

2000 Update

Pulse of the Estuary

MONITORING AND MANAGING CONTAMINATION ☐
IN THE SAN FRANCISCO ESTUARY

SFEI
San Francisco Estuary Institute

BAY VS. ESTUARY

Although most people still refer to the expanse of water inside the Golden Gate as *San Francisco Bay*, the term *San Francisco Estuary* is becoming more common. An estuary is a place where fresh and salt water meet. San Francisco Estuary includes San Francisco Bay, the Sacramento/San Joaquin River Delta, and all waters in-between. Using the term *San Francisco Estuary* avoids the geographic ambiguity of *San Francisco Bay*, which does not have a well defined upstream boundary.

ABOUT THIS REPORT

This report summarizes the current status of chemical contamination in the Estuary and efforts by environmental managers to reduce and prevent contamination problems. Most of the monitoring results in the report are a product of the San Francisco Estuary Regional Monitoring Program for Trace Substances (RMP), which is administered by the San Francisco Estuary Institute (SFEI), an independent nonprofit research organization based in Oakland, California.

The *Pulse of the Estuary* is one of three Regional Monitoring Program reporting products for 2000. The second product, *RMP 2000 Monitoring Results*, will be available on SFEI's web site (www.sfei.org) and includes comprehensive data tables and charts of 2000 monitoring results. The third product is the *RMP Technical Reports* collection. Each of these reports addresses a particular study or aspect of Estuary monitoring. A list of all technical reports produced or in preparation since the last *Pulse* is found on page 22.

This is the third *Pulse of the Estuary* report. New additions this year include comparisons to other urban estuaries in the U.S. (pages 7 and 8), a chart showing progress towards meeting all water and sediment quality guidelines (page 2), new information on previously unknown organic contaminants, and updated maps of contamination.

The two previous issues of the *Pulse* contain information that remains relevant. Introductory information on what is measured by the RMP and why can be found in the 1998 *Pulse*. The *Pulse* can be found at www.sfei.org.

Comments or questions regarding the activities of the Regional Monitoring Program can be addressed to Dr. Jay Davis, RMP Program Manager, (510) 746-7334, jay@sfei.org.

The Pulse of the Estuary

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This report is also available on the web at www.sfei.org.

San Francisco Estuary Contamination Overview

Q: How contaminated is the Estuary?

A: While the water and sediment of the Estuary meet cleanliness guidelines for most contaminants, a few problem contaminants are widespread. Of the recent (1996–2000) water and sediment samples collected by the Regional Monitoring Program (RMP), about 85% contained at least one contaminant at a level that failed to meet established guidelines. About 90% of the fish samples tested by the RMP in 2000 contained PCBs at a level that warrants concern for human health. About 7% of water samples and 75% of sediment samples tested were toxic to at least one species of test organism. Cleanliness guidelines can change based on new information; see *Contaminant Guidelines*, page 5.

Q: Is the contamination getting better or worse?

A: For most well-known contaminants, the Estuary is clearly better than in earlier decades. Since the start of RMP monitoring in 1993, there is some suggestion but no definite indication of continued improvement. If contaminant levels are still going down, the decrease is very gradual. For lesser-known contaminants that we are just starting to monitor (see *Closing in on Unidentified Contaminants*, page 18), we do not know yet if contamination is getting better or worse.

Q: Are contaminants in the Estuary harming the ecosystem?

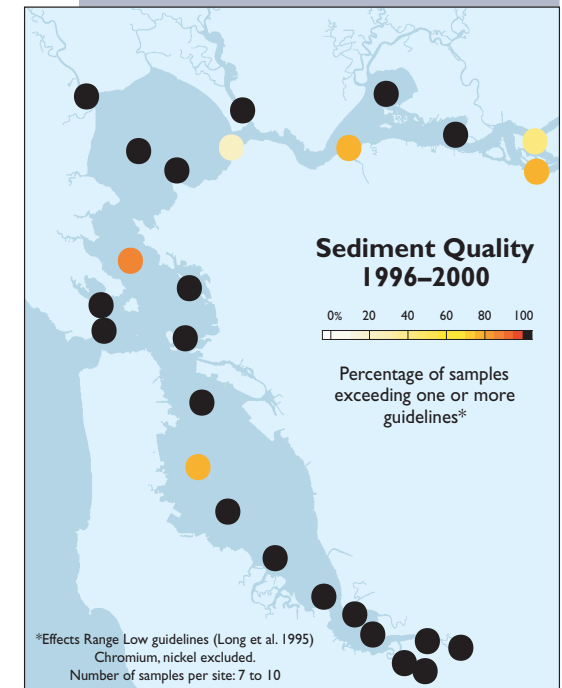
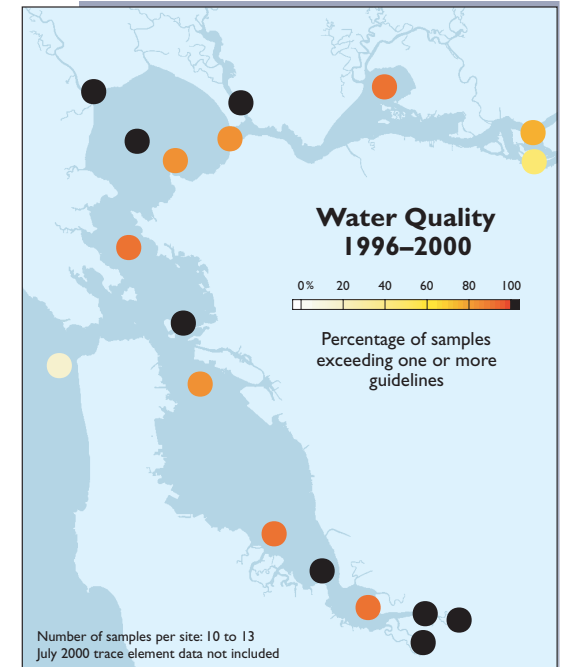
A: This critical question remains largely unanswered. There are indications that the current level of contamination is harming the health of the ecosystem, such as the frequent occurrence of contaminants above water and sediment guidelines, and the toxicity of water and sediment samples to lab organisms. About 75% of sediment samples collected between 1996 and 2000 were toxic to organisms in the laboratory. The RMP is conducting new work to increase our knowledge of contaminant effects; see *Measuring the Adverse Effects of Contaminants: A New Emphasis* on page 16.

Q: Do we know how to clean up the Estuary?

A: There are three general approaches to Estuary clean-up:

1. **Reducing the entry of additional contaminants is essential.** Preventing a contaminant from entering the Estuary requires knowledge of its source or an interceptable part of its path to the Estuary. We are just beginning to develop detailed descriptions of the sources, pathways and repositories of contaminants.

The maps on the right summarize overall contamination levels based on the last five years of water and sediment monitoring work performed by the RMP. Sites were usually sampled two (for sediment) or three (for water) times a year. The upper map shows the percentage of RMP water samples from each site containing any contaminants above water quality guidelines (see *Guidelines*, page 5). The lower map shows the same statistic for sediment samples. Nickel and chromium were excluded as they occur naturally at high levels, see *Naturally High Metal Levels*, page 10)



TOP KNOWN CONTAMINATION PROBLEMS

- High levels of mercury and PCBs in fish
- Estuary water is occasionally toxic, probably in part due to pesticides
- Estuary sediment is frequently toxic

SITES OF GREATEST CONCERN AND SITES OF LEAST CONCERN

Contamination is not spread evenly throughout the Estuary. Overall, monitoring sites in the lower South Bay, the Petaluma and Napa River mouths, San Pablo Bay, and Grizzly Bay (see map on page 1) are more contaminated than other sites. The South Bay sloughs are particularly contaminated (however, similar sloughs in other parts of the Estuary are not monitored). The least contaminated site is in the ocean west of the Golden Gate.

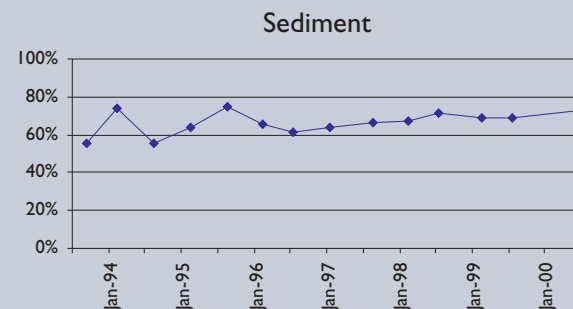
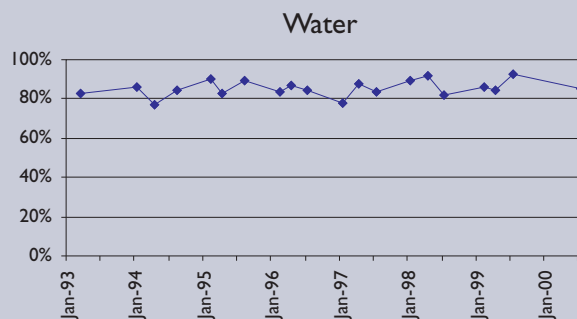
Most contaminant guidelines are being met. It is a relatively small number of problem contaminants that make it rare to find clean water or sediment in the Estuary.

tion. Much of this effort is in response to the Clean Water Act's requirement to develop contaminant clean-up plans known as Total Maximum Daily Loads (TMDLs, see page 3). Only known contaminant problems are being addressed by TMDLs; other problem contaminants may be developing, and contaminant surveillance is now being conducted to stay on top of this issue (see *Closing in on Unidentified Contaminants*, page 18).

2. **Removing some existing contaminants is possible.** Contaminated sediment can be dredged from the Estuary, placed on land and sealed with a layer of asphalt or similar material. Such dredging has been attempted in a few cases with mixed results (e.g. Weston *et al.* 2001). Contaminant removal will probably be just a small part of the solution.
3. **Allowing contaminants to degrade and disperse naturally is necessary.** Time will always be a large part of the remedy, naturally reducing the large quantity of contaminants now in the sediments through degradation, permanent burial under new, cleaner sediments, and transport to the ocean and atmosphere. For persistent contaminants found in large amounts in the sediments of the Estuary, such as mercury and PCBs, the time required to see change will likely be decades.

Progress towards meeting water and sediment quality guidelines

A value of 100% would mean all water or sediment samples met guidelines for all contaminants. Most contaminant guidelines are being met. It is a relatively small number of problem contaminants that make it rare to find clean water or sediment in the Estuary (as the maps on the previous page indicate). Neither chart shows a clear trend.



These charts were created by calculating, for each sampling period and contaminant, the percentage of samples that met the quality guideline. Results for each contaminant were then averaged within each sampling period to obtain the values plotted on the chart. A fixed group of RMP stations and contaminants were used for all sampling periods.

The water plot was made using silver, arsenic, copper, mercury, nickel, lead, selenium, zinc, diazinon, dieldrin, chlordanes, DDTs, PAHs and PCBs at Dumbarton Bridge, Redwood Creek, Yerba Buena Island, Golden Gate, San Pablo Bay, Pinole Point, Davis Point, Napa River, Grizzly Bay, Sacramento River and San Joaquin River stations.

The sediment plot was made using silver, arsenic, cadmium, copper, mercury, nickel, lead, zinc, dieldrin, chlordanes, DDTs, PAHs and PCBs at South Bay, Dumbarton Bridge, Redwood Creek, Oyster Point, Yerba Buena Island, Horseshoe Bay, Richardson Bay, Point Isabel, San Pablo Bay, Pinole Point, Davis Point, Napa River, Pacheco Creek, Grizzly Bay, Sacramento River and San Joaquin River stations.

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THE CLEAN WATER ACT AND TMDLS

The Clean Water Act recognizes that every body of water provides benefits that are valuable and worth protecting. The beneficial uses of a particular water body might include, for example, catching and eating fish, swimming, and drinking. Such uses require good water quality. Traditional management of water quality centers on maintaining standards for the cleanliness of wastewater. In some places this approach successfully protects the uses of a water body, but in others it does not. Water bodies that continue to lack the water quality necessary for supporting their designated uses are considered “impaired waters.” Each state is required to develop a list of impaired waters and the contaminants that impair them (known as the “303(d) list,” after the corresponding section of the Clean Water Act). Under the Clean Water Act, cleanup plans known as Total Maximum Daily Loads (TMDLs) must be developed for all impaired waters. The TMDL process takes a more comprehensive view of water quality by identifying all contaminant inputs to the water body, determining the total input the water body can handle, and designating particular inputs that need reduction.

