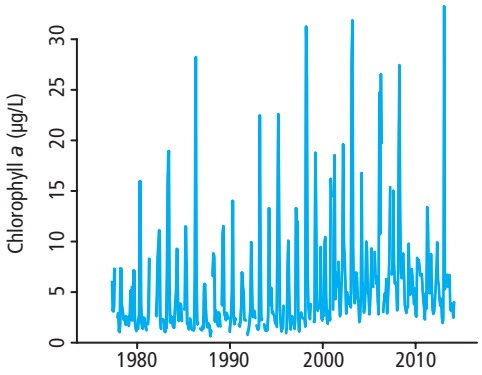
1 Chlorophyll in Suisun Bay



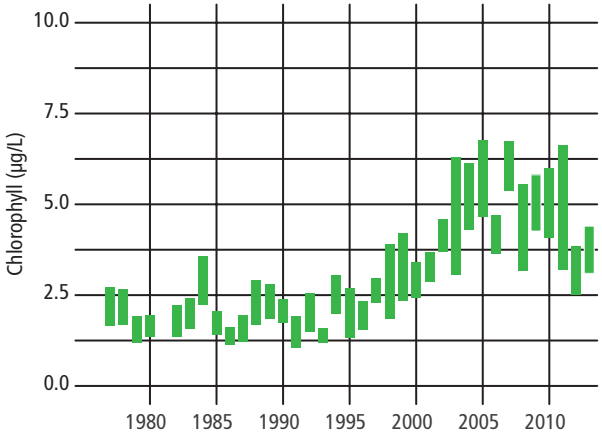
2 Chlorophyll in San Pablo Bay



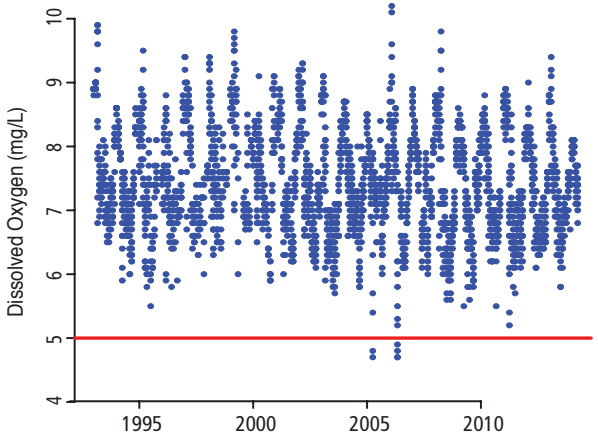
3 Chlorophyll in South Bay



4 Summer Chlorophyll in South Bay



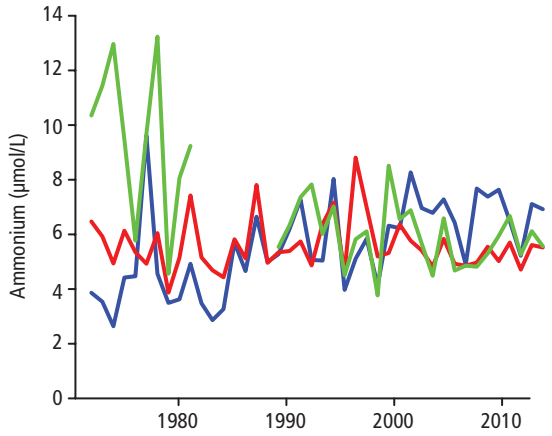
5 Minimum Dissolved Oxygen in South Bay

