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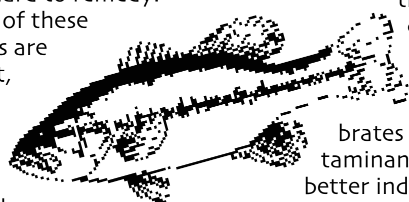
RMP Regional Monitoring News

Contaminant Concentrations in Delta Fish

by Ben Greenfield

Mercury and persistent organic contaminants are a thorn in the side of environmental managers. Fish in many freshwaters and estuaries of the nation contain mercury and organic contaminants at concentrations that are of potential human health concern, which has resulted in fish consumption advisories (recent advisories available on <http://www.epa.gov/ost/fish>).

Many of these contaminants can take thousands of years to break down into less toxic by-products, and because trace levels can have significant environmental impacts, contaminated areas can be very hard to remedy. Even though most of these synthetic chemicals are not used at present, their historical release has left a legacy of contamination. Most of the mercury in the Sacramento and San Joaquin rivers results from mining operations in the 19th century, but contaminated sediment and fish are still found in the Estuary today. The sale and production of PCBs and many other organochlorines such as DDT were banned ten to thirty years ago, but these compounds remain at levels of concern in sediments and water today.



In 1998, the San Francisco Estuary Institute, in collaboration with other agencies, measured contaminant concentrations in fish throughout the Sacramento–San Joaquin Delta and the lower San Joaquin River. A major goal of this study was to determine whether mercury, pesticide, and PCB concentrations in fish of this region are currently of human health concern. A secondary goal of the study was to compare contamination at different locations.

Mapping contaminant levels in fish is particularly important because fish consumption is a primary route for these contaminants into humans. The Sacramento–San Joaquin Delta is heavily fished; if some areas are particularly contaminated, anglers could avoid those areas and reduce their contaminant exposure. An auxiliary goal of the study was to see how fish contaminant levels have changed over time, in order to determine whether past efforts to reduce contaminant input have led to lower contaminant levels in fish (Figure 1).

For our study, we sampled largemouth bass and white catfish because they are popular sport fish, found throughout the Delta, and are high in the food web. The last consideration is important because fish that consume other fish and predatory invertebrates tend to have higher contaminant levels, making them better indicators of environmental contamination. Largemouth bass and white catfish represent different parts of the river ecosystem, and thus provide complimentary information.

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Data Transformed into Information

by John Ross

"Information is data endowed with relevance and purpose."
— Peter F. Drucker

A central mission of an effective monitoring program is to provide timely information to decision makers, be they managers, the public, or other scientists. The achievement of this goal requires transforming collected data into information. Information is data endowed with relevance and purpose. Publication of an annual report on the condition of the San Francisco Estuary is one way that the Regional Monitoring Program (RMP) attempts to meet this objective.

As such, the RMP annual reports, including the *RMP Results* and the *Pulse of the Estuary*, is the culmination of a multi-year cycle, repre-

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White catfish mostly feed on riverbed prey whereas largemouth bass eat more floating and swimming prey. We sampled the fish in the summer of 1998, using an electrofishing boat and nets, at 19 sites.

Concentrations in fish were compared to a "screening value" that indicates potential human health concern. Every contaminant measured had some concentrations above the screening value. High concentrations were most frequent for mercury. Approximately one half of the largemouth bass and white catfish samples analyzed exceeded the mercury screening value. Concentrations of PCBs were above the screening value in 30% of the samples and concentrations of DDT exceeded the screening value in 23% of the samples.

For both mercury and DDTs, concentrations were low in the central Delta (e.g. near Antioch), suggesting that this area is less contaminated, or that the contaminants are less available to the fish than upstream reaches of the Sacramento and San Joaquin rivers (Figure 2). Unlike mercury and DDT, PCB had localized hotspots, with contaminated sites surrounded both immediately upstream and downstream by uncontaminated sites.

