San Francisco Estuary
Regional Monitoring Program
for Trace Substances

1997 Annual Report

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Executive Summary

The *1997 Annual Report* is the fifth Annual Report from the Regional Monitoring Program for Trace Substances (RMP) and contains a comprehensive description of RMP results from the 1997 monitoring year. As in previous years, the report includes results from the Base Program (water, sediment, and bivalve monitoring) and results from Pilot and Special Studies completed in 1997, in addition to an update on the RMP Five-Year Review implementation. It also includes papers contributed by RMP investigators and other scientists. These articles address related monitoring activities, and help to provide additional insight into contaminant patterns and the impacts of those contaminants on the San Francisco Estuary.

The 1997 monitoring year proved to be an unusual one, with record-setting precipitation in December and January followed by unusually dry weather in February and March. These weather patterns had a visible effect on RMP results, frequently creating sharp contrasts in results between the first two sampling cruises of the year, and higher than normal contaminant concentrations at many RMP sampling sites in February. These results, and results from the other aspects of the RMP, are summarized below.

1997 Review Implementation

The original goals of the RMP have been met, and the Program continues to collect high-quality baseline data, examine trends in the Estuary, and collaborate with other local monitoring programs. However, during a comprehensive Five-Year Review of the program by seven independent scientists and specialists (the Review Panel), it became obvious that many improvements are still possible. These improvements include a refinement of RMP objectives and decision-making processes, as well as clarification of management and scientific questions.

The Review Panel also recommended more specific descriptions of the roles, responsibilities, and authorities of the people and organizations involved in the RMP. They proposed an increase in the amount of interpretation applied to RMP data, and a more thorough integration of other Bay Area monitoring and research program results. The Panel also suggested a revision of RMP objectives. New objectives, adopted by the Steering Committee in early 1998, are listed in the sidebar.

Workgroups of scientific experts were created to examine some of the more important components of RMP monitoring: pollutant groups (chlorinated hydrocarbons, metals, and pesticides), an important matrix (sediment), and pollutant sources, pathways, and loadings. These workgroups have developed additional recommendations for monitoring needs which will be integrated into the design of the RMP.

Revised RMP Objectives

1. To describe patterns and trends in contaminant concentration and distribution.
2. To describe general sources and loadings of contamination to the Estuary.
3. To measure contaminant effect of selected parts of the Estuary ecosystem.
4. To compare monitoring information to relevant water quality objectives and other guidelines.
5. To synthesize and distribute information from a range of sources to present a more complete picture of the sources, distribution, fates, and effects of contaminants in the Estuary ecosystem.

The Big Storm in January 1997, which resulted in a combination of high flows and elevated contaminant concentrations, probably caused the mass loadings of many contaminants to the Bay to be higher than in previous years.

Water Monitoring

Water Quality and Contaminants

A notable anomaly in water quality in 1997, a result of one of the strongest El Niño events in recent history, was the increase in temperatures in the eastern Pacific Ocean by over five degrees Celsius above normal. And while the surface water temperatures in the northern and southern portions of the Bay were not unusually high, the temperature of Central Bay waters—those closest to the Pacific Ocean—were the highest recorded by the RMP.

Another aberration was the Big Storm in January 1997, which resulted in a combination of high flows and elevated contaminant concentrations that probably caused the mass loadings of many contaminants to the Bay to be higher than in previous years. The extreme hydrologic variation at the beginning of the year created a distinct contrast in conventional water quality parameters between the first two sampling cruises in January and April. During January sampling, salinity in the Bay's surface waters was extremely low and the Baywide mean of total suspended solids (TSS) was the highest recorded by the RMP; in April, salinity had increased to almost twice its January value, while the mean TSS was less than half its January mean.

This contrast between sampling periods was also visible in dissolved trace element concentrations. In January, dissolved concentrations of trace elements were relatively high throughout the Estuary, with chromium, mercury, and lead exhibiting the highest Baywide average concentrations for any cruise since the beginning of the RMP. These dissolved trace element concentrations were especially high in the Northern Estuary and Rivers monitoring stations, while concentrations in the South Bay appeared to be unaffected by the Big Storm. Total (dissolved + particulate) concentrations of some trace elements that are transported primarily in the particulate phase—chromium, copper, mercury, nickel, lead, and zinc—were also sharply elevated in January, and mirrored the declines seen in TSS from January to April.

Organochlorine pesticides also exhibited high concentrations in January, with dissolved and total chlordanes and DDTs at high levels in the Northern Estuary, although clear seasonal variation of pesticides was not visible in the southern reach. Dissolved diazinon exhibited seasonal variability in both northern and southern portions of the Bay. The high dissolved + particulate concentrations of DDTs, chlordanes, and dieldrin in the Northern Estuary suggest that contaminated sediment particles from the Central Valley were transported during January's high flows. Total polychlorinated biphenyl (PCB) concentrations, however, did not increase as a result of the Big Storm, suggesting that sediment particles washed down

from the Central Valley were not as contaminated with PCBs as they were with organochlorine pesticides.