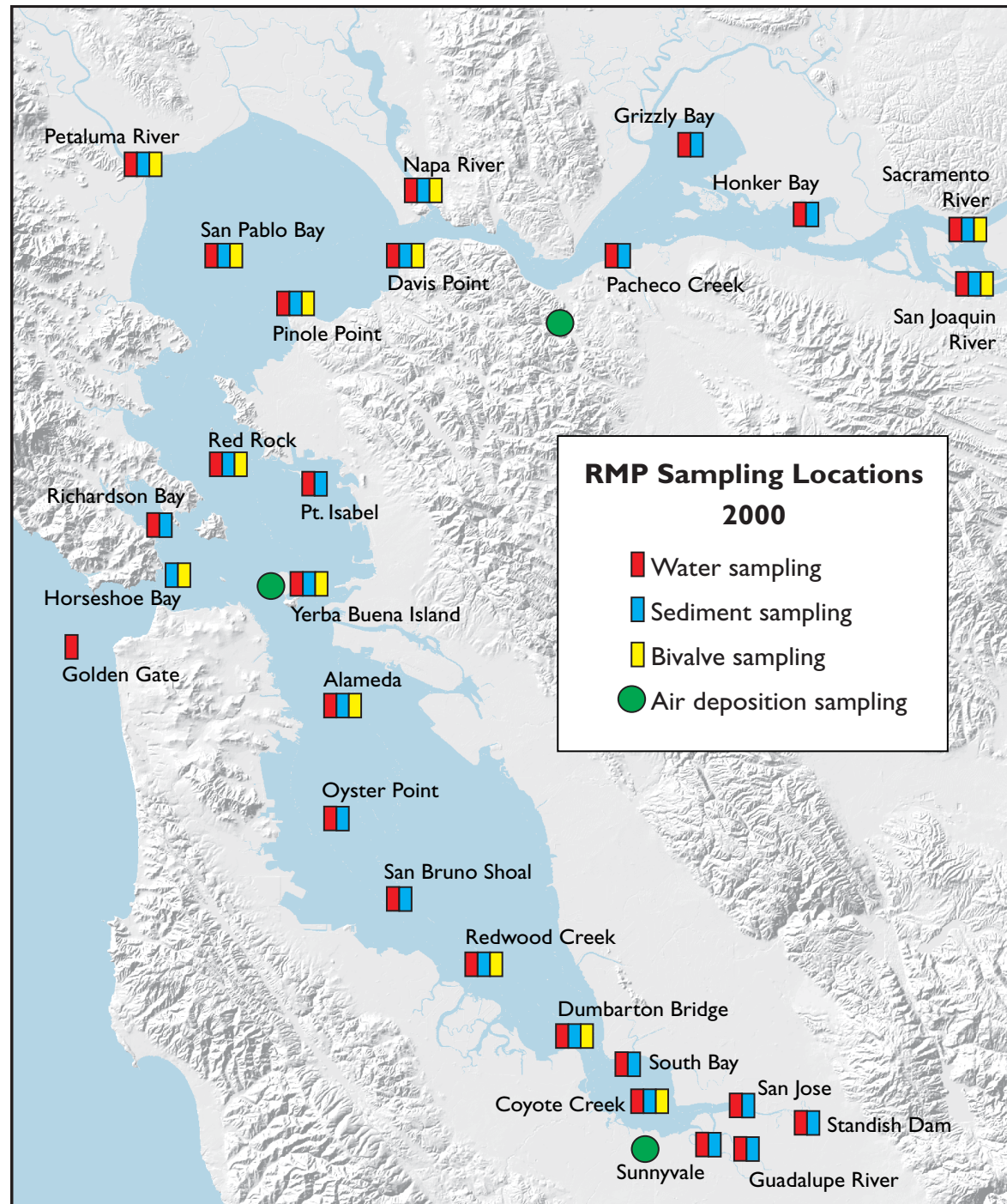
RMP PURPOSE

The Regional Monitoring Program exists to aid the management of contamination in the Estuary. It does this by providing information on:

- The status and trends of contamination
- The sources and pathways of contaminants and their relative importance
- The effects or potential effects that contamination is having on organisms that live in and use the Estuary, including humans

RMP ORIGIN

The Regional Monitoring Program was created in 1993 by the San Francisco Bay Regional Water Quality Control Board (Regional Board), with the help of the Estuary's wastewater dischargers and dredgers. The RMP is an innovative collaboration between the Regional Board (the local regulatory agency implementing the Clean Water Act and the California Water Code), the regulated entities that fund and participate in the Program (currently 72 wastewater and stormwater dischargers and dredgers), and the San Francisco Estuary Institute (SFEI), an independent nonprofit scientific research organization.



Introduction

What do the Estuary's environmental managers need from scientists?

At the most basic level, an environmental manager needs to know if any natural resources are being harmed, what the causes of harm are, and how best to correct the problem. Scientists can provide information in all these areas.

Comparing contamination levels to water or sediment quality guidelines can identify contaminants that may be at harmful levels. Evidence of harm can be obtained from tests of water and sediment toxicity (see *Toxicity Testing sidebar*, page 15) and studies of variation in animal communities such as bottom-dwelling organisms. Linking evidence of harm to a particular contaminant or contaminant group is possible through experiments that identify toxic agents or measure contaminant-specific organism responses.

Determining how best to correct a contamination problem requires the ability to predict the system's response to corrective actions. This is only possible by having a good understanding of contaminant sources, repositories, transformations and movements through the system. One expression of this understanding is a numerical model of the system that predicts contaminant behavior (see *The Five Decade Forecast for PCBs in the Bay*, page 14).

In the end, the well-informed manager and the public must decide if the cost of any remedy exceeds the expected benefit.

Top Known Contamination Problems: An Update

The top three known contamination problems in the Estuary remain the same as when first presented in the *Pulse* two years ago. They are:

1. High mercury and PCBs levels in fish

Mercury, a neurotoxin, and polychlorinated biphenyls (PCBs), a group of carcinogens and developmental toxins, have the potential to harm Estuary fish and the humans and wildlife that consume them.

2. Toxic water and 3. Toxic sediment

When Estuary water or sediment can harm or kill organisms in the lab (see *Toxicity Testing sidebar*, page 15), it indicates that life in the Estuary is potentially being harmed or killed. Trouble for one group of organisms can have a domino effect on other organisms linked by the Estuary food web. Research since 1996 implicates organophosphate pesticides as the cause of some water toxicity (Ogle *et al.* 2002), but other causes remain unknown.

UPDATE ON THE MERCURY PROBLEM

Tracking down sources and pathways

In the fall of 2000, local storm water management agencies completed the first phase of a multi-year effort to measure the distribution and concentrations of mercury and methylmercury in sediment collected from drainage areas of Bay Area watersheds and storm drains (Gunther *et al.* 2001, KLI 2001). Results from the first year of the study indicate that watersheds differ in mercury and methylmercury contamination, with higher concentrations in urbanized watersheds compared to less-developed drainage areas. Mercury concentrations in sediment from urban drainages were similar to concentrations in Bay sediment, except for elevated concentrations in a few watershed sites that are probably currently contributing mercury to the Estuary. Of 83 samples analyzed, five (6%) had mercury concentrations above 0.71 mg/kg, the guideline indicating probable harm to aquatic life (ERM guideline). The two highest concentrations, 4.3 and 2.1 mg/kg, were measured in sediment collected within the Guadalupe River watershed, which drains the inoperative

CONTAMINANT GUIDELINES

Contaminant guidelines* are generally intended to indicate if water or sediment is safe. Water and sediment are safe when those things we value (e.g. wildlife, being able to eat fish we catch, or ecosystem functions) are being protected. Guidelines provide a way to connect monitoring results, which are just numbers, with judgements on the condition of the environment.

It is a daunting task to figure out just how high is too high when referring to contaminant levels in the Estuary. It is assumed that all organisms can tolerate some level of exposure to contaminants, but if that exposure gets too high, an "adverse effect," such as abnormal embryo development or death, will occur.

Guidelines are set to protect Estuary wildlife and humans from adverse effects. Of course, what is too high for some organisms may be perfectly tolerable for others. Natural factors also can have an influence; what is too high at one temperature or salinity may be tolerable at another. Contaminant mixtures can also act additively or synergistically, causing adverse effects even if the contaminant levels taken individually are safe. Given these variables, setting a proper guideline is a challenging and inexact task. Guidelines can change as

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* In this report, the general term guideline is used to refer to several types of environmental quality benchmarks, from legally enforceable water quality objectives to unofficial benchmarks such as the Effects Range values for sediment (Long *et al.* 1995).

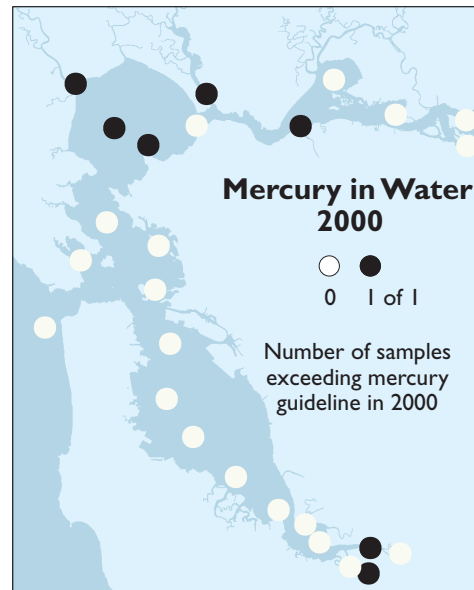
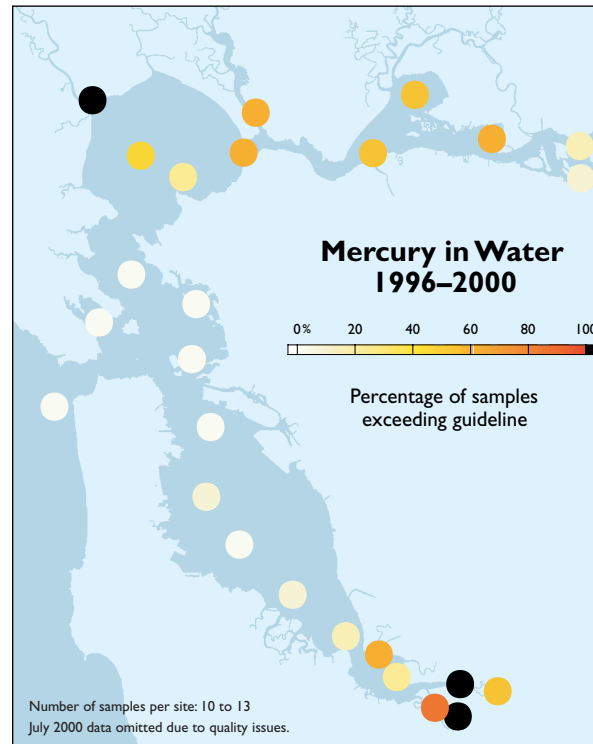
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new information becomes available that indicates a guideline is not protective enough or is inappropriately low compared to natural concentrations. RMP results have helped determine if guidelines are set appropriately. Most guidelines were created for use throughout the state or nation, not specifically for the Estuary. Guidelines specific to the Estuary have been developed for some contaminants.

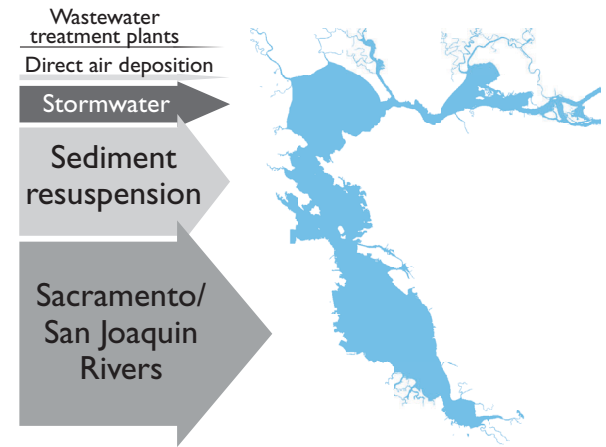
For water, guideline development incorporates both laboratory studies and field observations, and is designed to protect a particular set of qualities we value, known in the California Water Code as “beneficial uses.” Water quality guidelines are intended to protect most organisms most of the time, not all organisms all of the time. The Regional Water Quality Control Board, a state agency, sets water quality objectives with guidance from the U.S. Environmental Protection Agency. In 2000, the water quality objectives for the Estuary were revised. The revised values, collectively known as the California Toxics Rule, are used in this report. For a list of the values, see http://www.sfei.org/rmp/2000/2000_Annual_Results.htm.

For sediment, the guidelines used in the maps of this report (“Effects Range Low” or ERLs) are based on a study that compiled many observations of adverse effects on organisms in laboratories and natural settings around the world (Long *et al.* 1995). Using ERLs sets a high standard for Estuary cleanliness. For a list of the values, see http://www.sfei.org/rmp/2000/2000_Annual_Results.htm.

For fish, the guidelines, set by state and federal agencies, aim to protect human consumers and consider what is known about animal responses to ingesting contaminants.



Relative size of mercury inputs to the Estuary



mercury mines of the former New Almaden Mining District (see *Mercury* sidebar, page 7). This finding is consistent with RMP monitoring that has repeatedly found elevated concentrations of mercury in water and sediment near the mouth of the Guadalupe River (Leatherbarrow and Hoenicke 2002). Methylmercury is the form of mercury that accumulates in animals and is of greatest concern. Methylmercury concentrations did not follow the same pattern as mercury, but were probably related to areas with oxygen-poor sediment optimal for methylation.

A study by the RMP completed in 2000 concluded that mercury in the air is deposited on the Estuary surface at a rate of 30 kg/year. In comparison, mercury carried to the Estuary from local watersheds totals 170 kg/year, including 60 kg/year as “indirect atmospheric deposition” that falls on land surfaces and is carried to the Estuary by stormwater drains, creeks, and local rivers. The total air deposition is approximately seven times the amount contributed by local wastewater dischargers, whose contributions were found to be smaller than previously estimated due to improved sample collection and analytical methods.

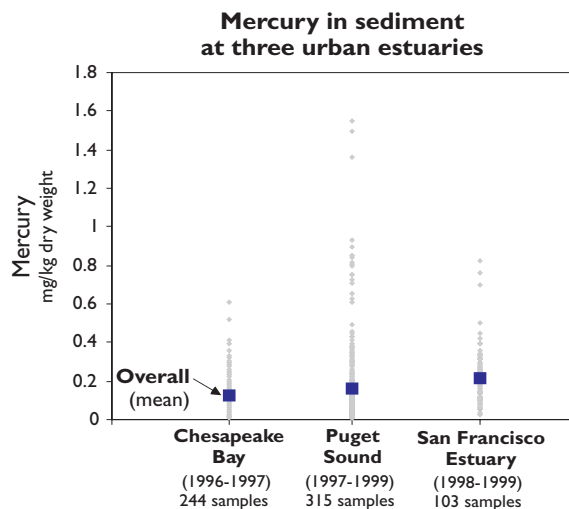
Regardless, total mercury conveyed to the Estuary by atmospheric deposition and wastewater discharges is very small compared to the amount carried in by the Sacramento and San Joaquin Rivers (estimated at 560-1150 kg/year) and resuspension of previously contaminated Bay sediments (estimated at 200-800 kg/year; see figure above). Additional work to characterize the proportions of each form of mercury carried by these different pathways would help us better understand their relative risks.

The Mercury TMDL

The state's clean-up plan for mercury in the Estuary, the mercury TMDL (see *The Clean Water Act and TMDLs sidebar*, page 3) has been drafted. The TMDL must undergo a series of approvals, culminating with approval by the U.S. EPA. If approved, regulators will begin taking action to bring about the reductions in mercury inputs specified in the TMDL, the largest of which is proposed for the inactive New Almaden mine in the Guadalupe River watershed.