We found some evidence that contaminant concentrations have declined over time. For mercury, PCBs, and DDTs, current tissue concentrations in white catfish appeared to be lower in 1998 than they were in the 1980s (Figure 1). However, we must be cautious when comparing the current data to older data. Analytical methods have changed, which may cause differences in measured concentrations. Additionally, long-term data only exist for two sites, so we cannot extrapolate to the entire region.

Our study demonstrated that many parts of the Delta have contaminant concentrations above screening values. To determine whether management actions result in reduced concen-

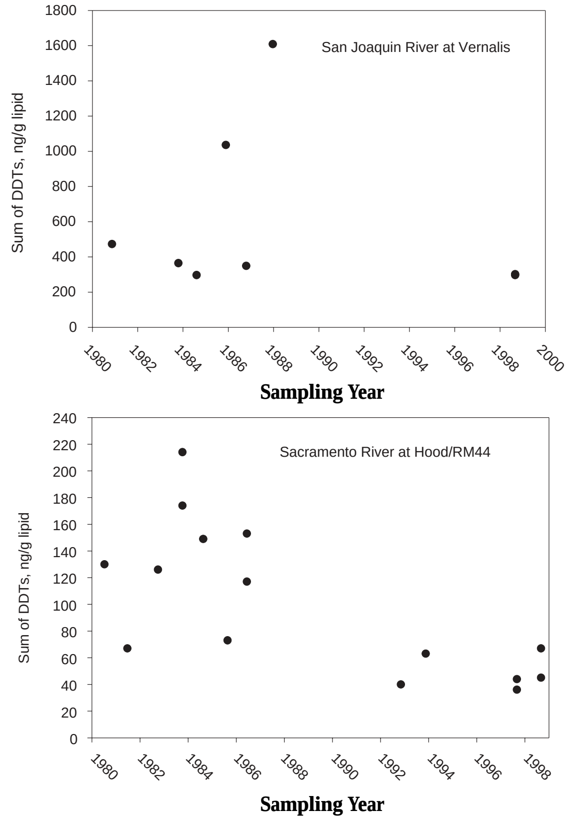
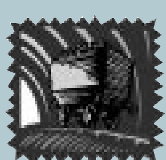


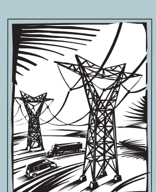
Figure 1. DDT concentratons in white catfish at two locations, 1980–1998.

Sources of Mercury, PCBs and Organochlorine Pesticides



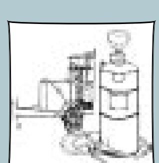
Mercury

The principal sources of mercury to aquatic ecosystems in northern California are historic mercury and gold mining sites, fossil fuel combustion, trace impurities in products such as bleach, and direct use of the metal in applications such as thermometers and dental amalgam (SFBRWQCB, 1998).



PCBs

PCBs were used in a wide variety of applications (e.g., in electrical transformers and capacitors, vacuum pumps, hydraulic fluids, lubricants, inks, and as a plasticizer) from the time of their initial commercial production in 1929 (Brinkmann and de Kok, 1980). In the U.S., PCBs were sold as mixtures of congeners known as "Aroclors" with varying degrees of chlorine content. By the 1970s a growing appreciation of the toxicity of PCBs led to restrictions on their production and use. Leakage from transformers or improper handling of PCB containing equipment has led to contamination of runoff from industrial areas. Other sources of PCBs to the Estuary are atmospheric deposition, effluents, and remobilization from sediment (Davis et al. 2000).



Organochlorine Pesticides

Organochlorine (OC) pesticides (including DDT, chlordane, dieldrin, toxaphene, and others) were used in a wide variety of applications in agricultural, domestic, and industrial settings. Since these chemicals are so persistent, concentrations remain elevated in areas where they were used decades ago. Runoff from these areas continues to transport OC residues into creeks, rivers, and, ultimately, the Estuary.

Figure 2. Map of sampling stations with contaminant concentrations above screening values. The data are from the Delta Study and the Sacramento River Watershed Program.

trations, this fish sampling should be continued on a long-term basis. We also recommend that additional fish sampling be performed in the San Joaquin River watershed, the lower reaches of which appear to be a focal point for pesticide contamination. Finally, a study to determine who eats these fish and how much they eat would improve our knowledge of the risk these fish pose to humans.