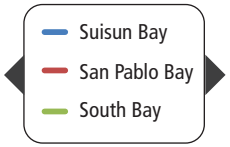


See page 53 for Graph Details

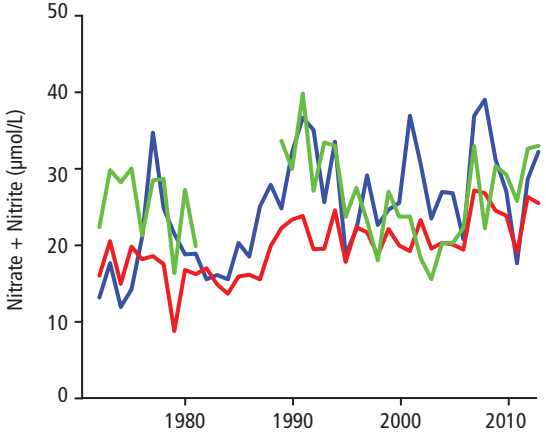
NUTRIENTS AND SEDIMENTS

1 Ammonium

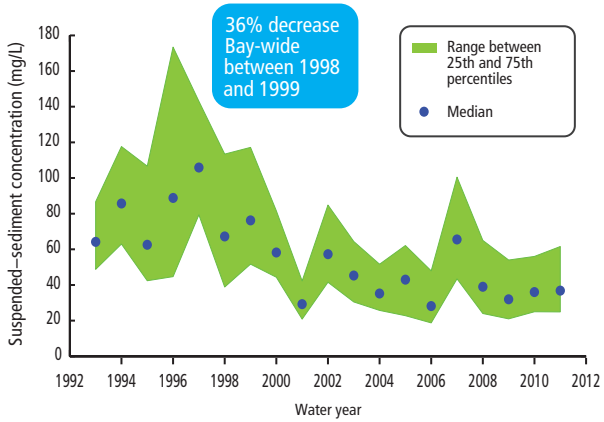




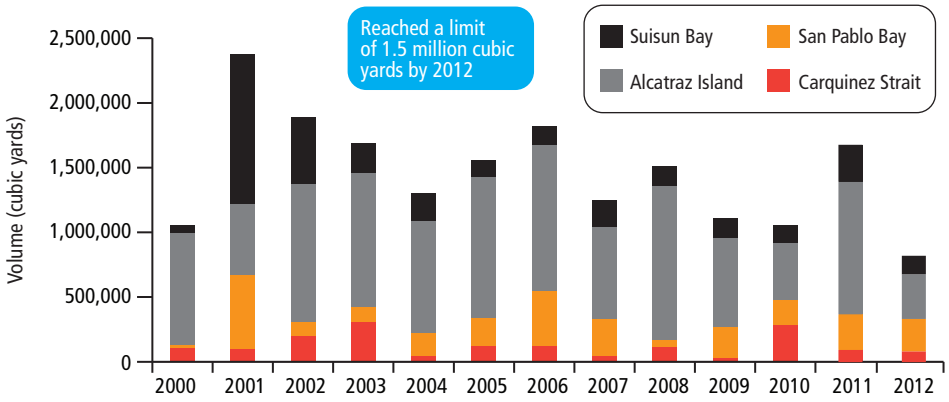
2 Nitrate and Nitrite



3 Suspended Sediment



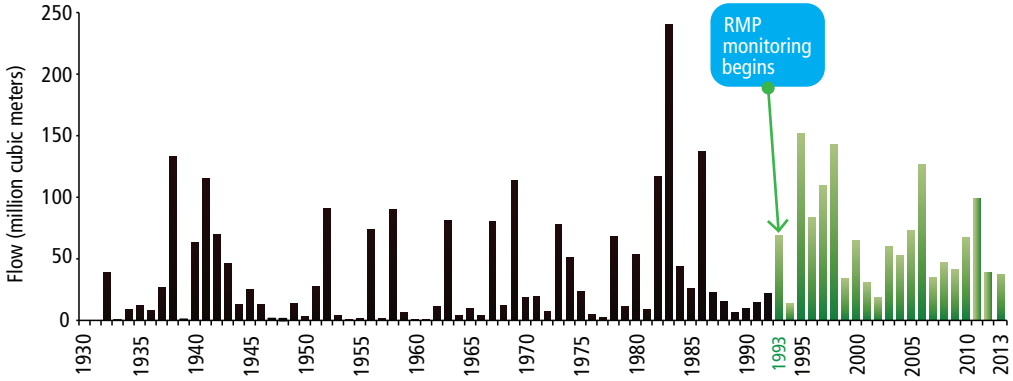
4 In-Bay Disposal of Dredged Material