How do other urban Estuaries compare?

Mercury in sediment at three urban estuaries compares mercury concentrations in Puget Sound, Chesapeake Bay, and San



Data from the Chesapeake Bay Program Toxics Characterization data files, the Puget Sound Ambient Monitoring Program/NOAA spatial monitoring database, and the RMP.

Francisco Estuary. Comparable time periods were chosen for each estuary, however, laboratory methods, sampling location characteristics, and other factors were not considered. Therefore, *consider this comparison a rough indication only*. Inspection of the comparison graph shows no striking differences in the contamination levels between the estuaries. Nevertheless, San Francisco does appear to have a higher average mercury concentration than the other two estuaries. This is consistent with the history of intensive mining operations in the watershed, performed on a scale not found in the watersheds of the other estuaries.

UPDATE ON THE PCB PROBLEM

Tracking down sources and pathways

As part of a study of local watershed contamination, storm water management agencies in 2000 measured PCB concentrations in storm drain and creek sediment (Gunther *et al.* 2001, KLI 2001). As with mercury, PCB concentrations in sediment collected from urban drainages were significantly higher than concentrations in non-urban drainage areas. Of the 83 samples collected, eleven (13%) contained PCB concentrations above 180 µg/kg, the guideline indicating probable harm to aquatic life. The highest sample, from an industrial area in Santa Clara Valley, was above 26,000 µg/kg. PCB concentrations in sediment from open-water RMP stations were generally lower than concentrations measured near the bottom of adjacent watersheds, implying these watersheds as current sources of PCBs to the Estuary. Plans for future monitoring will include additional monitoring for PCBs and other contaminants of concern, in an attempt to identify sources and movement within the watersheds.

Recent work by the RMP in the South Bay indicates Coyote and Guadalupe Creeks are current sources of PCBs to the Estuary, together contributing about 1 kg of PCBs a year (see *The Five Decade Forecast for PCBs in the Bay* on page 14 to put this figure in context). Most of the PCBs appear to have entered Coyote Creek between the Standish Dam and San Jose sampling stations (see map on page 4),

MERCURY (Hg)

Mercury is naturally abundant in the rocks of the Coast Range of northern and central California. Human activities over the past 150 years have moved a substantial amount of this mercury out of the rocks and into the ecosystem.

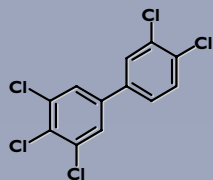
Mercury has numerous commercial and industrial uses, including thermometers, fluorescent lamps, dental fillings, and batteries. During the late 1800s and early 1900s, mercury was mined intensively in the California Coast Range for use primarily in gold extraction in the Sierra Nevada. Although the extraction of gold by mercury amalgamation has been banned in the United States, San Francisco Bay continues to receive mercury from mine drainage and mining debris deposits in upland watersheds (SFEI 1999a).

Mercury is found in several forms, some of which have much greater potential for harm than others. Methylmercury (CH₃Hg⁺) is the form of greatest concern since it accumulates in animal tissue and moves from prey to predator up the food web. Methylmercury is produced by bacterial action in sediment.

Mercury is of high concern with regard to human health since it accumulates in tissues, and its levels increase up the food web. Human exposure to mercury occurs primarily through consumption of contaminated fish. Mercury is a neurotoxicant and is particularly hazardous to the developing nervous system of fetuses and children.

Mercury also has potential to harm the ecosystem, especially birds and other wildlife high in the food web.

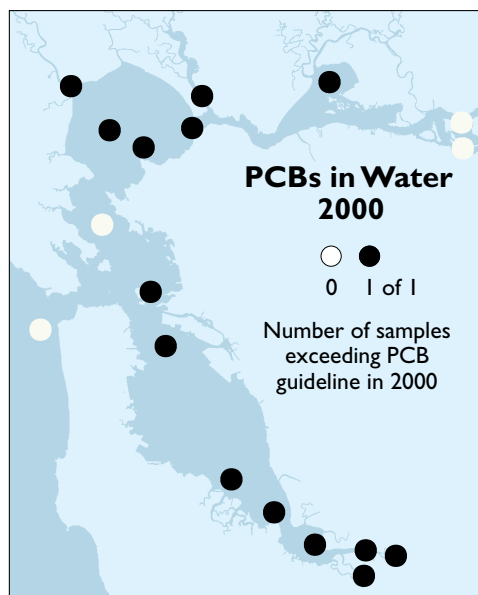
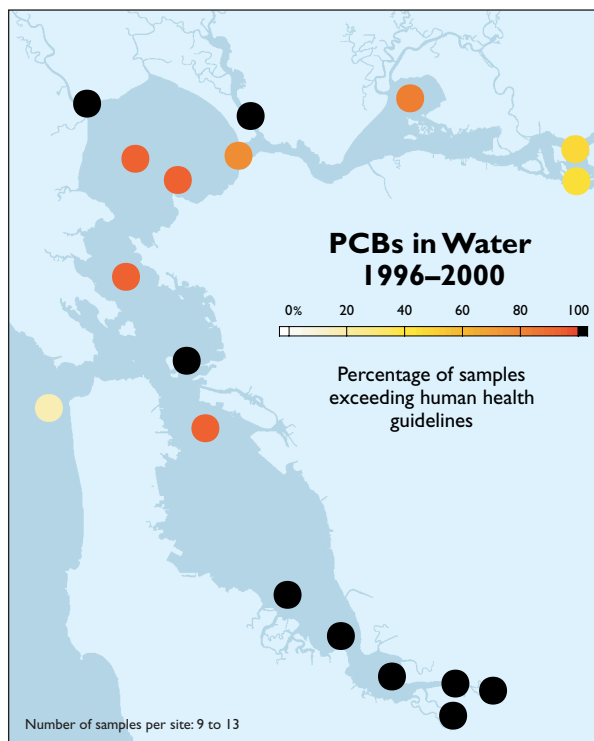
POLYCHLORINATED BIPHENYLS (PCBs)



PCBs are a group of over 200 organic chemicals with a number of characteristics that made them useful to industry. Manufactured from 1929 to 1979, PCBs were primarily used as hydraulic fluids, lubricants, plasticizers, in electrical transformers, and in carbonless copy paper. Smaller quantities were also used as pesticide extenders and in inks, waxes, and other products.

Growing awareness of the environmental impacts of PCBs, including their persistence and accumulation in animal tissue, led to a ban on their sale and production in the United States in 1979. Enclosed uses, such as in electrical transformers, are still permitted, and thousands of kilograms are known to be in use in the Bay Area. The bulk of the current PCB problem in the Estuary is believed to stem from activities prior to the 1979 ban.

PCBs tend to be found at higher concentrations in animals that are higher in the food web. Therefore, predatory fish, birds, and mammals near the top of the food web, including humans that consume fish, are particularly vulnerable to the accumulation and effects of PCB contamination. Individual PCBs vary in their toxicity, but in general PCBs are extremely toxic in long-term exposures and can cause developmental abnormalities, disruption of the endocrine system, impairment of immune function, and cancer.

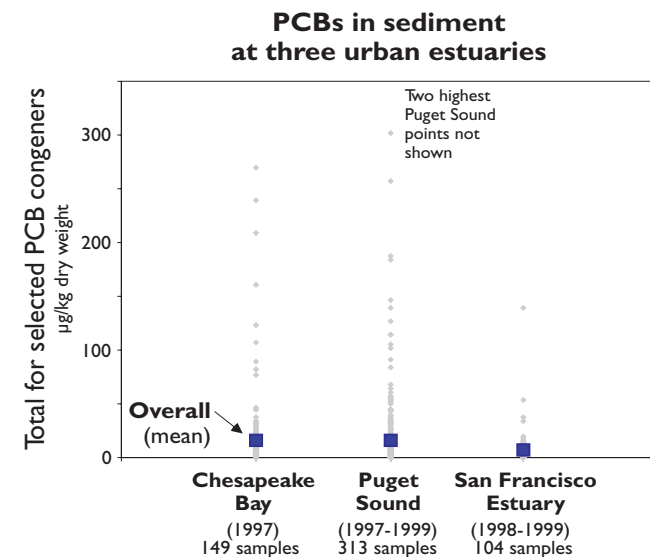


given the higher concentrations at San Jose. However, that station may be influenced by PCBs brought in with the tides (Leatherbarrow and Hoenicke 2002).

The RMP's atmospheric deposition study measured PCB concentrations in air and calculated that PCBs deposit on the Estuary at a rate of about 0.4 kg/year. At the same time however, PCB concentrations in water are sufficiently high to cause an estimated 7 kg/year of PCB vaporization, yielding a net loss of PCBs from the surface of the Estuary to the atmosphere. In fact, without this loss the concentration of PCBs in Estuary water would be much higher. PCB-contaminated sediments already in the Estuary and PCB-laden stormwater likely contribute most of the PCBs found in the waters of the Estuary.

How do other urban Estuaries compare?

PCBs in sediments at three urban estuaries compares PCB concentrations in Puget Sound, Chesapeake Bay, and San Francisco Estuary. Comparable time periods were chosen for each estuary, however, laboratory methods, sampling location characteristics, and other factors were not consid-



Data from the Chesapeake Bay Program Toxics Characterization data files, the Puget Sound Ambient Monitoring Program/NOAA spatial monitoring database, and the RMP.

ered. Therefore, *consider this comparison a rough indication only*. Inspection of the comparison graph reveals that there are no striking differences in the contamination levels between the estuaries. There is a suggestion that San Francisco has the lowest PCB contamination. PCB sediment contamination often takes the form of isolated “hot spots” with very high concentrations, and the higher overall results for Chesapeake and Puget Sound could reflect more sampling of hot spots, rather than an overall higher level of contamination.

Solving the PCB problem: The PCB TMDL

Fred Hetzel, Regional Water Quality Control Board

As reported last year, there are a number of challenges in the development of the San Francisco Bay PCBs TMDL. As with many other legacy organic pollutants, a large mass of PCBs is already present in the estuary. Based on data from the United States Geological Survey (USGS), 10,000 to 50,000 kilograms of PCBs are already present in Estuary sediment. This Estuary-wide estimate does not include local “hot spots” of PCB contamination. Inputs of PCBs from the disturbance of contaminated Estuary sediment needs to be evaluated and compared to other sources of PCBs to the Estuary.

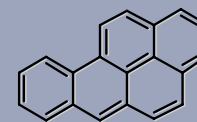
Other sources include deposition from the air, municipal and industrial wastewaters and storm water runoff. We now have an estimate of the flow of PCBs between the Estuary and the atmosphere (see *Tracking down sources and pathways*, page 7). Municipal and industrial facilities have quantified PCBs in their effluent (Yee *et al.* 2001). This was a state of the art study with a high degree of data variability due to the extremely low concentration being measured. Results indicate that municipal and industrial facilities discharge roughly 2–5 kilograms of PCBs each year into San Francisco Bay. We now know the PCB sediment concentrations in many creeks and storm drains (see *Tracking down sources and pathways*, page 7). When sediment concentrations are combined with measurements of sediment transport to the Estuary, PCB inputs can be

quantified. At several locations with very high PCB concentrations, sources are being identified, which will lead to the development and implementation of PCB management plans for storm water. A second phase of sediment sampling and analysis for PCBs was started in 2001.

Modeling results indicate that even relatively small masses of PCBs entering the Estuary can have a significant impact on the recovery of the Estuary. Therefore, control of ongoing sources of PCBs can accelerate the natural recovery of the Estuary. We will continue working with the various agencies and industries in identifying and controlling current sources of PCBs to the Bay.

Based on the data collected so far, Regional Board staff are preparing a draft report detailing permissible flows of PCBs to the Estuary. This report should be available in the spring and is due to U.S. EPA by April 2002, who must approve the plan before action is taken.

POLYCYCLIC AROMATIC HYDROCARBONS (PAHs)



PAHs are ubiquitous in the environment, forming whenever organic substances are exposed to high temperatures. PAHs form when plant material is burned. A forest fire, a log in a fireplace, charcoal in a grill, and car exhaust are all sources of PAHs. Crude oil and refined petroleum products contain PAHs. PAHs can be suspended in the air and deposited directly onto the surface of water during rainfall. PAHs also attach to dust particles that can settle on the surface of the Estuary or the ground. Rain water can wash particles from streets and parking lots into channels, creeks, and ultimately the Estuary. Higher concentrations of PAHs are found in urban areas due to higher emission rates.

When PAHs enter the Estuary, they accumulate in sediments and organisms at the base of the food web. They can elicit a wide variety of toxic effects in aquatic species, including impaired survival, growth, metabolism, reproduction, immune function, and photosynthesis. Due to the tendency of most PAHs to accumulate in sediment, they pose an acute hazard primarily to invertebrates living in sediments. These organisms are an important food source for many species of fish. PAHs, particularly the larger PAH molecules, are among the most potent carcinogens known.

NATURALLY HIGH METAL LEVELS

Because of the types of soils and rock within its watershed, Estuary sediment naturally contains large amounts of some metals and other trace elements, particularly nickel and chromium. Although all metal levels have been increased by human activities, certain metal levels that would indicate a problem in many water bodies appear to be causing no harm in the Estuary. Thus, comparing local metal concentrations to guidelines not specifically developed for the Estuary could be misleading, and the traditional goal of reducing concentrations below guidelines could be impossible to achieve for metals like chromium. A further complication is that many metals have several common forms which differ markedly in their potential to cause harm, yet in general current monitoring does not measure each form independently. Given these issues and the lack of Estuary-specific sediment metal guidelines, evaluating RMP sediment metal data in terms of Estuary health can be difficult. Knowledge of pre-industrial metal concentrations deep in sediment can help provide the perspective needed to establish Estuary-specific guidelines.

Water, Sediment, and Fish: Status and Trends Update

WATER

Status

Concentrations of one metal and several organic chemical groups have frequently exceeded water quality guidelines in the RMP: mercury, PCBs, DDTs, and PAHs (see figure, this page). PCBs have the worst track record of all of these problem contaminants.