For a pdf copy of the complete report, refer to <http:// www.sfei.org/ deltafish/dfc.pdf> on the Web.

senting the combined efforts of many individuals, both inside and outside the San Francisco Estuary Institute (SFEI). The RMP operates on a four-year work cycle. The first year is devoted to scoping budget needs and scientific efforts two years in advance; the second to planning and contracting for the sampling program; the third to sampling in the field. The focus of the fourth year is on validating, analyzing, and interpreting the data from the pervious year's sampling, and writing and producing the annual reports in order to communicate the results to appropriate audiences—particularly RMP Program Participants and the Regional Board.

What tasks are involved?

The tasks begin with planning and contracting for the collection of field samples. Water samples are currently collected twice per year in an effort to obtain seasonal perspectives of contamination, during the wet season (January to February) and in the dry season (July to September). Sediment and bivalve (tissue) samples are collected only during the dry season. After collection, field samples are sent to contracting laboratories for analysis. Laboratory analysis of samples is performed in compliance with both internal laboratory procedures and the Quality Assurance/Quality Control (QA/QC) guidelines developed at SFEI. Sample analysis used to take anywhere from several months to more than a year, depending on the matrix (water, sediment, or tissue), individual laboratory workloads, and necessary reanalyses, but all laboratories are now following a tighter submittal schedule.

Preparing water samples for analysis on board the *R/V David Johnston*.

Results of the laboratory analysis and written data documentation are submitted to the Institute upon completion. The submitted data set is assigned to one of several environmental analysts who is responsible for checking the submittal for completeness, formatting the data for input into the RMP database, generating preliminary data tables, and performing an initial QA/QC review. SFEI's QA/QC manager performs a more comprehensive review focusing on the key data quality indicators. The objective of the QA/QC program at SFEI is to assure all data generated or used by SFEI are scientifically valid, defensible, comparable, precise, and accurate. Data validation may take several weeks to accomplish, depending on workloads and any problems found with the submitted data.

Data validation completion is the precursor to the generation of data tables and figures for the annual reports, followed by data interpretation, and the writing of the annual reports. The written report sections, along with accompanying data tables and charts, are converted into PDF files and published on the SFEI Web site <www.sfei.org> with restricted access; allowing review by RMP participants. Feedback from the review process is incorporated before the Annual Report is released to the public.

Activities are ongoing

Activities related to the planning, contracting, sampling and data flow (validating, analyzing, and interpreting the data) are ongoing, occur simultaneously, and depend on preceding steps. For example, data validation cannot be completed until all labs have submitted their data to the RMP. As a consequence, adjustments to the monitoring program based on the final, validated results cannot be implemented until two years following sample collection.

