San Francisco Estuary
Regional Monitoring Program
for Trace Substances

1996 Annual Report

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Executive Summary

This report describes the results from the 1996 Regional Monitoring Program for Trace Substances (RMP). It is the fourth Annual Report from the RMP which began in 1993 and attempts to synthesize the most obvious data patterns from the last four years. This report includes data from Base Program monitoring activities, as well as results of Pilot and Special Studies conducted or completed in 1996. Additionally, several articles contributed by RMP investigators and others, are included. These articles provide perspective and insight on important contaminant issues identified by the RMP. This summary addresses which kinds of pollutants measured by the RMP appear to be at levels that warrant concern, what kinds of trends may be discerned, and which stations have consistently shown elevated contaminant levels.

The goals or general objectives of the RMP are:

1. To obtain high quality baseline data describing the concentrations of toxic and potentially toxic trace elements and organic contaminants in the water and sediment of the San Francisco Estuary.
2. To determine seasonal and annual trends in chemical and biological water quality in the San Francisco Estuary.
3. To continue to develop a data set that can be used to determine long-term trends in the concentrations of toxic and potentially toxic trace elements and organic contaminants in the water and sediments of the San Francisco Estuary.
4. To determine whether water quality and sediment quality in the Estuary at large are in compliance with objectives established by the Basin Plan (the regulatory planning document used by the Regional Water Quality Control Board).
5. To provide a database on water and sediment quality in the Estuary which is compatible with data being developed in other ongoing studies, including wasteload allocation studies and model development, sediment quality objectives development, in-bay studies of dredged material disposal, Interagency Ecological Program (IEP) water quality studies, primary productivity studies, local effects biomonitoring programs, and state and federal mussel watch programs.

Question: How contaminated is the Estuary, overall?

Answer: Almost all pollutants measured by the RMP are considerably higher in the Estuary than just outside the Golden Gate—some by as much as 50 times. Guidelines for water, sediment, and tissue quality are frequently exceeded for a number of trace elements and synthetic organic compounds. Toxicity in water and sediment at certain locations within the Estuary have been frequently observed during the last five years, although organisms living in sediment generally indicate unimpacted conditions. Long-term downward trends are apparent for a number of contaminants after data from the State Mussel Watch Program and the RMP were combined: Silver contamination in mussels has decreased by over ten times over the last decade and a half, and downward trends are also apparent for chlordane, mercury, and lead.

Question: What places measured by the RMP have the highest levels of contamination?

Answer: Most of the South Bay stations, especially the San Jose and Sunnyvale sites, have higher contamination levels than the more well-flushed Central Bay. In the northern reach of the Estuary, notably at the mouth of the Petaluma River and often at the San Pablo Bay station, some contaminant concentrations are also unusually high. The Sacramento and San Joaquin River stations exhibit the highest incidents of water toxicity to mysids.

The kinds of contaminants monitored and sites sampled remained essentially the same in 1996 as in the previous years.

Five types of samples were collected in the 1996 Base Program:

1. Conventional water quality and chemistry
2. Aquatic bioassays (toxicity tests)
3. Sediment quality and chemistry
4. Sediment bioassays (toxicity tests)
5. Transplanted bivalve bioaccumulation, survival, and condition

In collaboration with the RMP, the United States Geological Survey (USGS) monitors water quality and suspended sediments much more frequently to measure changes in the Estuary that occur on shorter time scales than what can be captured by RMP measurements three times per year. The RMP also conducted three Pilot Studies in 1996: the Benthic Pilot Study, the Watershed Pilot Study, and the Tidal Wetlands Pilot Study. Two Special Studies, sediment contamination indicators and a review of bivalve monitoring in the San Francisco Estuary, are also presented.

1996 Findings

Water

The 1996 monitoring year was considered a “wet” year, with Delta outflow during the February sampling period the highest measured since the inception of the RMP. However, 1996 findings generally showed patterns in pollutant concentrations and distributions similar to those of previous years. For example, the southern and northern ends of the Estuary exhibit the highest concentrations of many trace element and trace organic contaminants. Again, PCBs in water exceeded water quality criteria by a substantial amount at most stations. Several other classes of trace organic compounds also had concentrations above water quality guidelines, including polycyclic aromatic hydrocarbons (PAHs), primarily derived from car exhaust, and certain chlorinated pesticides which are still present in the Estuary long after the banning of their use. Of the ten trace elements measured, concentrations of chromium, copper, mercury, and nickel were higher than water quality guidelines on one or more occasions. Copper concentrations were most frequently above both guidelines for dissolved and total concentrations. Mercury, nickel, and chromium concentrations were also above guidelines in numerous instances.