Some locations in the North Bay (particularly the mouth of the Petaluma River and San Pablo Bay) and all three locations in the South Bay sloughs exceed water quality guidelines more frequently and with more contaminants than other locations (see figure, this page; and *Water Quality* figure, page 1). All samples from these sites contained one or more contaminants above guidelines. In general, river mouths and sloughs are more contaminated than open water areas.

Nearly all RMP monitoring has occurred during years of above average river flow, and results may be biased toward such conditions (Cloern *et al.* 1999).

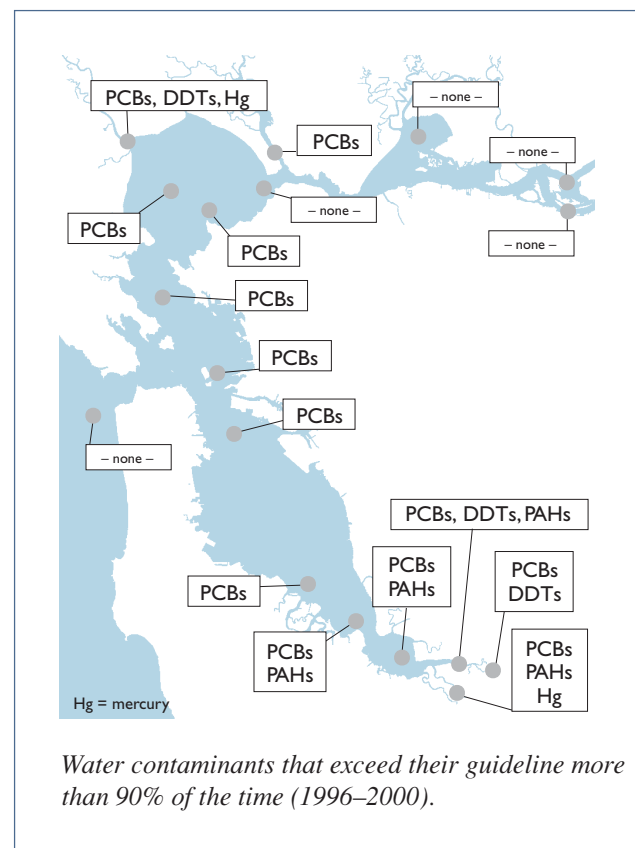
Trends

Since the RMP has only been in place since 1993 and the Estuary is highly variable, it is not possible to draw conclusions about long-term trends using RMP data alone. However, when RMP data are considered together with data from earlier monitoring efforts, such as the State Mussel Watch Program, sufficient data are available for a meaningful discussion of long-term trends.

Mussels readily accumulate organic compounds such as PCBs and DDTs and can be used as indicators of water quality. PCB concentrations in mussels dropped sharply in the early 1980s, then showed no perceptible change from 1982–1999. Concentrations of the organochlorine pesticides DDT, chlordane, and dieldrin generally were high in

1980, dropped sharply in 1981, and have declined very little since about 1988.

In spite of drastic reductions in the input of metals achieved by the ban on leaded gasoline and improvements in wastewater treatment, concentrations of lead and most other metals in water have changed little in the last 20 years (Flegal *et al.* 1996). One exception is silver; the dissolved form appears to have decreased significantly in the last decade, consistent with reduced industrial inputs (Squire *et al.* 2002). In the case of lead, researchers at U.C. Santa Cruz have concluded that inputs to the environment from leaded gas are still working their way downstream from throughout the watershed, and will be for decades (Steding *et al.* 2000; Squire *et al.* 2002).

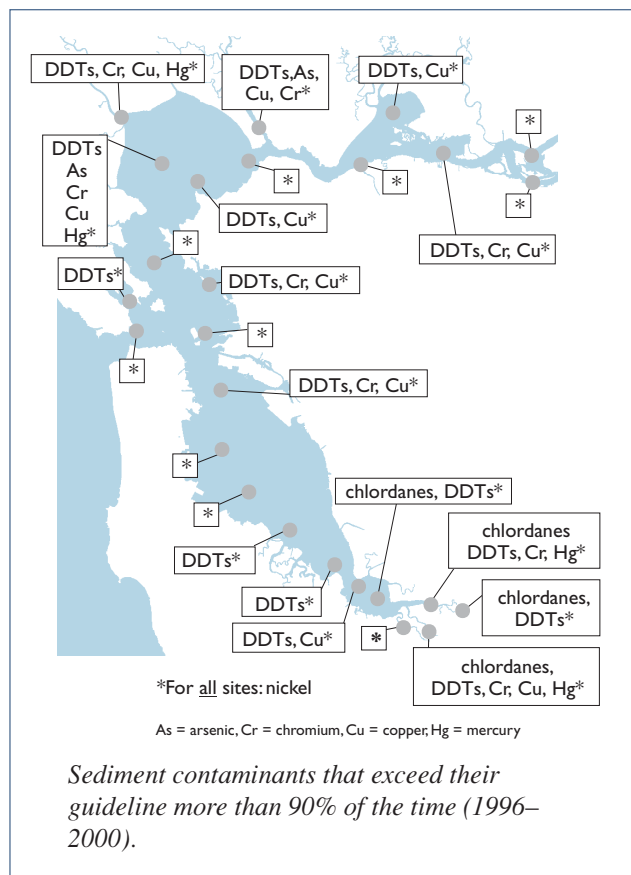


SEDIMENT

Status

At most sites, several trace elements (arsenic, chromium, copper, nickel, and mercury) and organic compounds (DDTs, chlordanes, and some PAHs) frequently exceed the guidelines (known as “ERLs”) indicating *possible* harm to aquatic life. Nickel usually exceeds the guideline indicating *probable* harm to aquatic life (ERMs). However, nickel and chromium are found at naturally high levels in Estuary sediment and are generally not considered to be a problem (see *Naturally High Metal Levels*, page 10).

DDT and its breakdown products are found at levels of concern in sediment throughout the Estuary. This is due to its widespread use prior to its ban in 1972. Additional



DDTs are entering the Estuary today as historically contaminated soils and sediments erode from the watershed. Recent work by the RMP in South Bay creeks indicates Coyote Creek above Standish Dam (see map on page 4) is a current pathway of DDT to the Estuary, likely due to past agricultural applications upstream (Leatherbarrow and Hoenicke 2002). Chlordanes, another widespread sediment contaminant used primarily in termite control, share a similar history to DDTs, but were not banned until 1988.

PAHs are another prominent group of sediment contaminants. Unlike DDTs, chlordanes, or PCBs, PAHs are still being actively created and enter the Estuary in a wide variety of ways. The combustion of gasoline and oil is one of the primary sources of PAHs to the Estuary. Combustion particles containing PAHs settle directly on the Estuary surface, or on land where they are washed via streams and storm drains to the Estuary. PAHs from refinery accidents and oil spills have also contaminated parts of the Estuary. The RMP work to identify contaminant sources indicates that Guadalupe and Coyote Creeks are current pathways of PAHs to the South Bay, with Guadalupe likely the larger of the two (Leatherbarrow and Hoenicke 2002).

Sites in the sloughs and creeks of the South Bay usually had the most guideline exceedances. The lowest sediment contaminant concentrations and fewest guideline exceedances occurred at sandy sites such as Red Rock and Davis Point; coarse sediment has less surface area for contaminants to collect upon. About 75% of the recent (1996–2000) sediment samples collected by the RMP were toxic to organisms in the laboratory.

Trends

There were few significant Estuary-wide trends in sediment contamination discernible over the last eight years. Chromium and nickel appear to be increasing, but this is thought to be a natural event due to increased rainfall (see *Naturally high metal levels*, page 10).

Sampling at a series of depths in the sediment can reveal trends in historical contamination levels. Such sampling indicates that most contaminants have dropped from peak levels seen in the 1960s and 1970s (Venkatesan *et al.* 1999, Hornberger *et al.* 1999), probably in response to wastewater

THE NEW 303(d) LIST

The Regional Water Quality Control Board makes a determination of contaminants of concern for the Estuary based on RMP results and other information. Creation of this list is required by section 303(d) of the Clean Water Act. Contaminants are listed by Estuary segment (there are eight) and by tributaries. The list is revised every three years, and proposed revisions, subject to U.S. EPA approval, were made in 2001. The proposed revisions no longer consider copper and nickel of concern in the Estuary, except at the mouth of the Petaluma River. Another concern in the Petaluma River is diazinon. Stege Marsh in Richmond, Mission and Islais Creeks in San Francisco, and Peyton Slough in Martinez are also newly listed due to sediment toxicity.

This is the proposed list for the Estuary and its major tributaries:

Trace elements

Copper (Petaluma River mouth)
Mercury
Nickel (Petaluma River mouth)
Selenium

Organochlorine pesticides

DDT
Chlordanes
Dieldrin
PCBs

Organophosphate pesticides

Diazinon

Others

Sediment Toxicity
Dioxins
Furans
Siltation
Pathogens
Nutrients
Exotic species

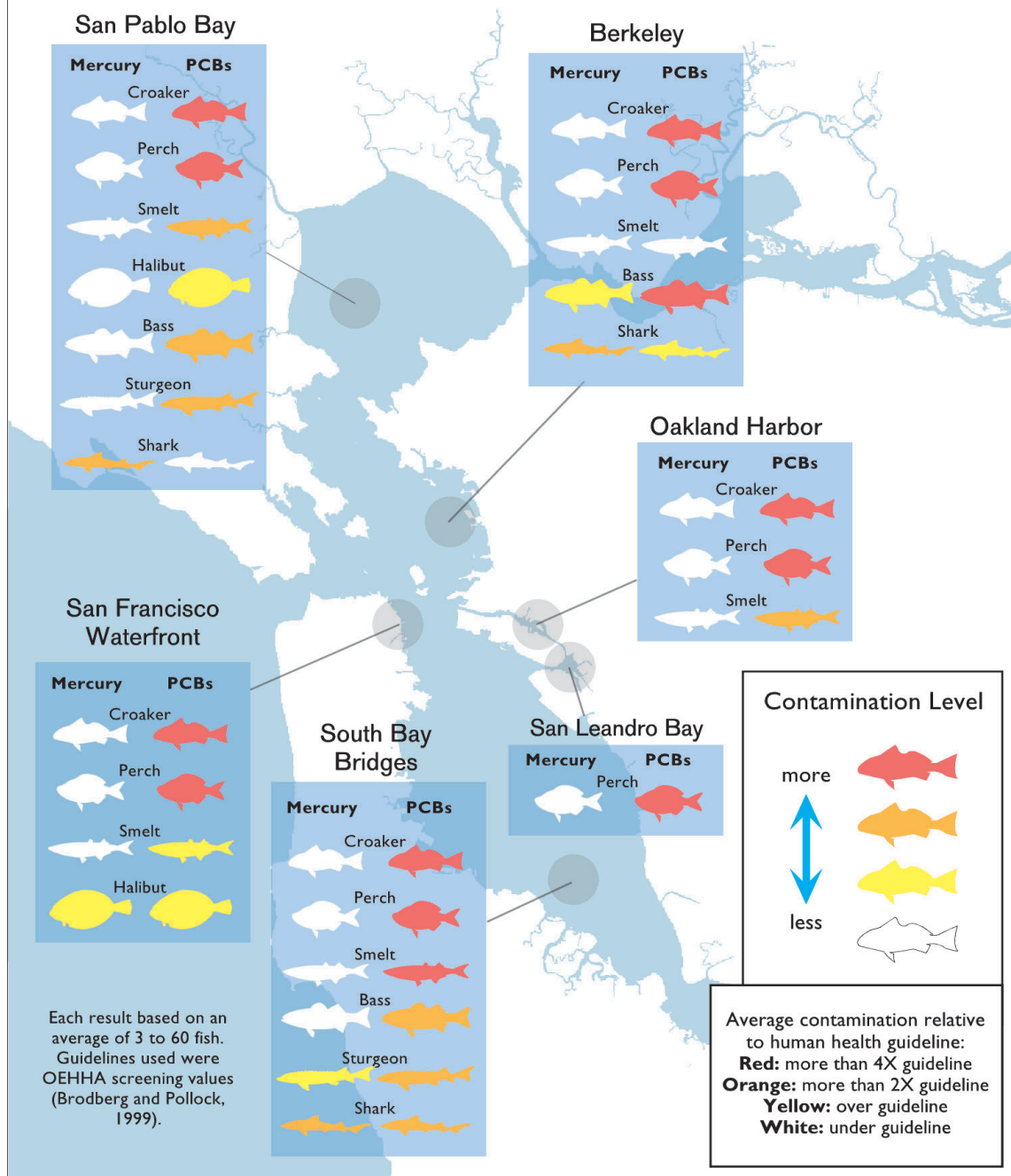
POTENTIAL THREATS

The Regional Board, as part of developing the revised 303(d) list (see previous sidebar), also created for the first time a list of potential threats to water quality. This is a list for contaminants where anecdotal information suggests they may be causing impairment but either the available data are inadequate to draw a conclusion, or the success of the existing regulatory program to control the contaminant is uncertain. Placement on this list is intended to trigger research so more informed decisions can be made in the future. The creation of this new preliminary list was prompted by the National Research Council. At the request of Congress, the NRC reviewed the TMDL process and suggested that this "preliminary list" be developed in addition to the 303(d) list.

This is the preliminary list for 2001 for chemical contaminants the Estuary:

Copper (San Francisco Bay)
Nickel (San Francisco Bay)
PAHs (San Francisco Bay)
PBDEs (San Francisco Bay)
Sediment Toxicity (Central Basin in San Francisco; Castro Cove in Richmond; Oakland Inner Harbor; San Leandro Bay)

Fish Contamination 2000—PCBs and Mercury



treatment improvements, product bans, and other regulatory actions. Nickel, on the other hand, appears to have remained at similar levels since prior to industrialization, due to its presence in rock in the watershed.

The US Geological Survey has monitored sediments and clams adjacent to wastewater treatment plants in lower south San Francisco Bay several times a year since 1977. A retrospective summary of this work (Hornberger *et al.* 2000) indicates marked decreases of average metal concentrations in sediments and resident bivalves prior to 1987. Measurements in more recent years generally show statistically insignificant changes in sediment concentrations, similar to RMP results in the same period.