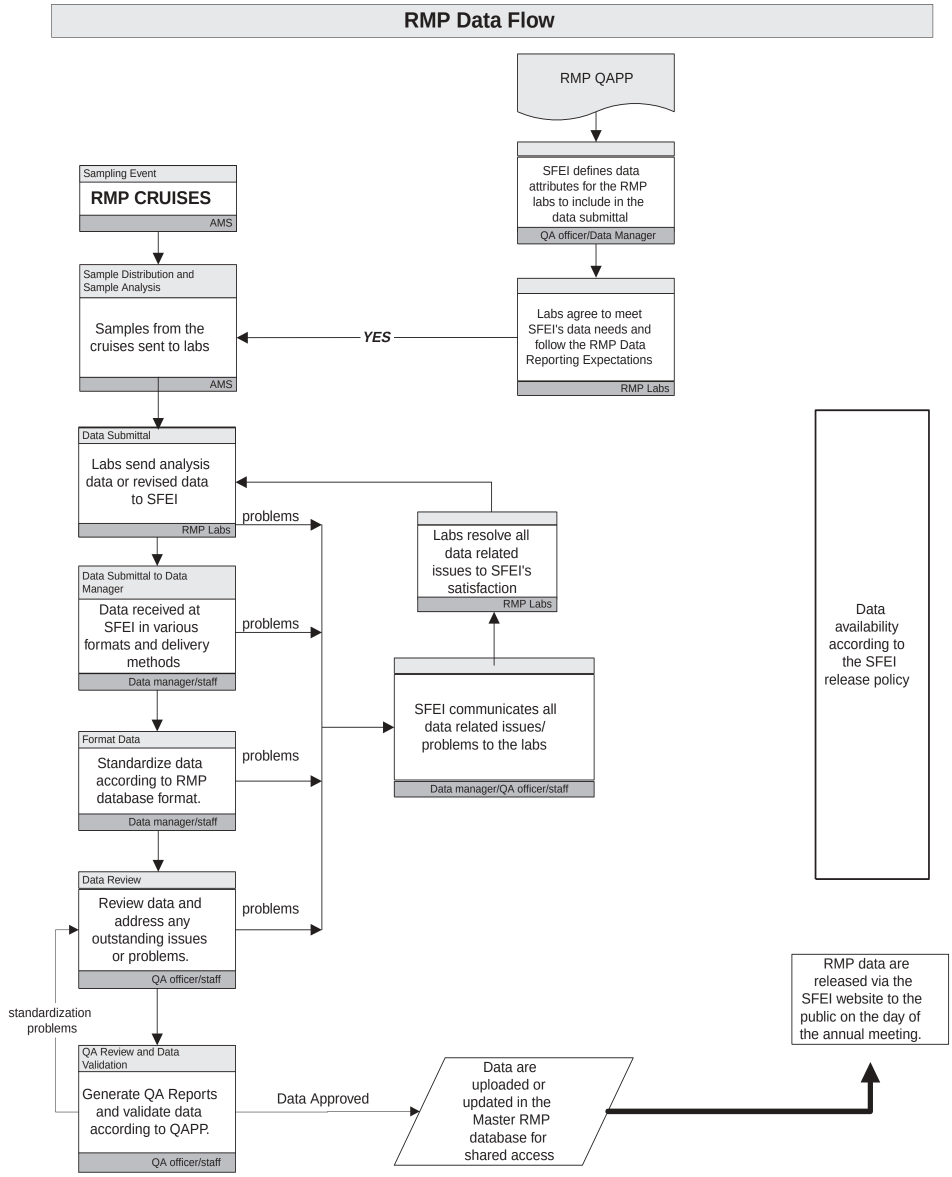
Collecting Water Samples. Water samples are collected approximately one meter below the water surface using pumps. The sampling ports for both the organic chemistry and trace element samplers are attached to aluminum poles that are oriented up-current from the vessel and upwind from equipment and personnel during the sampling procedure.

How does access to monitoring results at SFEI compare with other estuary programs?

Visits to the Web sites of the West Coast participants in the National Estuary Program—Puget Sound and Columbia River in Washington, Tillamook Bay in Oregon, and Morro and Santa Monica Bays in California—confirm the timeliness and quality of the RMP Annual Reports. Although the

Using the Sea-bird SBE19 Conductivity, Temperature and Depth probe (CTD). The CTD measures water quality parameters at depths throughout the water column. Casts are taken at each site during water and sediment sampling.

Sub-sampling sediment from a composite sample. Sediment sampling is conducted using a modified Van Veen grab.The top 5 cm of sediment is scooped from each of two replicate grabs and mixed in a bucket to provide a single composite sample for each station. The sample is divided on board for each analytic laboratory and for sediment toxicity tests.



majority of NEP Web sites provide on-line access to newsletters, management plans and scientific/technical Reports, publication of up-to-date monitoring results varies from good to nonexistent. A cursory review of these West Coast environmental management programs showed the following: The 1994 *State of the Bay* report is available on the Santa Monica Bay Web site, and the most recent *Columbia River Bi-State Report* available includes water quality results from 1994. Summaries of water and sediment contaminant results through 1997 are contained in the *2000 Puget Sound Update*. The only on-line publications found on the Morro Bay Web site were a newsletter and the *Comprehensive Conservation and Management Plan*. The most recent annual report found on the Web site of the Southern California Coastal Water Research Project covers the period 1992–93.