Many contaminants were above applicable water quality guideline (WQG) concentrations. Of the ten RMP trace elements that have established WQGs, chromium, copper, mercury, nickel, lead, selenium, and zinc exceeded guideline concentrations at least once, with chromium, mercury, and nickel most frequently above their established guidelines. Quite a few organic contaminants also exceeded established guidelines at least once, with dieldrin, total PCBs, and total PAHs most frequently above their guidelines. The largest number of contaminant concentrations over WQGs were found at the Southern Sloughs, the Northern Estuary, and the Estuary Interface stations.

Many of the fish populations currently in decline in San Francisco Bay rely on resident invertebrates as a key food resource during their early life stages, and their decline may be due to periods of high pesticide concentrations that coincide with the early life stages of these fishes.

Aquatic Toxicity

Aquatic toxicity testing revealed toxicity to mysids (*Mysidopsis*) in January at many of the Northern Estuary sites: Grizzly Bay, Napa River, and both River stations. In August, however, mysid toxicity was concentrated in the southern reach of the Bay, with all four South Bay stations showing low to zero percent survival.

A separate study of episodic water toxicity was conducted during the winters of 1996/1997 and 1997/1998, examining the effects of heavy storms (and thus increased river flow) on toxicity. Episodic toxicity is an important concern because contaminant concentrations can vary as a result of runoff following large rainstorms or agricultural pesticide applications. Toxicity frequently coincides with this runoff, and results from this year's study indicate that Northern Estuary waters may be toxic to resident invertebrates for up to a week following such events. Many of the fish populations currently in decline in San Francisco Bay rely on these resident invertebrates as a key food resource during their early life stages, and their decline may be due to periods of high pesticide concentrations that coincide with the early life stages of these fishes.

Sediment Monitoring

Contaminants in Sediment

As in previous years, most sediment contaminant concentrations were highest in the Southern Sloughs and South Bay, although the flood flows of January appeared to have an effect on contaminant concentrations in the northern reach of the Bay. Mercury concentrations were higher throughout the Estuary in February, and several contaminants, such as copper, lead, selenium, and polycyclic aromatic hydrocarbons (PAHs), had obviously elevated

Mysidopsis bahia

The Effects Range sediment quality guidelines were developed to identify concentrations of contaminants associated with biological effects in laboratory, field, or modeling studies.

The Effects Range-Low (ERL) value is the concentration equivalent to the lower 10th percentile of the compiled study data. Sediment concentrations below the ERL are interpreted as being "rarely" associated with adverse effects.

The Effects Range-Median (ERM) is the concentration equivalent to the 50th percentile of the compiled study data. Sediment concentrations above the ERM are "frequently" associated with adverse effects.

concentrations at the San Joaquin River site in the Northern Estuary. When compared to previous years, both copper and PAHs were higher than in the past at both River sites in the North Bay, while cadmium, chromium, nickel, chlordanes, and DDTs were higher in the South Bay. Trace element concentrations were fairly constant between 1993 and 1997, with few obvious increasing or decreasing trends.

Two different sets of guidelines were used to help interpret RMP results: the Effects-Range guidelines (see sidebar), and the Ambient Sediment Concentration (ASC) guidelines (see Chapter 4) developed by the San Francisco Bay Regional Water Quality Control Board (SFBRWQCB). The Effects-Range guidelines can be used to predict the potential for biological effects, while ASC guidelines are based on the ambient or "background" concentrations of contaminants in the Bay and can be used to indicate sites where contaminants exceed those background levels.

Sediment contaminant concentrations at most of the RMP sites were frequently above Effects-Range guidelines, with the highest concentrations occurring at the Estuary Interface sites, the Southern Sloughs, and in the South Bay. Most of the 1997 RMP sediment samples had more than one contaminant exceeding these guidelines, suggesting a potential for effects on resident species. ASC guideline exceedances appeared most frequently for nickel and chromium concentrations, as well as for some individual PAH compounds. Both Effects-Range and ASC guidelines had more exceedances in February than in August, suggesting that January's flood flows increased sediment contaminant concentrations and, therefore, potentially increased toxicity.

Sediment Toxicity

Toxicity to bivalve embryos or amphipods was most pronounced and occurred most frequently in Suisun Bay and at the Rivers sites, and in the South Bay, where more of the samples were toxic than in previous years. RMP investigators are searching for the causes of the observed toxicity, especially at the RMP Rivers stations, where consistent toxicity to bivalves and intermittent toxicity to amphipods has been observed over the past five years. RMP investigators believe metals may be the cause of the persistent toxicity to bivalve embryos at the Rivers sites.