FISH

Ben Greenfield, SFEI

Since 1997, every three years the RMP monitors contamination of commonly captured sport fish from the Estuary. This information is provided to the public and to agencies such as the Office of Environmental Health Hazard Assessment (OEHHA), who use it to determine potential health hazards of eating fish from the Estuary. RMP scientists also use this information to evaluate long-term trends in contamination and why certain fish species and fish from certain locations are more contaminated than others. The next sampling will happen in 2003.

Status

Contaminant concentrations in Estuary fish frequently exceed guidelines (see map, previous page), indicating a potential human health concern and the need for further study. In 2000, all white croaker, striped bass, and shiner surfperch samples measured for PCBs exceeded that guideline, with many fish having concentrations four times the guideline or more. All leopard shark and 30 to 42% of all striped bass, California halibut, and white sturgeon exceeded the mercury guideline. Concentrations exceeded guidelines less frequently for other contaminants, such as dieldrin and DDTs.

In general, fatty fish species have higher concentrations of organic contaminants such as PCBs DDTs, dieldrin, and chlordanes. When a fish consumes organic contaminants, they tend to collect in its fatty tissue. White croaker and shiner surfperch have the highest fat content, and consequently tend to have higher PCB concentrations than other Estuary species (see map, previous page). An RMP study has demonstrated that it is possible to reduce concentration of PCBs and other trace organic contaminants by removing skin and fatty tissue when preparing fish for human consumption (further information is available from OEHHA at <http://www.oehha.ca.gov/fish/general/broch.html>).

In the Estuary, mercury concentrations are generally higher in the largest fish species: shark, striped bass, and sturgeon (see map, previous page). Mercury concentrations build up over a fish's lifetime. Mercury also tends to increase in animals higher in the food web; when a predator consumes prey, it tends to retain the mercury from their tissues. Therefore, longer-lived species that consume other fish and large invertebrates as part of their diet, such as bass, sturgeon and shark, tend to accumulate more mercury. In 2002, RMP scientists will analyze fish age and diet data to determine how important these factors are for contaminant bioaccumulation.

Trends

RMP scientists evaluate long-term trends in fish contaminant concentrations by combining RMP data with data available from other programs. These trends must be viewed with caution because laboratory and field methods may vary among studies. Nevertheless, combining data among studies is

FISH CONSUMPTION ADVISORY

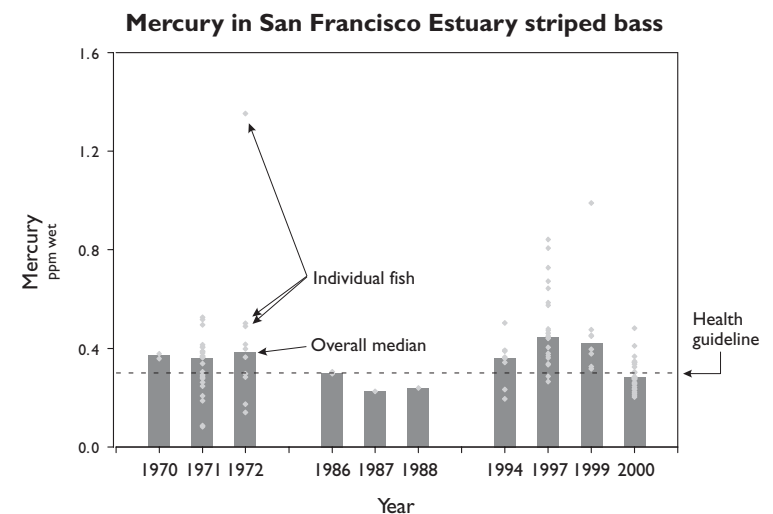
The following text is taken from the interim fish consumption advisory for San Francisco Bay. The full text is available at http://www.oehha.org/fish/nor_cal/int-ha.html.

Adults should limit their consumption of San Francisco Bay sport fish to, at most, two meals per month.

Adults should not eat any striped bass over 35 inches.

Women who are pregnant or who may become pregnant, or who are breast-feeding, and children under 6, should not eat more than one meal per month and, in addition, should not eat any meals of large shark (over 24 inches) or large striped bass (over 27 inches).

This advisory does not apply to salmon, anchovies, herring, and smelt caught in the bay; other ocean sport fish; or commercial fish.



Notes: Concentrations are standardized for length and represent the concentrations expected in a 55 cm total length fish. Data from CDF&G historical records (1970-1972), the TSMP (1986-1988), a CALFED-funded collaborative study (1999) the Bay Protection and Toxic Cleanup Program (1994) and the RMP (1997, 2000).

What if PCB inputs to the Bay were completely eliminated today?

The current best estimate is that it would take approximately 20 years for concentrations in sediment and water to fall to 50% of present values.

presently the best way to evaluate long-term patterns.

Mercury is a useful case study because striped bass mercury data exist from the early 1970s to the present. The concentration in individual fish captured in the Estuary may vary significantly from the average concentration in a given year (see figure, previous page). Average mercury concentrations vary somewhat from year to year, but the range of concentrations overlaps among years and there is no apparent trend. This suggests that mercury concentrations in the Estuary have not significantly changed in the past few decades. This result is not surprising, as most of the mercury in the Estuary derives from sediments generated during mining operations of the Gold Rush. The Estuary is very slow to respond to changes in inputs of persistent contaminants, so it may take decades before we observe changes in fish concentrations (for more information, see the 1999 *Pulse*, pages 8-10).

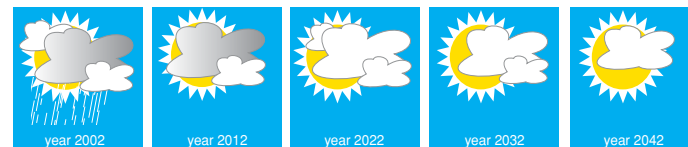
In addition to mercury, selenium and PCB concentrations in fish have also been compared between the RMP and other studies, such as the Cooperative Striped Bass Study, the Selenium Verification Survey and the Toxic Substances Monitoring Program. We see no significant increases or decreases in selenium since 1986.

There is evidence that shiner surfperch PCB concentrations have declined since Dr. Robert Risebrough performed the first chemical analyses on them in 1965. Whether management efforts to reduce fish contaminant concentrations are effective and concentrations are indeed declining can only be determined through long-term fish monitoring.

Current Issues

THE FIVE DECADE FORECAST FOR PCBs IN THE BAY

Dr. Jay Davis, San Francisco Estuary Institute



Sport fish in San Francisco Bay contain concentrations of PCBs that pose a potential human health concern and that have contributed to the existing advisory for consumption of Bay fish. PCB concentrations in two species, white croaker and shiner surfperch, are approximately 10 times higher than concentrations considered safe for human consumption. Concentrations in three other species, striped bass, white sturgeon, and jacksmelt, are about 2 times higher than the safe concentration. Through the PCB TMDL process, efforts are underway to reduce PCB concentrations in Bay fish and eliminate the need for the consumption advisory. The big question in this regard is: How long can we expect it to take for concentrations to fall below levels of concern?

The RMP has generated a wealth of valuable data on the status of contamination in the Estuary and trends over the past eight years. With the knowledge we have gained from the RMP and other Bay studies, the RMP is now in a position to move beyond description of recent conditions and past trends, and to attempt to predict future trends in concentrations of Bay contaminants. Through data synthesis and modeling we are trying to address the big question for PCBs and other contaminants.

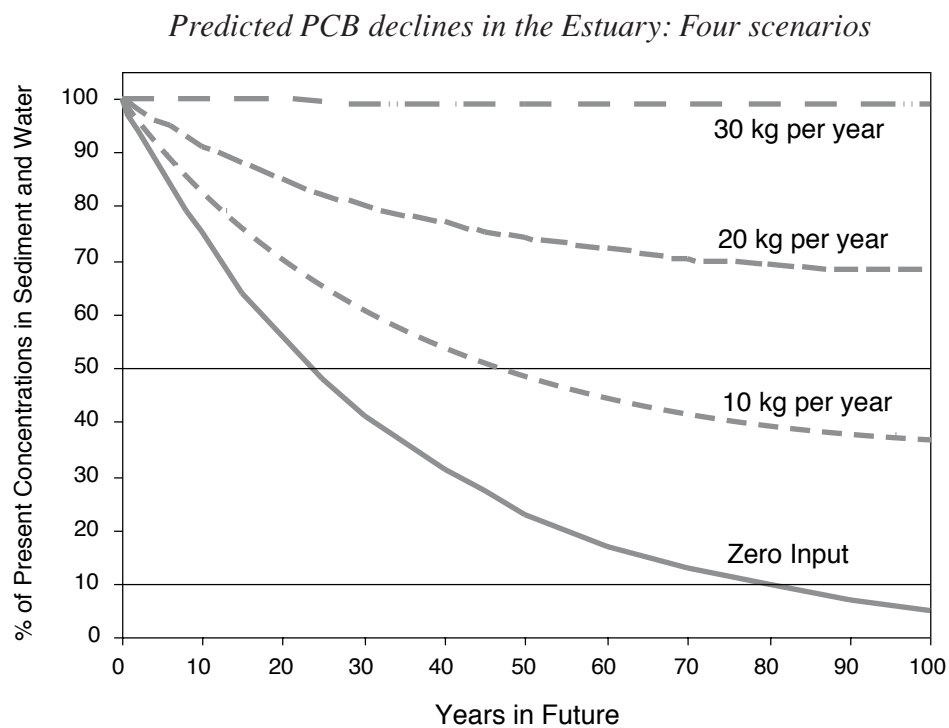
Mass budgets are the tools that are being used to predict future trends. A contaminant mass budget for the Bay is analogous to a household checking account. In a checking account, information on deposits and withdrawals is used to

determine the account balance. Mass budgets combine information from a variety of sources to estimate inputs (“deposits”), losses (“withdrawals”), and the mass of PCBs in the Bay.

The RMP is developing mass budgets for several priority contaminants, including PCBs, PAHs, and organochlorine pesticides. Other organizations have also recently developed budgets, including a mercury budget developed by the Regional Water Quality Control Board (SFBRWQCB 2000), a selenium budget for the North Bay developed by the USGS (Luoma and Presser 2000), and a budget for copper and nickel in the South Bay (Tetra Tech 2000). Of the budgets being developed in the RMP, the PCB budget is the farthest along. Some details of the budget were described in the 1999 Pulse of the Estuary. In 2001, a detailed draft report on the PCB budget was distributed for review, and many valuable comments were obtained from reviewers. A final report that incorporates these comments will be distributed in early 2002.

Based on reviewer comments on the PCB budget, different values have been selected for a few important input parameters. This process of refining details of the budgets will continue, and the budgets for PCBs and the other contaminants will be continually revised as better data become available. The forecasts that we can presently make are imprecise, and should be viewed as hypotheses based on our current understanding. An important next step in the development of RMP contaminant budgets will be quantifying the precision of predicted trends.

In spite of the present limitations of the PCB budget, two important general conclusions have emerged from the analysis. The first important conclusion is that the Bay is inherently slow to cleanse itself of persistent contaminants; based on reviewer comments, this process is even slower than previously thought. What if PCB inputs to the Bay were completely eliminated today? The current best estimate is that it would take approximately 20 years for concentrations in sediment and water to fall to 50% of present values (see graphic, this page). If fish concentrations follow water and sediment concentrations in a simple manner (a reasonable first approximation), then striped bass, white sturgeon, and jacksmelt would therefore be safe to eat in about 20 years. White croaker and shiner surfperch, however, would remain about 5 times higher



These curves are imprecise estimates based on our present understanding of contaminant fate in the Estuary. The estimates will continually be refined as better information becomes available.

TOXICITY TESTING

Using contaminant concentrations to predict harm to estuarine life is difficult, as a contaminant's potential for harm is affected by its context in the estuarine environment. Other contaminant levels, salinity, temperature, and many other variables may influence a contaminant's effect.

A more direct approach to assessing potential harm, which avoids many of the difficulties of interpreting contaminant concentrations, is to expose organisms (such as mussels or shrimp) to Estuary water or sediment in the laboratory and look for adverse effects such as developmental abnormalities or death. If a clear adverse effect is seen, it is considered an indication that harm is occurring in the Estuary itself. The ecological relevance of laboratory tests is a matter of some debate, as some of the species used in RMP tests do not actually reside in the Estuary. The RMP is considering increasing its use of resident species to address this issue.

Toxicity tests give no indication of what in the sample is responsible for the observed toxicity. Additional tests, known as toxicity identification evaluations (TIEs) attempt to identify the toxic agent(s). In TIEs, toxic samples are treated to remove a particular type of chemical, and toxicity tests are rerun to see if the toxicity has been eliminated. In this way, indirect identifications can be made. When contaminant mixtures are present, conclusive identification of what is causing the toxicity is often not possible. The RMP plans to increase the use of TIEs on water and sediment samples.

For information on the specific toxicity tests used by the RMP, see the RMP Annual Results reports at www.sfei.org.

Small PCB inputs to the Bay would significantly delay declines in concentrations.

than the safe concentration. After 50 years, sediment and water concentrations would fall to about 20% of present concentrations. If PCB concentrations in white croaker and shiner surfperch fall proportionately, they would remain about two times higher than the safe concentration. After 80 years, sediment and water concentrations would be about 10% of present concentrations, and PCBs in sport fish may cease to pose a human health concern.

Why is the Bay so slow to cleanse itself of sediment-particle-associated contaminants such as PCBs? The primary reason is the high degree of vertical mixing of Bay sediments. The shallow depth of the Bay is largely responsible for this deep sediment mixing. Although the Bay is part of one of the largest estuaries in North America, its average depth is only 5.3 m (17 ft), and most of the Bay is less than 2 m (6 ft) deep. Storms and strong wind- and tide-driven currents combine with this shallow water column to cause relatively intense mixing of the sediment. Bottom-dwelling organisms that burrow in the sediment also cause significant mixing. As contaminants enter the Bay they get mixed into this large pool of active sediment and remain trapped there for long periods of time. The deep mixing of the sediment increases the volume of the active sediment pool and has the effect of significantly lengthening response times for persistent contaminants.