Examples of the reporting cycle of other large-scale monitoring programs can be found on the U.S. EPA Environmental Monitoring and Assessment Program (EMAP) Web page <www.epa.gov/emap>. A four-year assessment (1990–93) on the ecological condition of estuaries in the Virginian Province (Chesapeake Bay, Delaware Bay, Hudson-Raritan system, and Long Island Sound), and three tidal rivers in Chesapeake Bay (Potomac, Rappahannock, and James Rivers) was published in 1999. The condition of Mid-Atlantic estuaries (Delaware Estuary, the Chesapeake Bay, and the Delmarva coastal bays) from the early- to mid-1990s was presented in 1998 by the U.S. Environmental Protection Agency. A comprehensive report (July 1984–December 1997) on the long-term benthic monitoring and assessment component of the Chesapeake Bay Water Quality Monitoring Program was available in 1998. Also available in 1998 were the results of the 1995 EMAP estuaries demonstration project in the Carolinian Province, and a compendium of environmental data for estuaries sampled in the North Carolina portion of the Carolinian Province during summer 1994–1996.

What does it all mean?

SFEI's stated mission is to foster the development of scientific understanding needed to protect and enhance the San Francisco Estuary through research, monitoring and communication. Publication of accurate and timely annual reports—documenting as it does the status and trends in the San Francisco Estuary—is a key component in achieving this goal.

Playing by the Rules—

by Patricia Chambers

The State Implementation Plan for the California Toxics Rule sets the game plan for California's waterways. Is RMP helping to level the playing field?

Background

Could it be that the environmental impact posed by human activities is outpacing the tonic forces of nature? Human intervention may be more powerful than we think. In the fifty years since water pollution control programs first began in the United States, environmental policy has struggled to keep up in the race between preserving our resources and living with the consequences wrought by the impacts of Industry and human activities on the environment.

Today, efforts to control the discharge of toxic pollutants into the nation's waters continue to encounter formidable challenges. According to the EPA, more than 25 percent of our nation's rivers, nearly 50 percent of our lakes, and 15 percent of our estuaries are polluted with trace amounts of heavy metals, organic chemicals, and pesticides to the point of impairing the "beneficial uses" of these water bodies. (Beneficial uses include, for example, fishing, boating, salmon fish spawning, livestock watering, irrigation, and water contact recreation.)

Fraught with technical and political complications, the evolution of our pollution control strategies has suffered through a slow, reactionary process, barely able to keep up with the toxic payloads generated several decades before. In 1976, dissatisfied with the lack of progress on this front, the Natural Resources Defense Council (NRDC) led a court-battle that resulted in a settlement that recast the entire toxics regulatory system.

The court settlement required that the EPA develop a specific list of toxic chemicals to be regulated. What they developed represented 129 distinct substances, commonly known as "priority pollutants." (Two volatile chemicals and one water unstable chemical were removed from the list, leaving a list that at present consists of 126 priority toxic pollutants.) In 1977, this priority pollutant list became amended to the Clean Water Act. (The list has not been modified since, though according to a recent Bill Moyers' investigation, an average of twenty new chemicals enter the marketplace every week, most of which have not been tested for their potential adverse effects to human health and the environment.)

Priority pollutants refer to carcinogens, suspected carcinogens, or pollutants known to be seriously toxic at low levels and that are discharged by one or more major industries. These pollutants include heavy metals and specific organic chemicals.

The Clean Water Act also required that the EPA develop water quality criteria for each of the priority pollutants reflecting the best scientific assessment of all the identifiable effects on aquatic life and human health. These water quality criteria take into consideration " designated uses" of a water body. The object was twofold: to allow for assessment of water quality, and to provide a basis for determining pollutant limitations to protect the designated uses of that water body.