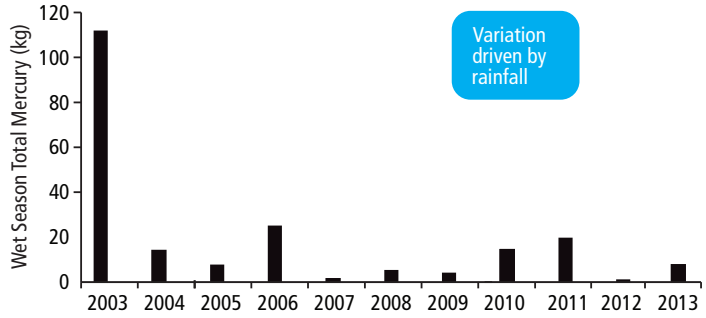
See page 53 for Graph Details

FLOWS AND LOADS

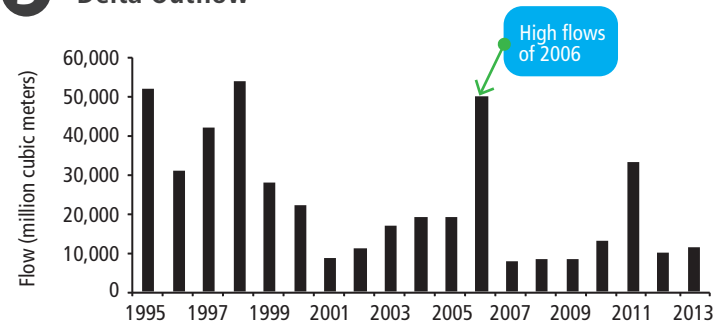
1 Guadalupe River Flow



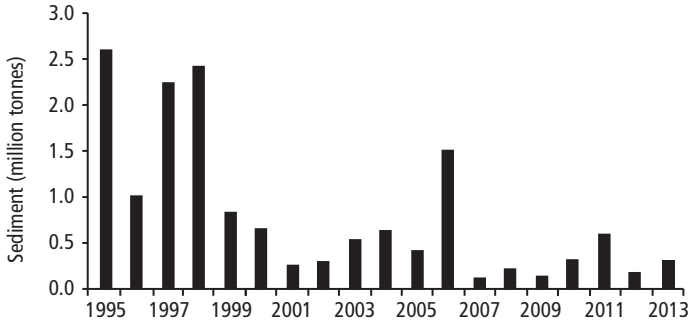
2 Guadalupe River Mercury Load



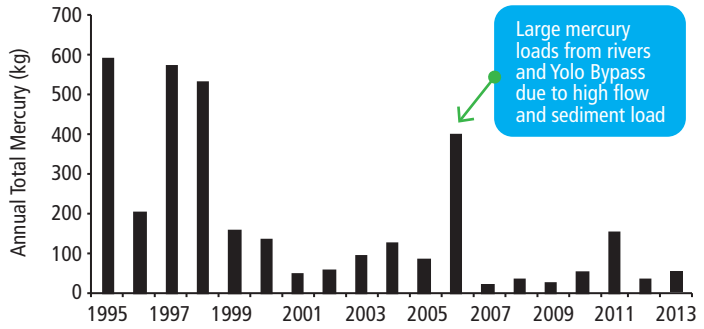
3 Delta Outflow



4 Delta Sediment Load