Another important reason that the Bay is slow to cleanse itself is that there is not enough uncontaminated sediment entering the Bay. Burial of sediment below the active layer is one of the primary ways contaminants become unavailable to the aquatic food web. Currently, however, there is not a large enough supply of new sediment to support burial in the Bay, and thus the bottom of large portions of the Bay is eroding (Jaffe *et al.* 1998). Possible causes of the reduced sediment supply include large scale dam building in the watershed and the declining transport of sediments mobilized during hydraulic gold mining. Making matters worse, since the buried sediment layers were deposited prior to restrictions on PCB use and other modern improvements in water quality management, erosion of these

layers is actually bringing old PCBs back into circulation and exacerbating the problem of food web contamination.

The second important general conclusion to emerge from the PCB budget is that small PCB inputs to the Bay would significantly delay declines in concentrations. With an annual PCB input of just 10 kg, it would take about 50 years for sediment and water concentrations to fall to 50% of present values, approximately twice as long as it would take with no inputs (see graphic, previous page). After 100 years, concentrations would remain at about 40% of present values. Annual inputs of about 30 kg would cause concentrations to remain at present levels indefinitely. Although these numbers are only estimates, they do represent our best estimates at this time, and they do support the general conclusion that identifying and controlling PCB inputs to the Bay should be a top management priority.

In 2002, RMP scientists will continue to refine the PCB budget and budgets for other contaminants. A food web model is being developed that will link PCB concentrations in sediment and water with concentrations in sport fish. Other efforts will be made to make the budgets more accurate representations of the Bay. The goal of these efforts is to develop a sound enough understanding to confidently forecast the recovery of this sensitive ecosystem from contamination by PCBs and other persistent contaminants, and to inform management decisions by establishing realistic expectations for the effectiveness of management actions.

MEASURING THE ADVERSE EFFECTS OF CONTAMINANTS: A NEW EMPHASIS

Sarah Lowe, San Francisco Estuary Institute

The Estuary's environmental managers need to know if the fish, shellfish, and other wildlife in the Estuary are adversely affected by contaminants. The RMP's water and sediment toxicity measurements do not provide enough information in this regard. In 2001, staff from SFEI, the U.S. Geological Survey, Applied Marine Sciences, the San Francisco Bay Regional Water Quality Control Board, and other interested

MANAGEMENT QUESTIONS REGARDING ESTUARY CONTAMINATION

Do contaminants adversely effect:

- primary productivity (plant growth)?
- survival, reproduction or growth of fish, shellfish, other wildlife, or their prey?
- safe consumption of fish, shellfish and other wildlife by humans?

The suite of biological effects and exposure indicators to be evaluated for use in the RMP.

EFFECTS	
Tissue disease in fish	Examine liver and gonads in conjunction with the fish contamination study. Include biomarker tests and other measures.
Body functions of seals	Examine contaminant levels in blood (or fat tissue), and overall health measures.
Toxicity (invertebrates)	Compare aquatic and sediment toxicity in laboratory test species to resident species. Include tolerance testing.
Toxicity (fish larvae)	Consider using a rare or endangered species to address beneficial use questions.
Egg hatchability	Study species that integrate the region (cormorants) for certain contaminant groups (e.g. halogenated hydrocarbons) and/or region-specific species for other contaminant groups (e.g. diving ducks for Se and Hg).
Benthic community evaluations	Take advantage of NOAA-WEMAP sampling to continue development of a <i>local</i> benthic assessment. Explore <i>in situ</i> gradient studies using the sediment quality TRIAD approach.
EXPOSURE	
Bioaccumulation: PAHs, synthetic herbicides and pesticides, PCBs, PBDEs and phthalates	Bioaccumulation studies provide information about exposure and what contaminants tend to build up in the tissues of organisms. Could take advantage of the field collections of fish tissue and bird egg samples for the bioaccumulation studies to be sampled in 2002 and 2003.
Biomarkers: P450, vitellogenin, macrophage aggregates, acetylcholinesterase, DNA-Comet test, others	Biomarkers provide information about exposure to specific contaminant groups. Could be studied in invertebrates, fish and/or birds. Take advantage of the field collections of fish tissue and bird egg samples for the bioaccumulation studies to be sampled in 2002 and 2003.
Toxicity Identification Evaluations (TIEs)	This is an ancillary measure for toxicity testing that identifies contaminant groups in the test samples and provides information about exposure.

stakeholders began developing a biological effects pilot study to address management questions related to contaminant effects (see *Management Questions Regarding Estuary Contamination*, this page). By incorporating the recommendations of other groups who have done similar work, reviewing existing research literature, and surveying the local scientific community, the group outlined a preliminary study design.

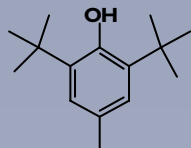
Field studies will begin in 2002, and over a five year period the study will evaluate a comprehensive suite of contaminant *effects* and *exposure* indicators (see *Effects vs. Exposure* sidebar, this page) that respond to *general* and *specific* contamination at the biochemical, cellular, individual, population, and community level. The study will evaluate contaminant exposure and effects in a variety of environments (on the Estuary floor, in the water column, and in wetlands), and scales (specific sites, regionally, and estuary-wide). These overarching principles incorporate recommendations from the Indicator Workshop convened by SFEI in 1994 (SFEI 1999b), and the Interagency Ecological Program's Effect Workgroup in 1999 and 2000. The literature review is ongoing.

A suite of indicators has been chosen for evaluation (see table, this page). Following study and assessment, the best indicators found will be incorporated into the routine monitoring of the RMP. It is hoped that a "toolbox" of indicators can be developed for use in the Estuary to monitor both at specific locations (e.g., using toxicity tests and benthic community assessments) and regionally (e.g., measuring reproductive success, bioaccumulation of contaminants, and general health of fish, bird, and seals).

EFFECTS VS. EXPOSURE

An animal can be *exposed* to contaminants without experiencing adverse *effects*. Although pesticides may be found in clam tissue, the clam is not necessarily being harmed by their presence. The clam can even have a *response* to contaminant exposure, such as a measurable biochemical change, that is still interpreted only as an indication of exposure. Nevertheless, when indications of exposure are combined with unambiguous indications of harm, such as reduced egg hatching, reduced growth, or death, a strong case for contaminant-caused adverse effects can be made.

CHEMICALS NEWLY DETECTED IN THE ESTUARY

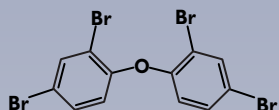


Name: Butylated hydroxytoluene (BHT)

Use: Antioxidant for food, animal feed, petroleum products, synthetic rubbers, plastics, animal and vegetable oils, and soaps. Anti-skinning agent in paints and inks.

Adverse effects: Unknown

Occurrence: Found in most samples

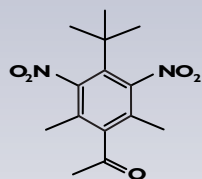


Name: 2,2',4,4'-Tetrabromo diphenyl ether (a PBDE)

Use: Flame retardant in plastic products, polymers, resins and components of electronic devices, building materials and textiles.

Adverse effects: Accumulates and magnifies in biological tissues; disrupts hormonal systems.

Occurrence: Found occasionally in samples



Name: Musk ketone

Use: Fragrances and personal care products.

Adverse effects: Induces toxifying liver enzymes.

Occurrence: Found occasionally in samples

CLOSING IN ON UNIDENTIFIED CONTAMINANTS

Dr. Daniel Oros, San Francisco Estuary Institute

Karen Taberski, Regional Water Quality Control Board

The recent addition of a surveillance component in the RMP was prompted by a need to make the regulatory system more proactive in anticipating potential problem contaminants. In 2000, a study was begun to determine the past and present distributions of previously unknown and newly identified organic compounds of concern in the Estuary. Most of these chemicals have not been tested for toxicity, and thus do not have water quality objectives. However, if action is not taken now to measure these chemicals in the environment, evaluate their risk and, if needed, control or ban their use, they may become the legacy pollutants of the future.

The study analyzed gas chromatographic-mass spectrometric (GC-MS) data from RMP water and sediment samples collected in 1993 and 1994, and treated discharge collected from a wastewater treatment plant in 1998. The electronic outputs of GC-MS instruments can be used to measure organic contaminants in samples. These outputs contain, in addition to signals of known contaminants, signals of hundreds of unidentified contaminants. There is usually sufficient information in the outputs to allow additional detective work to determine the identities and sources of many of these contaminants. Work on archived GC-MS outputs can thus determine contaminants' environmental distribution in the past and present. This information, when coupled with toxicological data, could then be used to make preliminary assessments of the need to regulate, manage, or end chemical use.

Preliminary findings reveal the presence of both natural (e.g., plant-based) and human-made (e.g., biomass burning, meat cooking, fossil fuels, synthetics, etc.) organic compounds and their decomposition products. The organic contaminants that are of immediate concern

because of their potential to harm the environment include:

- antioxidants and metabolites (butylated hydroxytoluene and butylated hydroxyanisole)
- flame retardants (polybrominated diphenyl ethers)
- detergent ingredients (nonylphenol and alkylbenzenes)
- pesticides (oxadiazon)
- industrial polymer plasticizers (di-n-butylphthalate, butyl benzyl phthalate and bis(2-ethylhexyl)phthalate)
- a flame retardant plasticizer (triphenylphosphate)
- nitro and polycyclic musk compounds used in fragrances and personal care products (musk ketone, galaxolide and versalide).

These chemicals enter the Estuary mainly through human activity, via pathways such as discharge from wastewater treatment plants, deposition from the atmosphere, and urban and agricultural runoff.

This effort will enable the Regional Board to manage these contaminants in a proactive manner. Instead of reaching the point where species become endangered and remedial measures are necessary, newly identified chemical contaminants can be controlled before they become a problem. As new contaminants are identified in the RMP, the Regional Board will enlist the assistance of stakeholders to find the best way to reduce or eliminate those that are a threat to human and environmental health.

Contaminant focus: BFRs

Brominated flame retardants (BFRs) are one group of increasing concern due to their recognized persistence in the environment, ability to bioaccumulate and toxicity. These chemicals became commercially available in the 1960s because of their effectiveness as flame retardants in furniture, electrical appliances, office equipment, building materials and carpets. Use of BFRs grew substantially in the 1980s with the growing

popularity of personal computers and other electronics. There are four classes of BFRs. Most is known about two classes, PBDEs (polybrominated diphenyl ethers) and PBBs (polybrominated biphenyls), which appear to bioaccumulate more than the other classes. PBBs were banned in the U.S. in 1977 and, therefore, are similar to PCBs in being a legacy pollutant. PBDEs and PBBs have been found in sediments, fish, bird eggs, marine mammals, and human milk, tissue and blood. Although most studies have been conducted in Europe, studies in the Bay Area have shown PBDE levels in harbor seals to be among the highest reported anywhere, and PBDE levels in humans to be the highest levels reported to date.

Although current PBDE levels are not thought to be harmful based on current information, their dramatic increase in animal tissue and the possibility that they could act together with other similar chemicals causes serious concern. In Europe and the United States, studies have shown a dramatic increase in these chemicals in human and environmental samples collected between the 1970s and the late 1990s. More is known about the toxicity of PBBs than other BFRs due to a 1973 poisoning incident in Michigan where 9 million people were exposed to food containing PBBs. The effects of PBBs were found to be essentially the same as PCBs. In animal studies, some PBDE compounds have been found to disrupt thyroid hormones, which can adversely affect fetal brain and body development and result in permanent disturbances in behavior, memory and learning. Thyroid hormone disruption is also associated with other adverse health effects such as goiter and neuro-developmental toxicity. Because PBDEs have a similar structure to PCBs and dioxins, they may also affect estrogenic activity and cause cancer and immunotoxicity. In addition, all of these chemicals with similar structure may act in an additive manner.

As a result of concerns about the environmental and human effects of BFRs, the European Union adopted a precautionary directive giving member states until 2007 to ban the sale of new electrical equipment containing some types of PBDEs and PBBs. PBBs are no longer used in European electrical and electronic equipment and production ceased in May 2000.

In the United States an increasing number of studies are being conducted to measure these compounds in humans and the environment, assess their toxicity, and identify sources. The regional office of U.S. EPA is putting together a workgroup that will assess general sources and pathways of BFRs. The Regional Board has listed San Francisco Bay as “threatened” by PBDEs and will be working to identify local sources and pathways. In addition to the surveillance work described above, the RMP started routine measurements of PBDEs in 2001.

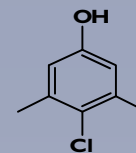
A NEW APPROACH TO MONITORING WATER AND SEDIMENT

Cristina Grosso and Sarah Lowe, San Francisco Estuary Institute

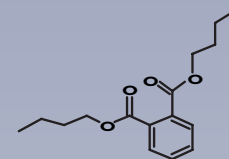
If you have been following the activities of the RMP for some time, you are no doubt familiar with RMP sampling locations, such as Red Rock, Golden Gate, and San Bruno Shoal. In 2002, however, most of these stations will become monitoring history. In a major shift for the Program, the RMP has adopted an entirely new approach for choosing places to sample the Estuary’s water and sediment.

Since the first year of sampling in 1993, the RMP has employed what is called a *deterministic* monitoring design, using the same fixed locations each year. The original selection of monitoring locations was designed to cover the geographical extent of the Estuary, continue sites from previous monitoring efforts, and avoid locations near point discharges such as wastewater outfalls.