Clear indications of aquatic toxicity were observed in bioassays with shrimp-like *Mysidopsis* in February at the

Sacramento and San Joaquin Rivers, Grizzly Bay, and Napa River stations. Survival was sharply depressed at three of these stations, and only in water from Grizzly Bay did more than 8% of the test organisms survive. Toxicity was also observed in July samples from the Sacramento and San Joaquin Rivers, and Grizzly Bay stations. The timing and geographical location of this toxicity suggest that organophosphate pesticides carried by agricultural runoff from the Central Valley, and possibly Napa Valley may have had a role in causing the toxicity.

Sediment

Nickel in sediments exceeded sediment quality guidelines developed by the National Oceanic and Atmospheric Administration at all sites, although the nickel guidelines are considered to be imprecise. Chromium, arsenic, mercury, total DDTs, and dieldrin also frequently exceeded the level where adverse effects are possible.

Bivalves

Contaminant bioaccumulation by bivalves in 1996 reflected the unusually high Delta outflows during the wet season. More metals showed appreciable bioaccumulation in 1996 than in 1995. No generally acceptable tissue guidelines for both trace elements and trace organics are available for the bivalve bioaccumulation data. However, maximum tissue residue levels (MTRLs), which are relatively recent, science-based guidelines, can be used as a relative "yard-stick". As in previous years, most major classes of trace organic contaminants in bivalve tissues were above the MTRLs in 1996. PCBs and PAHs were above MTRLs in all 1996 tissue samples.

Although the 1996 monitoring year did not yield any surprising new results, with the possible exception of unusually high trace organic contaminant concentrations at the San Jose monitoring station, some patterns, trends, and associations are beginning to emerge from RMP data after four years of data collection (six years counting the Pilot Studies). In addition to the RMP Base Program results, knowledge from several Pilot and Special Studies, as well as some non-RMP studies together contribute to our growing understanding of contaminants and their potential effects in the Estuary.

Question: Is the Estuary getting better or worse in terms of contamination?

Answer: So far, the data suggest that it is getting better, albeit slowly. Sediments, still significantly enriched with pollutants that have accumulated since the industrialization and urbanization of the Estuary's shores, appear to be a continuing source of many contaminants to the overlying water, thus preventing rapid recovery. Information to determine trends over time from various sources of contamination has not been fully evaluated.

Since the manufacturing of PCBs has been banned and their use restricted for more than two decades, their appearance in water is believed to derive primarily from reservoirs of historically deposited PCBs in sediments of the Estuary, contaminated soils of the Estuary's watershed, or accidental releases from a variety of dispersed sources.

Contaminants and Sites of Concern

The identification of contaminants and sites of concern using RMP data can be made in two ways:

1. Based on the frequency of measurements that exceed appropriate guidelines for water, sediment, and tissue by each contaminant measured. Such an evaluation assumes that the guidelines have been set at levels protective of aquatic life and/or human health and that exceedances indicate an increased potential for adverse effects attributable to contaminants.
2. Based on RMP water and sediment bioassays (toxicity tests).

Contaminants of Concern

It is important to note that the RMP measures a select suite of contaminants that is by no means exhaustive. The RMP parameter list includes several persistent synthetic organic chemicals that are known to impact wildlife and humans, but whose use is now banned, while other trace organic contaminants currently in use are not measured for a variety of reasons.

In water, PCBs and copper concentrations exceeded guidelines most frequently. Since 1993, total PCBs in water have exceeded the EPA criterion in nearly all samples collected. PCBs were also the contaminant group most frequently elevated in fish tissue samples collected in the early 1990s. Because the manufacturing of PCBs has been banned and their use restricted for more than two decades, their appearance in water is believed to derive primarily from reservoirs of historically deposited PCBs in sediments of the Estuary, contaminated soils of the Estuary's watershed, or accidental releases from a variety of dispersed sources.

The pesticides diazinon and chlorpyrifos are considered to be contaminants of concern by their apparent association with aquatic toxicity. Although those pesticides had relatively low frequencies of exceedances in 1996, seasonal pulses of these pesticides from the Central Valley and in the Guadalupe River may have been responsible for observed aquatic toxicity.