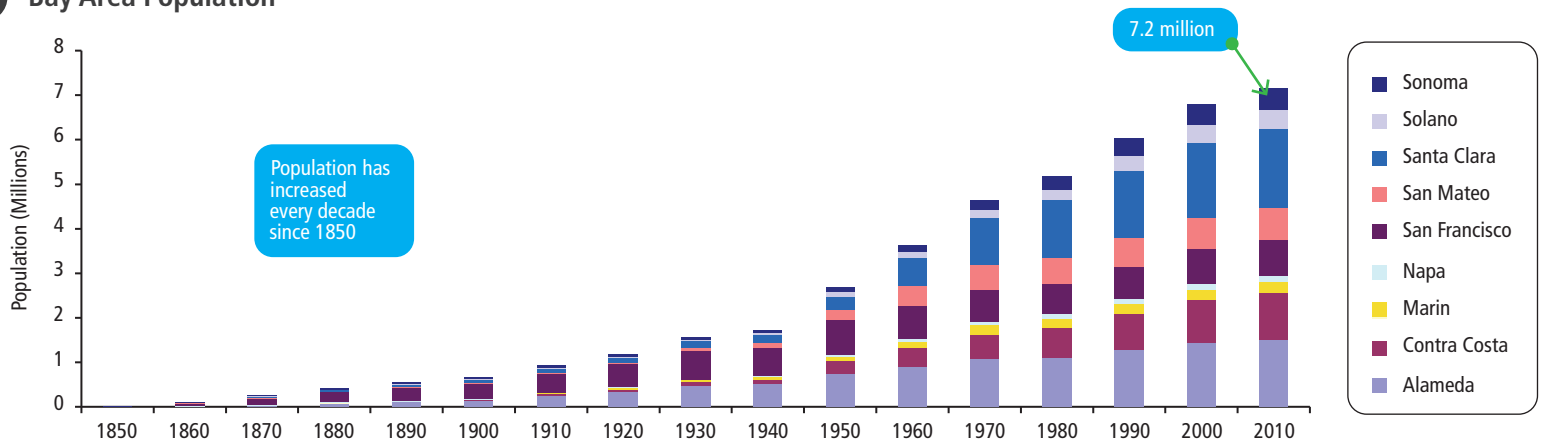
5 Delta Mercury Load



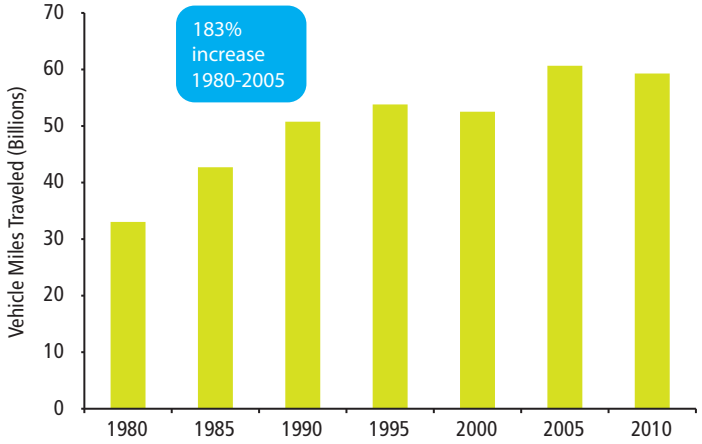
See page 53 for Graph Details

HUMAN PRESENCE

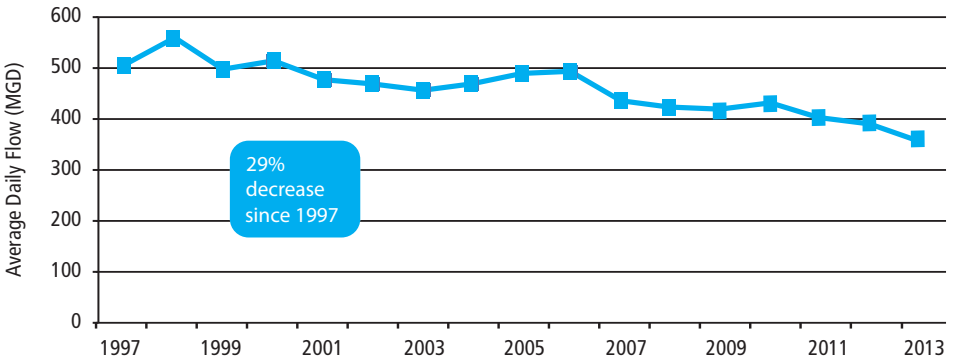
1 Bay Area Population



2 Bay Area Vehicles Miles Traveled



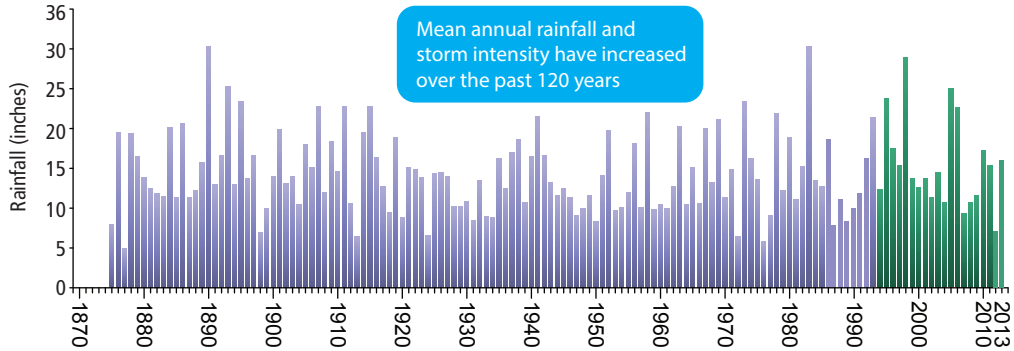
3 Flows from Top Ten Wastewater Treatment Plants