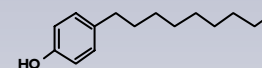
In 2001, SFEI assembled a workgroup of sampling experts to review the sampling scheme. The workgroup concluded that while the original design was a good way to track long-term trends at these locations, it was not the best design for describing the overall levels of contamination in the Estuary. A better approach is to choose sampling locations *randomly*, using a *probabilistic* design. This way, over time, all parts of the Estuary will be sampled: shallow areas, deep channels, near and far from shore. The



Name: Chloroxylenol
Use: Antiseptic and germicide, applied for mildew prevention.
Adverse effects: Unknown.
Occurrence: Found occasionally in samples



Name: Di-N-butyl phthalate
Use: Plasticizer added to polyvinyl chloride to increase flexibility, adhesives, and coatings. Lubricant for aerosol valves, antifoaming agent, skin emollient, plasticizer in personal care products and cosmetics.
Adverse effects: Disrupts hormonal systems and reproductive development.
Occurrence: Found in most samples



Name: Nonylphenol
Use: Preparation of lubricating oil additives, resins, plasticizers, pesticides, anionic detergents, surface-active agents, and toiletries.
Adverse effects: Disrupts hormonal systems and reproductive development.
Occurrence: Found occasionally in samples

OVERVIEW OF 2002 RMP MONITORING DESIGN

Water Sampling

- Dry weather sampling at 33 sites, both random and historical sites
- Sampling region outlined by the three-foot contour at mean lower low water
- Analyses done in previous years continued
- New analyses include trace organic contaminants PBDEs, Phthalates, and p-Nonylphenol
- Aquatic toxicity sampling at 15 sites

Sediment Sampling

- Dry weather sampling at 49 sites, both random and historical sites
- Sampling region outlined by the one-foot contour at mean lower low water
- Analyses done in previous years continued
- New analyses exclude pore-water sampling
- Sediment toxicity sampling at 29 to 49 sites (depending on budget)

Bivalve Sampling

- Dry weather deployment at 15 sites
- Only trace organics analyses in 2002
- Trace elements will be analyzed on a five-year cycle (scheduled for 2006)
- Same analyses as in previous years for trace elements and trace organics
- New analyses exclude tributyltins

Episodic Toxicity Sampling

- Wet weather water sampling for 5 storm events at Mallard Island and four other tributaries

results from the new design will be more representative of the entire Estuary downstream of the Delta. The new sampling design provides data better suited to answering regulatory questions and enables stronger statistically-supported conclusions. The group worked in three-phases to design the new sampling scheme:

- 1) develop a new segmentation scheme for the Estuary,
- 2) determine the number of samples needed in each segment, and
- 3) devise a random, spatially-balanced site selection process.

Developing a new segmentation scheme

The Regional Board manages water quality in the Estuary by segments. The seven segments currently used by the Regional Board and outlined in the *San Francisco Bay Basin Plan* (SFBRWQCB, 1995) are defined by major bridges. Regulatory work, such as developing Total Maximum Daily Loads (TMDLs) and issuing National Pollutant Discharge Elimination System (NPDES) permits, are conducted on a segment basis. Contamination should therefore be evaluated by segment as well, but the old sampling scheme was not designed to do this, and the lack of information on individual segments presented an obstacle to regulatory decision-making. Furthermore, the workgroup did not think that the current segmentation represented the most technically sound way to divide up the Estuary. They devised new segments by reviewing and evaluating the hydrological and sedimentological regions of the Estuary, surveying local scientists' opinions about the natural hydrological and ecological boundaries, and performing statistical analyses on RMP data collected between 1989 and 1998.

Five major segments emerged from the analysis: Suisun Bay, San Pablo Bay, Central Bay, South Bay, and Lower South Bay. The most notable variations from the original segmentation were: 1) in the Central Bay segment, which was originally bounded by the Richmond and Bay bridges but now extends to Point San Pablo (in the north) and San Bruno Shoal (in the south), and 2) in the South Bay where

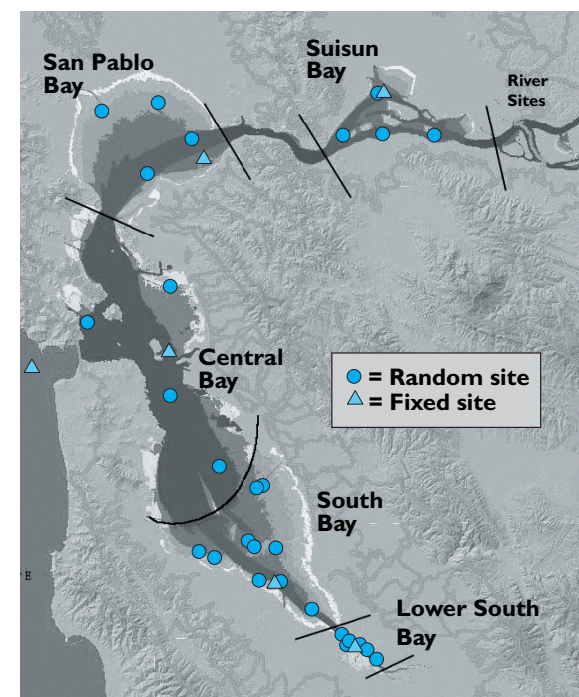
the geographical constriction at the Dumbarton Bridge is identified as the new segment boundary.

Determining the number of samples per segment

After choosing new segments, the workgroup determined the number of samples necessary in each segment to characterize it properly. The Regional Board needs to decide if a segment is meeting or exceeding guidelines, which is not always easy given the variation inherent to the system. The statistical tool of power analysis was used to evaluate the number of samples in each segment needed to permit a desired level of statistical confidence in comparisons to contaminant guidelines.

The group found that when contaminant concentrations varied widely within a given segment, or when the observed mean concentrations were close to a guideline value, an

New RMP Water Sample Sites, Year One



impractically large number of samples was needed to achieve adequate statistical power. Therefore, the focus of the power analysis was narrowed to the contaminants and segments of greatest concern to the Regional Board (dissolved copper in water, and copper, mercury, and total PAHs in sediment, and segments such as South Bay and Lower South Bay), and practical sampling numbers were devised. The workgroup decided that sampling for both water and sediment will occur once a year during the dry season, which is the least variable time of the year. They also decided that seasonal fluctuations of contaminants were best addressed through separate, focused studies.

Selecting sampling sites

With the sampling design and number of samples per segment determined, the next step was to select the sites themselves. With the help of Don Stevens, a statistician from the Oregon EPA, a sophisticated site selection framework developed for the federal Environmental Monitoring and Assessment Program was used to choose a random, even distribution of locations (Stevens 1997; Stevens and Olsen 1999; Stevens and Olsen 2000). For sediment, eight random sites and one site from the current design per segment were chosen (see map, this page). Repeat sampling at selected locations will allow long-term trends to continue to be tracked, and maintaining some of the current sites will provide some continuity with the existing data. For water, a non-repeating design of four to ten sites per segment was chosen. With no repeat locations, trends in water will be tracked for each segment as a whole. Two historical fixed stations will also be maintained, as well as the Golden Gate site for a relatively clean reference (see map, previous page).

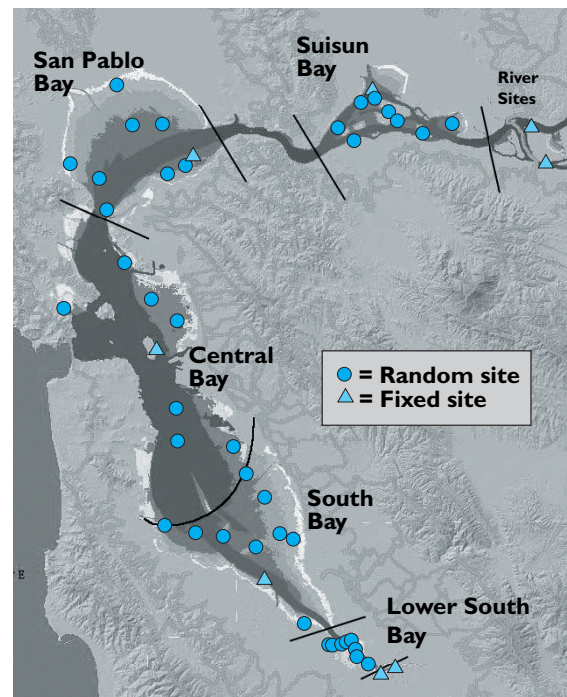
Bivalves will also continue to be monitored at three fixed stations per segment. However, only trace organics will be analyzed in tissue samples; trace elements will be measured in bivalves on a five-year cycle beginning in 2006. Sediment and aquatic toxicity testing will continue to be conducted in 2002 at 28 and 15 sites, respectively.

Conclusion

A new era for the RMP is beginning in 2002. The new random sampling design (see Overview of 2002 RMP Monitoring Design sidebar, page 20) will allow the RMP to provide the Regional Board with sound characterizations of contamination in each segment and the Estuary as a whole. From this new design, the RMP will better estimate the patterns of water and sediment contamination in the Estuary, better determine if segments are above regulatory guidelines, and better estimate what proportion of the Estuary is toxic to laboratory test organisms. The new sampling design will provide a solid foundation for evaluating progress in reducing contaminant concentrations in water and sediment in the decades to come.

In 2002, most RMP stations will become monitoring history.

New RMP Sediment Sample Sites, Year One



RMP TECHNICAL REPORTS

Technical reports offer a detailed look at Estuary contamination topics and provide a way to learn more about some of the information contained in the Pulse of the Estuary. This list includes all technical reports in preparation or produced since the last RMP Annual Report. Reports are organized by topic. Some reports are published journal articles and are noted as such. If a report is available on the web, a web address (URL) is provided. Hard copies of each report are available for purchase from the San Francisco Estuary Institute (510) 746-7334, unless otherwise noted.

Benthos

Results of the Benthic Pilot Study, 1994–1997

II: A Preliminary Assessment of Benthic Responses to Sediment Contamination in San Francisco Bay

Target Availability: March 2002

Authors: Bruce Thompson and Sarah Lowe

The objectives of the second chapter of the Benthic Pilot Study report are to identify benthic indicators of contaminated sediments in the Bay, determine background or reference benthic conditions for the Bay's major benthic assemblages, and develop a benthic assessment procedure to determine the degree of impact by contamination.

Estuary Contamination, General

A PCB Budget for San Francisco Bay

Target Availability: Spring 2002

Author: Jay A. Davis

A mass budget for PCBs was developed in order to evaluate the likelihood of continuing inputs of PCBs to the Bay and to understand the response time of the Bay for PCBs. The modeling approach described here is a simple, first step toward a quantitative understanding of the long-term fate of PCBs in the Bay. The model allows evaluation of the long-term response of the Bay to varying PCB loads, providing information that is valuable in understanding the potential impact of cleanup efforts.

Effective Application of Monitoring Information in Environmental Decision-Making:

The Case of San Francisco Bay

In press

Authors: Rainer Hoenicke, Jay A. Davis, Thomas E. Mumley, Khalil Abu-Saba, and Karen Taberski

The San Francisco Estuary Regional Monitoring for Trace Substances (RMP) is an innovative partnership among a regulatory agency and an independent scientific organization that has made the regulatory system increasingly responsive to

emerging management needs, particularly with regard to the development of total maximum daily loads (TMDLs) and ecosystem impairment assessment. Through multi-agency partnerships within and outside the RMP institutional structure, major information gaps for several pollutants of concern have been narrowed, resulting in a successful consensus-based regulatory approach to managing copper and nickel mass inputs into the Estuary. One of the most important contributions of this collaborative monitoring program is the deliberate and systematic adjustment of management and research questions that serve to influence and add relevance to the overall research agenda related to San Francisco Estuary ecosystem assessment.

Published in *Environmental Monitoring and Assessment* (in press). Reprints available from Jay Davis at jay@sfei.org.

Seafood Consumption

San Francisco Bay Seafood Consumption Study, Technical Report

March 2001

Authors: California Department of Health Services' Environmental Health Investigations Branch and SFEI

The purpose of this study is to gather quantitative data that can be used to characterize the consumption of Bay-caught fish by the general fishing population of San Francisco Bay. Further goals of the study are to (1) identify people who may be highly exposed to chemicals from consuming Bay fish, and (2) to gather information needed to develop educational messages.

URL: http://www.sfei.org/rmp/reports/Seafood_consumption/SCstudy_final.pdf

San Francisco Bay Seafood Consumption Study, Public Summary

March 2001

Authors: California Department of Health Services' Environmental Health Investigations Branch and SFEI

Results from the San Francisco Bay Seafood Consumption Study are presented for a general audience.

URL: http://www.sfei.org/rmp/reports/sfc_report/sfc_publicsummary.pdf

Sediment

Investigation of Chemicals Associated With Amphipod Mortalities at Two Regional Monitoring Program Stations

Target Availability: Spring 2002

Authors: Brian Anderson, John Hunt, Bryn Phillips, and Jose Sericano

Seasonally variable mortality of amphipods has been observed at a number of RMP stations, particularly those in the South Bay and in the northern Estuary. Amphipod mortality is measured in whole sediment samples using the estuarine

amphipod, *Eohaustorius estuarius*. This report discusses results of preliminary experiments designed to investigate chemicals responsible for the mortality of amphipods at the Redwood Creek and Grizzly Bay RMP stations.

Sources, Pathways and Loadings

Results of the Estuary Interface Pilot Study, 1996-1999

Target Availability: April 2002

Authors: Jon Leatherbarrow and Rainer Hoenicke

The Estuary Interface Pilot Study was initiated in 1996 with the goal of characterizing contaminant contributions from the watersheds of the Guadalupe River and Coyote Creek to the Lower South San Francisco Bay. This report summarizes results from four years of contaminant monitoring in water and sediment at two stations located near the estuary-watershed interface: Guadalupe River (BW15) in the Alviso Slough and Standish Dam (BW10) in Coyote Creek. The study identified contaminants with potential watershed sources, provided rough estimates of contaminant loads from the tributaries, and discussed the limitations of the current RMP monitoring design to characterize sources and loadings of contaminants to San Francisco Bay. Based on these limitations, the report provided recommendations for improving sampling methodology for future tributary monitoring intended to assist TMDL-related activities in the San Francisco Bay.

San Francisco Bay Atmospheric Deposition Pilot Study

[Three Part Report]

Deposition of pollutants from the atmosphere to surface water can occur by several processes, including rain or snow-scavenging of gases and particles, dry deposition of dust particles, deposition through cloud and fog water, and air-water exchange processes. The primary objectives of this Pilot Study include estimating annual atmospheric loading of selected pollutants to the San Francisco Estuary and comparing atmospheric loading with loading from other sources and pathways.

Part 1 – Mercury

July 2001

Authors: Pam Tsai and Rainer Hoenicke

This report presents study methodology, concentrations of mercury detected in the ambient air and precipitation, estimated deposition loads to the San Francisco Estuary, and comparison of loadings from different primary sources and pathways. Ambient air and precipitation samples were collected at three sites strategically located in close proximity to the Estuary. Sampling was conducted from August 1999 through November 2000.