To help achieve this goal, Congress created the National Pollutant Discharge Elimination system (NPDES) permit program and authorized the Regional Water Quality Control Boards from each state to issue permits with specific water quality criteria. By 1987, Congress, concerned about the states' rate of adoption of water quality criteria, deemed it necessary to establish deadlines for each state. In response, the State Water Resources Control Board of California adopted the Inland Surface Waters Plan and the Enclosed Bays and Estuaries Plan in 1991.

This set of water quality plans seemed a positive step toward satisfying the conditions of the Clean Water Act. In 1994, however, a court ruling successfully challenged the manner in which the plans were adopted in California, once again leaving the state without specific water quality standards.

For the last six years, state officials, in collaboration with the EPA, have been trying to reestablish a regulatory framework that would bring California in compliance with the federally established Clean Water Act under a unified State Implementation Plan.

CTR and Statewide Implementation

On March 2, 2000 the State Water Resources Control Board (SWRCB) adopted the EPA-promulgated California Toxics Rule, reestablishing water quality criteria for toxic pollutants in the state's rivers, streams, lakes, enclosed bays and estuaries. The Policy (also known as the State Implementation Plan) lists water quality criteria for 126 priority pollutants in California's inland waters, and requires dischargers to determine the "reasonable potential" of their discharge contributing to the receiving water being above the water quality criterion for each priority pollutant.

Under the Clean Water Act, states have the primary responsibility for developing and implementing water quality standards. Until the recent adoption of the Policy, California was "the only state in the nation for which the CWA was substantially unimplemented," says an EPA Office of Water bulletin.

Since 1994, permit issuers have been operating without defined numerical criteria, relying, as per the state's instructions, on their "best professional judgement," said SF regional regulator Shin-Roei Lee. "The Policy provides statewide consistency for regional regulators, and it gives us a level playing field for writing permits." Large or small, corporations or privately owned companies alike, "All dischargers are required to comply with the conditions of the California Toxics Rule," noted Lee.

Just how the compliance schedule is implemented for each discharger, however, seems to be of some controversy. Though the reinstated Policy will enable regional regulators to more easily issue permits with strict limits on toxic pollutants discharged by industries and municipalities, concerns arise that through the Total Maximum Daily Loads (TMDL) provisions outlined in the plan, compliance deadlines for certain dischargers may be too lenient. In some cases, TMDL-based schedules could delay CTR compliance up to 15 years.

Special Provisions

TMDLs act as "pollutant load budgets," said Lee. TMDLs take into account receiving waterways listed as "impaired" by the State and EPA, the total allowable levels of a particular pollutant to that waterway, and the amount of reduction necessary to meet water quality standards for that water body.

Through the TMDL program—also under the Clean Water Act—if dischargers are unable to achieve immediate compliance with the CTR criteria, they may be granted a longer compliance schedule if they demonstrate progress toward TMDL development.

California currently lists 509 impaired waterways, including rivers, lakes, and bays, many containing multiple pollutants. These water bodies, referred to as the 303(d) list, contain elevated levels of toxic pollutants such as mercury, PCBs, and dissolved trace metals that exceed the benchmarks established for priority pollutants, that are likely to impair designated uses, or that do not meet narrative standards, such as "no toxic substances in toxic amounts."

According to the State's overall pollution reduction program implemented by the Regional Boards, TMDLs are considered a more "comprehensive" strategy toward eliminating total pollution in California's waterways. By prioritizing a list of watersheds, addressing the significant sources of pollutants, and adequately addressing the economic impacts of regulatory procedures, the hope is that greater overall improvements to water quality will be achieved.

"The Policy is a reasonable compromise," said Lee. "Dischargers are required to comply…they aren't in violation if they initiate action to deal with the issue."

Initiating action, in many cases, will require a collaborative effort on behalf of industries, landowners, environmental monitoring programs and a variety of regulatory agencies. RMP's monitoring and reporting components are a crucial part of this collaborative approach.

RMP's Involvement

Through both laboratory studies and field observations, the RMP has helped to compare water quality parameters in the Estuary with many of the environmental benchmarks used in the CTR. As dischargers work to meet these legally enforceable water quality criteria, the RMP will be able to provide assistance on ambient background concentrations and the monitoring and reporting requirements necessary to comply.