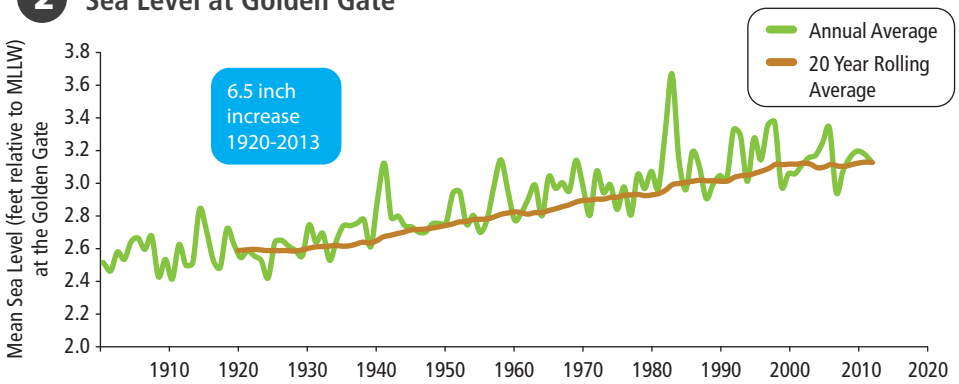
See page 53 for Graph Details

CLIMATE AND HABITAT

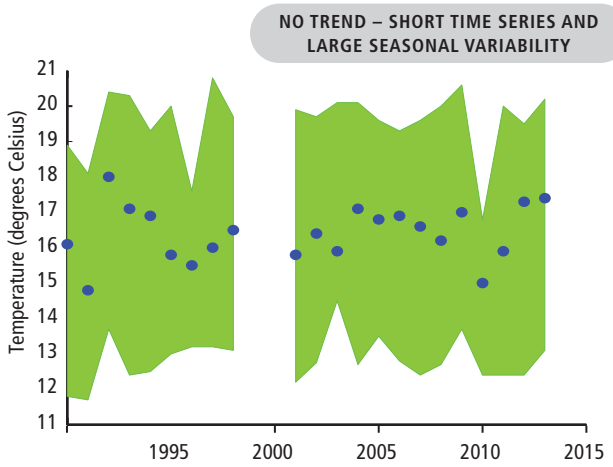
1 Rainfall in the Bay Area



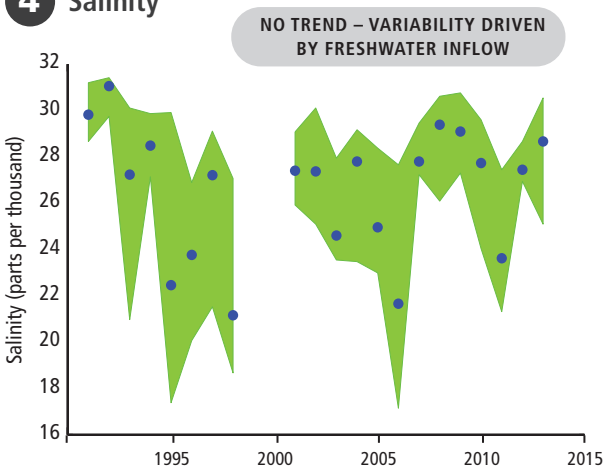
2 Sea Level at Golden Gate



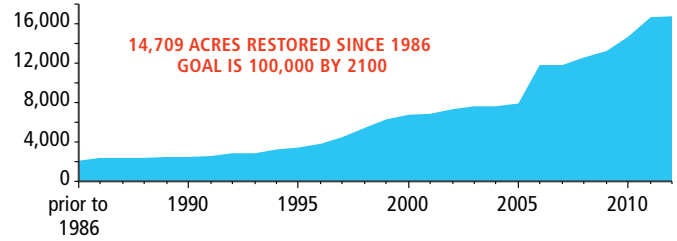
3 Water Temperature



4 Salinity



5 Restored Wetland Opened to Tidal Action

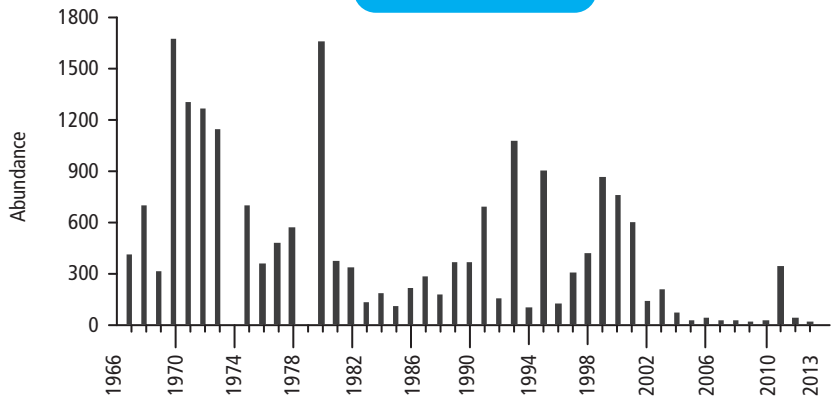


See page 53 for Graph Details

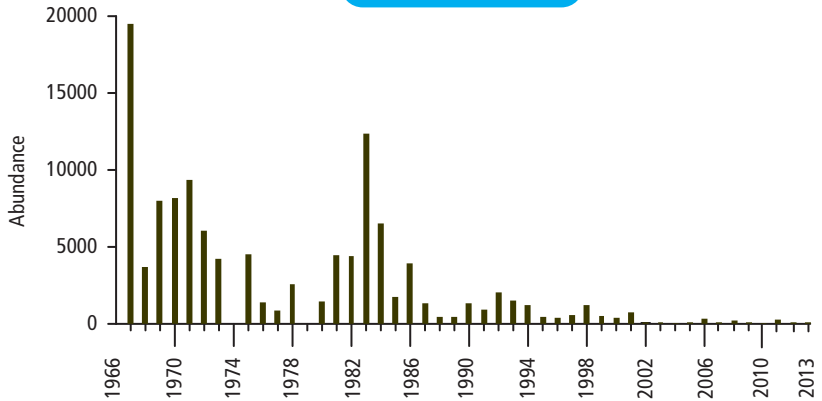
POPULATIONS

Pelagic Organism Decline

DELTA SMELT

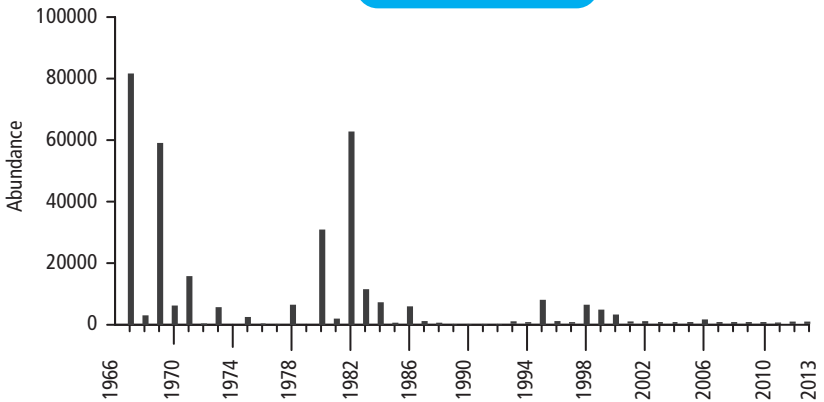


STRIPED BASS

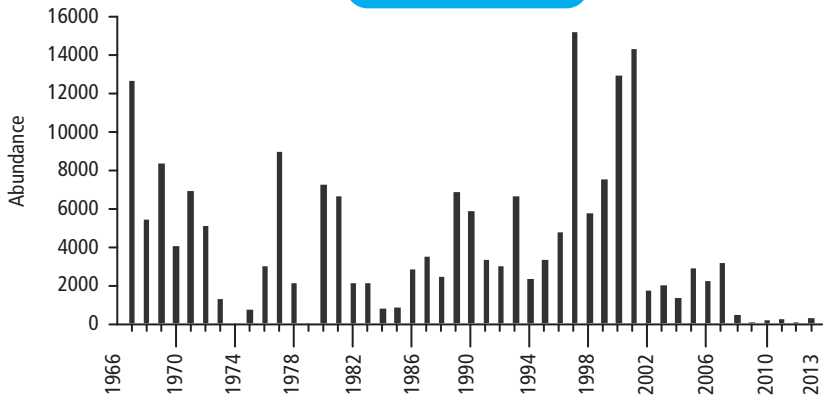


ALL SPECIES HAVE BEEN NEAR RECORD LOWS SINCE 2002

LONGFIN SMELT



THREADFIN SHAD



See page 53 for Graph Details

GRAPH DETAILS

Bay mud in the Ponar sampler.
Photograph by Thomas Jabusch.

Page 46

1) Bay-wide average methylmercury concentrations. Averages for striped bass based on concentrations for individual fish normalized to 60 cm. The no consumption advisory tissue level for mercury is 440 ppb, and the two serving advisory tissue level is 70 ppb.