Reprints available from Patricia Chambers at pchambers@sfei.org.

Part 2 – Trace Metals

September 2001

Authors: Pam Tsai, Rainer Hoenicke, Eric Hansen, and Kenneth Lee

This report presents study methodology, concentrations of the trace metals copper, nickel, cadmium, and chromium detected in the precipitation, deposition rate of trace metals that are entrapped in particulate matter, and estimated deposition loads to the San Francisco Estuary. Comparison of loading from atmospheric deposition with that from other primary sources and pathways are also evaluated. Sampling was conducted from August 1999 through August 2000 at three sites strategically located in close proximity to the Estuary.

Reprints available from Patricia Chambers at pchambers@sfei.org.

Part 3 – PAHs and PCBs

October 2001

Authors: Pam Tsai, Rainer Hoenicke, Joel E. Baker, and Holly A. Bamford

This report presents study methodology, concentrations of PAHs and PCBs detected in the ambient air, and estimated deposition loads to the San Francisco Estuary. Ambient air samples were collected at one location in Concord. Sampling was conducted from August 1999 through November 2000.

Reprints available from Patricia Chambers at pchambers@sfei.org.

Standard Operating Procedures

Field Sampling Manual for the Regional Monitoring Program for Trace Substances

February 2001

Authors: Nicole David, David Bell, and Jordan Gold

The RMP annually monitors contaminant concentrations in water, sediments, and shellfish tissue in the Estuary. This manual outlines the sampling methods and standard operating procedures for water, sediment, and bioaccumulation sampling. Cruise objectives, vessel safety, equipment list and preparation, sample containers, storage and handling, and sampling procedures are discussed separately for each matrix.

URL: <http://www.sfei.org/rmp/documentation/fom/FOM2001.pdf>

2001 Quality Assurance Project Plan for the Regional Monitoring Program for Trace Substances

September 2000

Authors: Donald Yee, Sarah Lowe, Rainer Hoenicke, and Jay Davis

This document presents the San Francisco Estuary Institute's quality assurance and quality control (QA/QC) protocols and requirements for contract laboratories associated with the Regional Monitoring Program for Trace Substances (RMP). It includes (1) a summary of the RMP and its organization, (2) an overview of quality assurance and control in the RMP, (3) quality assurance and control measures in the field, and (4) quality assurance and control measures in the laboratory.

Reprints available from Donald Yee at donald@sfei.org.

CONTAMINANTS ANALYZED

The water quality results in this report are based on results for the following contaminants:

Arsenic (dissolved), Cadmium (dissolved), Chromium (dissolved), Copper (dissolved), Lead (dissolved), Mercury (total), Nickel (dissolved), Selenium (total), Silver (dissolved), Zinc (dissolved), Total PCBs, Chlorpyrifos, Diazinon, Total DDTs, p,p'-DDD, p,p'-DDE, p,p'-DDT, Total Chlordanes, Heptachlor, Heptachlor Epoxide, alpha-HCH, beta-HCH, gamma-HCH, Dieldrin, Endrin, Mirex, Total PAHs, Acenaphthene, Anthracene, Fluorene, Benz(a)anthracene, Chrysene, Pyrene, Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(k)fluoranthene, Dibenz(a,h)anthracene, Fluoranthene, Indeno(1,2,3-cd)pyrene.

The sediment quality results in this report are based on results for the following contaminants:

Arsenic, Cadmium, Chromium, Copper, Lead, Mercury, Nickel, Silver, Zinc, 2-Methylnaphthalene, Acenaphthene, Acenaphthylene, Anthracene, Benz(a)anthracene, Benzo(a)pyrene, Chrysene, Dibenz(a,h)anthracene, Dieldrin, Fluoranthene, Fluorene, Naphthalene, p,p'-DDE, Phenanthrene, Pyrene, Total Chlordanes, Total DDTs, Total HPAHs, Total LPAHs, Total PAHs, Total PCBs,

Tissue

The Challenges of Bivalve Bioaccumulation Monitoring in a Highly Variable Environment

Target Availability: Spring 2002

Authors: Dane Hardin, Rainer Hoenicke, Andrew Gunther, David Bell, and Jordan Gold

Bivalve bioaccumulation monitoring has been widely used to estimate bioavailable contaminants, to assess the relative differences in the degree of contamination, and to provide an estimate of the ecological effects of contamination. This report analyzes RMP bioaccumulation data from 1993–1998 to determine whether variation in non-contaminant water-quality parameters (salinity, temperature, and the concentrations of dissolved oxygen, suspended particulate matter, and chlorophyll) could affect levels of bioaccumulation and indicators of health in bivalves deployed in the Estuary.

Contaminant Concentrations in Fish from the Sacramento-San Joaquin Delta and Lower San Joaquin River, 1998

September 2000

Authors: Jay A. Davis, Michael D. May, Gary Ichikawa, and David Crane

In spite of the popularity of the Delta as a fishing location and the recent human health concerns regarding fish tissue contamination in the Sacramento River watershed, very little systematic sampling has been conducted in the Delta to evaluate human health risks associated with chemical contamination of fish tissue. This report documents the most comprehensive survey of chemical contamination of fish in the Delta to date. The primary objective of this study was to determine whether mercury, organochlorine pesticides, and PCBs occur in the fish that are being used as human food in the Delta at concentrations of potential human health concern. Sampling was performed during the late summer of 1998 and focused on largemouth bass and white catfish, two abundant and popular sport fish species.

URL: <http://www.sfei.org/deltafish/dfc.pdf>

Contaminant Concentrations in Sport Fish from San Francisco Bay, 1997

in press

Authors: Jay A. Davis, Michael D. May, Ben K. Greenfield, Russell Fairey, Cassandra Roberts, Gary Ichikawa, Matt S. Stoelting, Jonathan S. Becker, and Ronald S. Tjeerdema

A pilot study to measure concentrations of contaminants in muscle tissues of sport fish caught in San Francisco Bay was conducted in 1994. The study indicated that there were six chemicals or chemical groups that were of potential human health concern for people consuming Bay-caught fish: mercury, PCBs, DDT, chlordane, dieldrin, and dioxins. As a result of this pilot study, the California Office of Environmental Health Hazard Assessment (OEHHA) issued a health advisory for people consuming fish from San Francisco Bay, which is still in place. In 1997, the

RMP incorporated a fish tissue monitoring component, and the results from the first year are presented in this report. The objectives of this monitoring are: 1) to produce the information needed by regulatory agencies for updating human health advisories and conducting human health risk assessments; and 2) to measure contaminant levels in fish species over time to track trends and to evaluate the effectiveness of management efforts. This monitoring is scheduled to be repeated once every three years.

Published in *Marine Pollution Bulletin* (*in press*). Reprints available from Jay Davis at jay@sfei.org.

Wastewater Effluent

Bay Area Clean Water Agencies (BACWA) Polychlorinated Biphenyls in Municipal Wastewater Effluent Study

Target Availability: April 2002

Authors: Don Yee, Jon Leatherbarrow, and Jay Davis

Polychlorinated biphenyls (PCBs) are a class of synthetic organic contaminants that pose ecological and health risks because of their bioaccumulative nature and toxicity, particularly to organisms at high trophic levels in the food web. Because effluent from publicly owned treatment works (POTWs) is one pathway of PCB transport to the Estuary, detecting and quantifying PCB concentrations in wastewater are necessary for making appropriate management decisions. This PCB monitoring project was undertaken to comply with a National Pollutant Discharge Elimination System (NPDES) permit provision information request issued by the San Francisco Bay Regional Water Quality Control Board for a number of small and large POTWs that discharge into the San Francisco Bay. The primary objective of this study was to determine the concentrations of PCBs in the effluent of several participating POTWs using methods sufficiently sensitive to quantitate most congeners individually. Other objectives of this study are to assess uncertainty in quantitation arising from sampling or measurement variability and to evaluate differences between plants and effects of seasonal rainfall on effluent concentrations.

South Bay/Fairfield-Suisun Trace Organic Contaminants in Effluent Study

Target Availability: April 2002

Authors: Don Yee, Jon Leatherbarrow, and Jay Davis

The purpose of this low-level organic contaminant monitoring project is to comply with a National Pollutant Discharge Elimination System (NPDES) permit provision for Fairfield-Suisun and three South Bay publicly owned treatment works (POTWs) operated by the cities of Palo Alto, San Jose, and Sunnyvale. Effluents from each of these plants were sampled on four occasions. The objectives of this study are: (1) to determine the concentrations of the organic pollutants (polyaromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), organochlorine pesticides (OCPs), and polychlorinated dibenzo-dioxins and furans) in POTW effluents using techniques with the most sensitive methods practicable, and (2) to assess sources of variation in the results from three different laboratories.

Water

Ambient Water Toxicity in the San Francisco Estuary

Target Availability: April 2002

Authors: R. Scott Ogle, Andrew J. Gunther, David Bell, Jeffrey Cotsifas, Jordan Gold, Paul Salop, and Rainer Hoenicke

The purpose of this RMP Special Study is to begin documenting the frequency and duration of episodic toxicity events in the San Francisco Estuary. This report summarizes and reviews toxicity testing results of ambient water samples collected following significant rainstorm events and high frequency sampling at a location influenced by agricultural discharges during 1996-2000. Episodes of ambient water toxicity to *Mysidopsis bahia* have been documented that probably would not have been detected using traditional periodic ambient water sampling designs. Results of ELISA analyses suggest that some of this toxicity may be due to organophosphate pesticides in runoff, while the causes of most of the observed ambient water toxicity remains unknown. Results also suggest that changes in the types of ambient toxicity in the Estuary may be occurring. Therefore, it is critical that monitoring programs such as the RMP adapt their monitoring approach to reflect changes in activities within the watersheds of the monitoring area.

Acknowledgements

Thanks to all who provided feedback on this edition of the *Pulse*, including Robert Brodberg, Tom Grovhoug, Andy Gunther, Tom Hall, Michael Kellogg, Kathy Kramer, Samuel Luoma, Tom O'Connor, John Ross, David Schoellhamer, Bruce Thompson, Sheila Tucker, and Chuck Weir.

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2000 RMP Program Participants

MUNICIPAL DISCHARGERS:

Burlingame Waste Water
Treatment Plant
Central Marin Sanitation
Agency
City of Benicia
City of Calistoga
City of Hercules
City of Palo Alto
City of Petaluma
City of Pinole
City of Saint Helena
City and County of San
Francisco
City of South San
Francisco/San Bruno
City of San Jose/Santa
Clara
City of San Mateo
City of Sunnyvale
Delta Diablo Sanitation
District
East Bay Dischargers
Authority
East Bay Municipal Utility
District
Fairfield-Suisun Sewer
District

Las Gallinas Valley
Sanitation District
Marin County Sanitary
District #5, Tiburon
Millbrae Waste Water
Treatment Plant
Mountain View Sanitary
District
Napa Sanitation District
Novato Sanitation District
Rodeo Sanitary District
San Francisco International
Airport
Sausalito/Marin City
Sanitation District
Sewerage Agency of
Southern Marin
Sonoma County Water
Agency
South Bayside System
Authority
Town of Yountville
Union Sanitary District
Vallejo Sanitation and
Flood Control District
West County Agency

INDUSTRIAL DISCHARGERS:

C & H Sugar Company
Chevron Products Company
Dow Chemical Company
General Chemical
Corporation
Phillips 66 at Rodeo
Rhodia, Inc.
Shell Martinez Refining
Company
Ultramar Inc., Avon Refinery
USS-POSCO Industries
Valero Refining Company

COOLING WATER:

Mirant of California
STORMWATER:
Alameda Countywide Clean
Water Program
Caltrans
City and County of San
Francisco
Contra Costa Clean Water
Program
Fairfield-Suisun Urban
Runoff Management
Program

Marin County Stormwater
Pollution Prevention
Program
San Mateo Countywide
Stormwater Pollution
Prevention Program
Santa Clara Valley Urban
Runoff Pollution Prevention
Program
Vallejo Sanitation and Flood
Control District

DREDGERS:

Black Point Launch Ramp
Captain Edward Payne
Chevron Products Company
Mr. R.S. Gilley
Mr. Gary Scheier
Mr. Ron Valentine
Golden Gate Bridge
Marin Yacht Club
Paradise Cay
Port of Oakland
Port of San Francisco
Sierra Point Marina
TOSCO Corporation
US Army Corps of Engineers
Valero Refining
Vallejo Yacht Club
Yerba Buena Island

RMP Technical Review Committee

(as of March 2002)

Wastewater Treatment Plants (POTWs)	Diane Griffin, EBMUD
South Bay Dischargers	Rosanna Lacarra, City of Sunnyvale
Refiners	Bridgette Deshields, Harding Lawson Associates
Industry	Maury Kallerud, USS-POSCO
Cooling Water	Steve Gallo, Mirant of California
Stormwater Agencies	Jim Scanlin, Alameda County Clean Water Program
Dredgers	Jon Amdur, Port of Oakland
Regional Board 2	Karen Taberski, SFB RWQCB
Regional Board 5	Chris Foe, Central Valley RWQCB
U.S. EPA	Kathleen Dadey
SWRCB	Craig Wilson, SWRCB
Interagency Ecological	Leo Winternitz
Studies Program	CA Dept. Water Resources
City of San Jose	David Tucker , City of San Jose
City/County of San Francisco	Michael Kellogg
<i>RMP Technical Review Committee Chairman in Bold Print</i>	

RMP Steering Committee

(as of March 2002)

Small POTWs	VACANT
Medium-sized POTWs	Daniel Tafolla, Vallejo Sanitation and Flood Control District
Large POTWs/BADA	Chuck Weir, East Bay Dischargers Authority
Refiners	Kevin Buchan , Western States Petroleum Association
Industry	Maury Kallerud, USS-POSCO
Cooling Water	Steve Gallo, Mirant of California
Stormwater Agencies	Larry Bahr, Fairfield-Suisun Sewer District
Dredgers	Ellen Johnck, Bay Planning Coalition
SFBRWQCB	Dyan Whyte
	Karen Taberski
<i>RMP Technical Review Committee Chairman in Bold Print</i>	