Benthic Pilot Study

Another method currently being developed by RMP investigators to evaluate sites for contaminant effects is the use of benthic assemblages. The RMP Benthic Pilot study began in 1994, with the objective of assessing the use of benthic information to evaluate the health of the Estuary; its ultimate goal is to use benthic community

characteristics to determine ecological effects of sediment contamination. In previous years, the project focused on identifying benthic assemblages specific to the San Francisco Bay Estuary and Delta. In 1997, RMP investigators began evaluating the biological response of benthic communities to sediment contamination. Data are being compiled from additional sources (Bay Protection and Toxic Cleanup Program, Bay Area Dischargers Association Local Effects Monitoring Program, and the Department of Water Resources) and added to the RMP database in order to demonstrate benthic response to contamination. While analysis is not yet complete, preliminary results indicate that most RMP sites are inhabited by many species characteristic of unimpacted conditions.

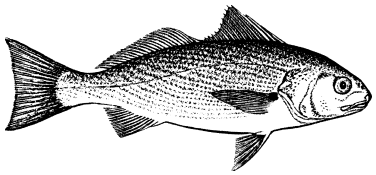
Bivalve Monitoring

Bioaccumulation results were generally consistent with those of previous years, although the large freshwater inflow during January 1997 caused high mortality in *Mytilus californianus*, a species adapted to oceanic intertidal conditions. Certain contaminant trends in bivalve tissue within the Estuary became more visible in 1997. By combining the databases of the RMP and the State Mussel Watch Program, RMP investigators found statistically significant declines in silver in both the Central and South Bay reaches, and less pronounced declines in mercury and lead concentrations. They also found that chlorinated hydrocarbon (CHC) concentrations in bivalves, after steep declines in the early 1980s, appeared to have leveled off. At some individual stations, for example, declines in PCBs were observed, while no statistically significant trends were detectable at other stations.

In 1997, the bivalve component of the RMP had an increased emphasis on evaluating the effectiveness of bivalve monitoring and how it might be improved. While bivalves are good trend indicators for many contaminants, they do not bioaccumulate all contaminants equally well. Additionally, as the bivalve data review section in Chapter 5 indicates, the high variability of non-contaminant water quality parameters (e.g., salinity, chlorophyll *a*, dissolved oxygen, temperature) during the wet season sometimes makes bioaccumulation difficult to interpret, and the 1997 monitoring year was no exception. Thus, special attention was given to assessing the use of bivalve monitoring within the context of the RMP, and to finding methods of normalizing data that might prove helpful in uncovering contaminant trends within the Estuary.

After extensive evaluation, RMP scientists concluded that while bivalves are effective as a tool for monitoring spatial and temporal trends, they are of limited use when applied to trace elements such as arsenic and mercury—elements that do not accumulate appreciatively above background levels in bivalve tissues. They can, however, provide valuable insight into contaminant concentrations in the Estuary, for

Mytilus



White Croaker from Freshwater Fishes of California. Copyright (c) 1984 by Samuel M. McGinnis and Doris Alcorn. Reprinted by permission of the University of California Press. All rights reserved.

while water and sediment sampling only provides a brief snapshot of contamination, bivalve bioaccumulation studies provide an integrated measure of water contamination over a three month period.

Pilot and Special Studies

Fish Tissue

As a follow-up to a 1994 Regional Board study, a special study of contaminant concentrations in San Francisco Bay fish was performed. RMP fish sampling in 1997 targeted seven species frequently caught and eaten by Bay fishers at seven popular fishing areas around the Bay. The results revealed that persistent toxic chemicals in Bay fish remained at concentrations of potential human health concern. For instance, mercury exceeded a human health screening value in 44 of 84 Bay samples, with all leopard shark and striped bass samples exceeding the screening value. PCBs and other trace organics were highest in white croaker and shiner surfperch, the two species with the highest fat content in their muscle tissue. PCBs exceeded the human health screening value in more than two-thirds of the Bay samples, while dieldrin, DDT, and chlordane had fewer samples above screening values. Dioxins and dibenzofurans exceeded their screening values in all seven of the analyzed samples.

There was significant variation in contaminant concentrations among Bay locations: Oakland Harbor had significantly elevated concentrations of mercury, PCBs, DDTs, and chlordanes compared with other Bay locations. Mercury concentrations in 1997 were not significantly different from 1994 levels, but statistically significant declines in concentrations from 1994 to 1997 were observed for PCBs, DDTs, chlordanes, and dieldrin. However, continued monitoring is needed in order to establish whether these observed declines are true indications of declining contaminant masses in the Bay instead of variation due to other factors.