2) Bay-wide average PCB concentrations. The no consumption advisory tissue level for PCBs is 120 ppb, and the two serving advisory tissue level is 21 ppb. White croaker were analyzed without skin in 2009, and with skin in previous years.

3) Bay-wide average dioxin TEQ concentrations. The San Francisco Bay Water Quality Control Board has developed a screening value for dioxin TEQs of 0.14 parts per trillion (ppt). White croaker were analyzed with skin from 1994-2006, and without skin in 2009.

4) Sediment samples are tested using amphipods and mussel larvae.

5) Average of Bay Area summer beach season (April-October) grades from Heal the Bay's annual beach report card.

Page 47

Data from USGS: sfbay.wr.usgs.gov/access/wqdata. Data from prior to 1969 from USGS. Data collected monthly at fixed stations along the spine of the Bay. Data for stations D10, D8, D7, D6, and D41 from IEP: www.water.ca.gov/bdma/meta/Discrete/data.cfm

1) Chlorophyll a, averaged over top 3 meters and all stations, in Suisun Bay (stations D10, D8, D7, D6, s4, s5, s6, and s7).

2) Chlorophyll a, averaged over top 3 meters and all stations, in San Pablo Bay (stations D41, s11, s12, s13, s14, and s15).

3) Chlorophyll a, averaged over top 3 meters and all stations, in South Bay (stations s21, s22, s23, s24, s25, s26, s27, s28, s29, s30, s31, s32, and s33).

4) Chlorophyll a averaged over the top 2 meters during August-October at stations s21, s22, s24, s25, s27, s29, s30 and s32.

5) Minimum dissolved oxygen concentration from stations s21, s22, s23, s24, s25, s26, s27, s28, s29, s30, s31, s32 and s33, averaged across all stations. Minimum dissolved oxygen values typically occur at or near the bottom of the water column. Horizontal line indicates 5 mg/L, the current Basin Plan DO standard.