Certain contaminants in sediments have exhibited consistently elevated levels in sediment over the past four years. Chromium, arsenic, mercury, DDT compounds, and dieldrin frequently exceeded the level where adverse effects are possible. Nickel concentrations have been above sediment quality guidelines at all stations since the inception of the RMP in 1993, but it should be noted that

soils in the immediate Bay Area watersheds are naturally high in nickel, and guidelines for nickel are known to be quite imprecise. Based on an analysis of relationships between sediment toxicity test results and sediment contamination, the additive influence of numerous sediment contaminants was highly associated with toxicity to sediment-dwelling invertebrate species. At several sites elevated chlordane concentrations were associated with toxicity, as were low- and high-molecular weight PAHs at other sites. Dissolved trace metals from sediment at the River stations and Grizzly Bay were associated with bivalve larval toxicity through tests known as toxicity identification evaluations (TIEs) conducted at the Rivers confluence and Grizzly Bay sites.

Concentrations of silver, mercury, lead, and chlordane were shown to be decreasing in tissues over long time periods. In fish, PCB, dioxin, mercury, dieldrin, DDT, and chlordane concentrations have been shown to exceed EPA screening values for human consumption. Except for dioxins (not measured in RMP), those are the same organic contaminants that exceed the MTRLs in bivalve tissues measured by the RMP.

In other studies, the USGS has shown that bioaccumulation of cadmium by the Asian clam *Potamocorbula* was related to decreased biological condition and reproductive function. Bioaccumulation of selenium by *Potamocorbula* is believed to be related to increases in selenium in sturgeon tissues, approaching concentrations of concern. Mercury is another trace element with high bioaccumulation potential (although not reflected in bivalve tissue), as evidenced by concentrations found in fish tissue that exceed levels of concern to human health.

It is reasonable to consider the contaminants of highest concern to be those actually shown to be related to bioaccumulation or adverse effects. Of the contaminants measured in the RMP these include:

- diazinon and chlorpyrifos in water,
- DDTs, chlordanes, and PAHs in sediments, and
- PCBs, cadmium, mercury, selenium, PAHs, chlordanes, dieldrin, and DDTs in bivalve and fish tissue.

Although copper and nickel are of current regulatory interest, there is no conclusive evidence of biological effects from exposures to those contaminants in the Estuary. Several other trace elements (arsenic, silver, lead and zinc) are usually below guidelines and/or have shown no evi-

The sites at opposite ends of the Estuary, those at the mouth of Coyote Creek in the South Bay, and sites at the Rivers confluence and Suisun Bay in the Northern Estuary, are more impacted by contaminants than other RMP sites. Those locations are at the bayward ends of major tributaries where contamination might be expected to accumulate.

dence of bioaccumulation or association with biological effects in the Estuary. However, as suggested for sediments, a mixture of contaminants, such as that found in the Estuary, may have a greater cumulative effect than any of those contaminants considered alone.

Sites of Concern

Comparisons of exceedances of guidelines and incidences of toxicity among sites are difficult since not all measurements are made at all sites. Using the information available, a general picture can be seen: sites in the far South Bay and Southern Sloughs (BA10, C-3-0, C-1-3) had more exceedances of water and sediment guidelines than other locations in the Bay, and concentration gradients of many contaminants from South to Central Bay were apparent. The San Jose monitoring station (C-3-0) had the highest number of water quality exceedances and the highest measure of sediment contamination of any site sampled. Additionally, the Watershed Pilot Study samples from Standish Dam (head of tide) in Coyote Creek often had higher concentrations of some trace organic contaminant groups than any of the RMP Base Program sites.

Although there have been no indications of aquatic toxicity in the South Bay since monitoring began in 1993, Pilot Studies of episodic aquatic toxicity reported some toxicity associated with runoff in Guadalupe Slough. Redwood Creek (BA40) had the highest incidence of sediment toxicity to amphipods over the past six years (90% of tests) of any site in the Estuary.

These results underscore the importance of several non-RMP activities currently being conducted in the South Bay. The City of San Jose will be developing estimates of Total Maximum Daily Loads (TMDL) for copper and nickel that will attempt to model and calculate contributions of those elements from various sources in the South Bay. That exercise should help us to understand contributions of other contaminants as well. The Regional Board and South Bay stakeholders are collaborating on a Watershed Management Initiative in the South Bay that is examining new ways to manage contaminant inputs and restore impaired biological resources.

In the Northern Estuary, the Petaluma River (BD15) had numerous exceedances of water guidelines. San Pablo Bay (BD20) had the largest number of sediment contaminants above levels where effects are possible in August, largely due to elevated concentrations of several individual PAH compounds. Sites at San Joaquin River (BG30), Davis Point (BD40), and San Pablo (BD20) had the highest

number of tissue organics that exceeded the MTRL guidelines.