Estuary Interface Pilot Study

Many RMP sampling stations are located along the “spine” of the Estuary in order to monitor locations which, over time, are helpful in determining ambient concentrations for different reaches of the Estuary, and in detecting broad-scale spatial and temporal trends in chemistry and toxicity. During the first three years of RMP monitoring, it became evident that stations at the South Bay Estuary margins tended to exhibit higher concentrations of trace elements and organic pollutants than stations in the deeper portions of the Bay. In an attempt to determine which factors were responsible for this occurrence, and to determine how adjacent watersheds are affecting pollutant inputs, RMP investigators sampled at the interface between bay and upland waters.

Persistent toxic chemicals in Bay fish remained at concentrations of potential human health concern.

Some definite patterns are beginning to emerge after two years of sampling. The particulate fraction of water contaminants entering the Estuary from the Guadalupe River has greatly elevated concentrations of copper, mercury, and nickel compared to the sediment concentrations of these metals in the Southern Sloughs and South Bay. Water organics at the Estuary Interface (EIP) sites were also extremely high, with CHC concentrations higher than at any of the Estuary reaches. Additionally, using PCB fingerprinting methods (see text), SFEI scientists found that PCB concentrations in water were highest at the EIP stations, displaying a concentration gradient between these stations and the South Bay.

Related Monitoring Activities

RMP sample cruises are not exclusively limited to collecting RMP baseline data. During the sediment cruises, for example, U.S. Geological Survey and U.C. Berkeley researchers collected sediment samples in order to examine populations of benthic foraminifers. Sand-sized protozoans, foraminifers are sensitive indicators of marine and estuarine pollution, especially trace metals, and because they have a rapid rate of reproduction they respond relatively quickly to environmental contamination. Preliminary results of sampling in San Francisco Bay have shown that no stations were completely devoid of foraminifers, even at RMP sites characterized by high sediment trace element concentrations.

Another project which utilized 1997 RMP sampling cruises examined nickel concentrations in water in South San Francisco Bay. Because different forms of nickel differ in their degrees of toxicity and different sources discharge different nickel compounds, measurements of nickel speciation in the water column can be important in determining temporal patterns of nickel sources and toxicity in the South Bay. While stronger nickel complexes in the Bay originate mostly from wastewater effluent, the weaker, more toxic nickel-organo complexes are found in surface water runoff. Experiment results showed that the percentage of strongly complexed nickel in the Bay decreases during the wet winter months, when the weaker nickel complexes entering the Estuary via runoff are present. In the drier summer months, concentrations of complexed nickel are at their highest.

Other Monitoring Activities

Two major monitoring programs are currently in place on the Sacramento River: the Sacramento River Watershed Program (SRWP) and the Sacramento Coordinated Water Quality Monitoring Program (CMP). The CMP has been in place since 1992, and is a cooperative effort of three public agencies. Its primary purpose is collecting data to help develop and implement water quality policy

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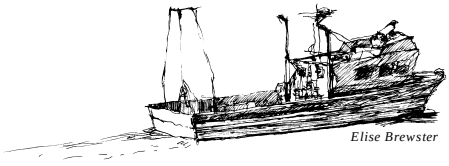
and regulations in the Sacramento area. The SRWP began in 1996 and is a stakeholder-driven effort to restore and protect beneficial uses of the Sacramento River Basin. Both programs involve ambient water quality monitoring, including trace elements, pathogens, and conventional water quality parameters (such as pH, temperature, and dissolved oxygen). The SRWP monitoring also includes toxicity testing, fish tissue monitoring, and biological indicators such as benthic invertebrates, as well as a public outreach and education component which works to promote knowledge and awareness of the watershed. The two programs are being coordinated at several levels: they have adopted compatible sampling and analytical methods, they share sampling duties and the resulting data, and together, the two groups sponsored the State of the Watershed Conference.

Conclusions

In general, contaminant concentrations throughout the Estuary tended to be higher than normal in January, due to high flows from the Big Storm. Water concentrations of mercury, chromium, and lead were at an all-time, Baywide high. Water quality parameters measured in January were also abnormal: salinity in the surface water of the Bay was extremely low, while total suspended solids were the highest ever measured by the RMP. Sediment contaminant concentrations, however, did not seem to be unusually affected by the January floods.

Now in its fifth year, the RMP has established itself as a source of reliable, high-quality data, and in cooperation with other Bay Area monitoring and research programs, it has the potential to provide important insights into contaminant sources and trends in the San Francisco Estuary. The Review Panel declared the Regional Monitoring Program for Trace Substances to be “a valuable environmental monitoring program based on a unique partnership between regulatory agencies and dischargers that can serve as a model for others.” But even before the changes recommended by the Review Panel have been fully implemented, RMP data and research have resulted in major changes to policy development by providing focus for the SFBRWQCB and helping them to identify unanticipated sources of pollution.



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