Page 48

1 and 2) Data from USGS (sfbay.wr.usgs.gov/access/wqdata)and IEP (http://www.water.ca.gov/bdma/meta/Discrete/data.cfm). Average water column nutrient concentration per station was averaged within subembayment and then annually averaged.

3) Water year median and interquartile range suspended-sediment concentration, Dumbarton Bridge, 20 feet below mean lower low water. Based on 15-minute data collected by the U.S. Geological Survey (Buchanan and Morgan 2014). The station did not operate from November 2011 to March 2013 due to Bridge construction.

4) Data from the U.S. Army Corps of Engineers.

Page 49

1) Data from USGS. Data for all graphs are for water years (Oct 1 to Sep 30).

2) Total loads for each water year. Additional matching funds for this study provided by the CEP, USACE, SCVWD, and SCVURPPP.

3) Daily average Delta outflow from DAYFLOW. DAYFLOW data are available from the California Department of Water Resources (www.water.ca.gov/dayflow/).

4) Total sediment loads for each water year. Loads based on continuous measurements taken at Mallard Island by USGS sfbay.wr.usgs.gov/sediment/cont_monitoring/).

5) Total loads for each water year. Loads from 2002–2006 are based on field data. Loads for earlier and later years are estimated from relationships observed between suspended sediment and mercury in 2002–2006.

Page 50

1) Data from the Association of Bay Area Governments and U.S. Census Bureau. census.abag.ca.gov/counties/counties.htm

2) Data from Caltrans: trafficcounts.dot.ca.gov/

3) Data provided by the ten largest municipal wastewater dischargers to the Bay: San Jose, East Bay Dischargers, East Bay Municipal Utility District, San Francisco, Central Contra Costa, Palo Alto, Fairfield-Suisun, South Bayside System Authority, San Mateo, Vallejo.

Page 51

1) Annual rainfall measured at San Jose shown as index for Bay Area rainfall. These data are for climatic years (July 1 to June 30 with the year corresponding to the end date). Source: Jan Null, Golden Gate Weather Services

2) Data from National Oceanic and Atmospheric Administration: tidesandcurrents.noaa.gov/data_menu.shtml?bdate=19000520&edate=20110521&wl_sensor_hist=W5&relative=&datum=6&unit=1&shift=g&stn=9414290+San+Francisco%2C+CA&type=Historic+Tide+Data&format=View+Data

Water year median water temperature and interquartile range, San Mateo Bridge, 4 feet below mean lower low water. From 15-minute data collected by USGS (Buchanan 2013). 1999-2000 not shown because data were temporarily not collected during Bridge construction. Some variation is caused by different periods of missing data.

4) Same information as #3. Salinity reflects freshwater inflow to the Bay with lower values for higher inflows. Ocean water has a salinity of 35 parts per thousand.

5) Data from the California Wetlands Portal (www.californiawetlands.net/tracker/).

Page 52

All data from: www.dfg.ca.gov/delta/data/fmwt/indices.asp

GLOSSARY

ATL	Advisory tissue level
BACWA	Bay Area Clean Water Agencies
CECs	Contaminants of emerging concern
CEP	Clean Estuary Partnership
DDT	Dichlorodiphenyltrichloroethane
DO	Dissolved oxygen
MRP	Municipal Regional Stormwater Permit
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
RMP	Regional Monitoring Program
PAHs	Polycyclic aromatic hydrocarbons
PCBs	Polychlorinated biphenyls
PBDEs	Polybrominated diphenyl ethers
PFC	Perfluorochemicals
PFOS	Perfluorooctane sulfonate
POTW	Publicly-owned treatment works
ppb	Parts per billion
ppm	Parts per million
PPCPs	Pharmaceuticals and personal care products
SCVURPP	Santa Clara Valley Urban Runoff Pollution Prevention Program
SCVWD	Santa Clara Valley Water District
SQOs	Sediment quality objectives
SSC	Suspended sediment concentration
TEQs	Toxic equivalents
TMDL	Total maximum daily load
USACE	United States Army Corps of Engineers
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
WWTP	Wastewater treatment plant
WY	Water Year

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