Sediment samples from wetland channels in China Camp State Park and Petaluma Marsh generally were more contaminated than samples from the adjacent San Pablo Bay. Using sediment-dwelling organisms as an indicator suggested some degree of contamination in the marsh sediments from China Camp.

The Sacramento and San Joaquin Rivers (BG20, BG30) and Grizzly Bay (BF20) sites had the highest incidences of water toxicity to mysid shrimp (39% of tests) between 1994–1996. As noted above, because of the timing and location of those "hits", the cause of that toxicity is believed to be the pesticides diazinon and chlorpyrifos, but further investigation is needed. However, there has been no toxicity of water samples to bivalve larvae at those sites. Interestingly, the same sites have shown the highest incidence of toxicity from sediment contaminants to bivalve larvae (100% of tests). As noted above, preliminary toxicity identification evaluations have suggested that dissolved trace elements in sediments may be the cause of toxicity. Those same sites also had the greatest degree of trace organics bioaccumulation. Toxicity of sediments to *Eohaustorius* amphipods (a sediment-dwelling invertebrate species) occurred in about half the tests conducted since 1991 at the Napa River and Grizzly Bay stations, and in only about 10–20 % of tests at the Sacramento and San Joaquin River sites.

Because RMP station locations were not randomly chosen, the RMP results are not necessarily representative of conditions in the Estuary as a whole. Other locations in the Bay that are not sampled by the RMP, particularly areas along the Estuary margins near some of the major harbors, closed military bases, Superfund sites, or other locations may be quite contaminated, while still other locations may be less contaminated than what the RMP database may indicate.

Generally, the Central Bay has the fewest exceedances of guidelines and the lowest incidence of toxicity of all Bay sites, probably due to the regular tidal flushing and greater water depths resulting in lower suspended sediment concentrations.

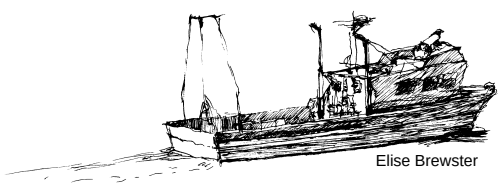
Trends in Contamination

Trends over time and site-specific patterns over time have been noted in this report for water, sediment, and tissue monitored by the RMP. In water, examination of dissolved contaminant data revealed strong gradients of contamination in the Estuary, with as much as a 50-fold difference between the stations with the highest and lowest concentrations. Station gradients have been consistently observed over the course of the RMP for most contaminants. Clear, consistent seasonal variation has also been evident for dissolved concentrations of many contaminants. These

patterns are apparent in the dissolved data because concentrations in the dissolved fraction are relatively independent of other water quality variables whose fluctuations might obscure the patterns. In sediment, spatial gradients and longer-term changes between 1991–1996 were indicated, but consistent seasonal variation has not been observed. In bivalves, the utility of the data for detecting station gradients is limited by the widely varying salinities of the Estuary and the restricted salinity tolerance of the three species employed, but some seasonal and long-term temporal trends have been observed.

A qualitative comparison of the trends observed in the three data sets (dissolved water, sediment, and bivalve) reveals little consistency. The strong station gradients in water were generally not mirrored by sediment concentrations. The exceptions to this were concentrations of PCB, DDT, and chlordane, which had similar composition of compounds in each pollutant group in water and sediment, dominated by relatively high concentrations at San Jose (C-3-0). These data clearly indicate source(s) of these compounds in that portion of the Estuary. Only two trace elements (nickel and silver) showed spatial variation that was roughly similar in water and sediment. Seasonal trends were obvious in the water data, and in one case (silver), the bivalve data indicated a similar increase in the dry season as observed in water. Long-term trends were indicated by an analysis of bivalve data collected from 1980–1996 under the State Mussel Watch Program and the RMP and from graphical analysis of the sediment data. In one case (chlordane) long-term declines in bivalves in sediment were consistent with declines noted since 1994.

The Program, as currently designed, does not attempt to determine contaminant source categories, inputs, or contaminant transport and fate. However, in 1997, the RMP underwent a thorough external review that recommended, among many other items, to modify the current program objectives to include determinations of contaminant sources and inputs. In addition, the information accumulated so far lends itself to a more thorough analysis to be used to re-design the monitoring program.



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