Twenty-six RMP sampling stations are currently situated throughout the Estuary collecting background water quality data. The data contain a mixture of information, on ambient levels of trace elements and some trace organic pollutants present in the Estuary. Dischargers may use these data when calculating whether they exceed or meet water quality-based effluent limitations.

As per the provisions outlined in the CTR, dischargers are required to conduct self-monitoring programs and submit reports. In many cases, the Regional Board recognizes that dischargers may find themselves contracting with other agencies and regional monitoring programs in order to meet these reporting requirements.

CTR History

- April 1991, the California State Water Resources Control Board adopts two water quality control plans: the Inland Surface Water Plan and the Enclosed Bays and Estuaries Plan. These two plans set numeric water quality criteria for priority toxic pollutants and satisfy the conditions of the federal Clean Water Act.
- 1994, a state court decision rescinds the water quality plans when a lawsuit by several discharges successfully challenges how the plans were developed. California is left without statewide standards for many priority toxic pollutants that are being discharged into the state's inland surface waters, enclosed bays and estuaries
- 2000, the EPA sets forth the California Toxics Rule in an attempt to meet federal compliance of the Clean Water Act, and restores water quality criteria for priority toxic pollutants in the state. The state of California adopts the Policy for Implementation of Toxic Standards for Inland Surface Waters, Enclosed Bays, and Estuaries of California ("Inland Waters Plan"). The plan outlines the state's implementation policies.

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From the list of 126 priority pollutants requiring measurement under the CTR, the RMP currently monitors 43 pollutants. Next year, the RMP hopes to close this data gap by determining the concentrations of the remaining toxic pollutants.

This effort, in conjunction with other newly-prioritized RMP redesign efforts — such as contaminant budget studies, studies on contaminant effects on aquatic life, and investigations into emerging chemicals of concern — will provide critical information to help regional regulators in the overall management of the Estuary. While the RMP will continue to monitor the ambient conditions of the Estuary, the program's increased efforts to track down specific contaminant sources and their effects on the Estuary will help form a more complete picture of what's needed in order to more expediently address urgent environmental pollution issues.

—Thanks to Sarah Lowe and Rainer Hoenicke for the consultation they provided for this article.

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California Toxics Rule (May, 2000) parameters. Pollutants in black are measured by the RMP as of 1999.

Antimony
Arsenic
Beryllium
Cadmium
Chromium (III)
Chromium (VI)
Copper
Lead
Mercury
Nickel
Selenium
Silver
Thallium
Zinc
Cyanide
Astestos
2,3,7,8-TCDD (Dioxin)
Acrolein
Acrylonitrile
Benzene
Bromoform
Carbon Tetrachloride
Chlorobenzene
Chlorodibromomethane
Chloroethane
2-Chloroethylvinyl Ether
Chloroform
Dichlorobromomethane
1,1-Dichloroethane
1,2-Dichloroethane
1,1-Dichloroethylene
1,2-Dichloropropane
1,3-Dichloropropylene
Ethylbenzene
Methyl Bromide
Methyl Chloride
Methylene Chloride
1,1,2,2-Tetrachloroethane
Tetrachloroethylene
Toluene
1,2-Trans-Dichloroethylene
1,1,1-Trichloroethane
1,1,2-Trichloroethane
Trichloroethylene
Vinyl Chloride
2-Chlorophenol
2,4-Dichlorophenol
2,4-Dimethylphenol
2-Methyl-4,6-Dinitrophenol
2,4-Dinitrophenol
2-Nitrophenol
4-Nitrophenol
3-Methyl-4-Chlorophenol
Pentachlorophenol
Phenol
2,4,6-Trichlorophenol
Acenaphthene
Acenaphthylene
Anthracene
Benzidine
Benzo(a)Anthracene
Benzo(a)Pyrene
Benzo(b)Fluoranthene
Benzo(ghi)Perylene
Benzo(k)Fluoranthene
Bis(2-Chloroethoxy)Methane
Bis(2-Chloroethyl)Ether
Bis(2-Chloroisopropyl)Ether
Bis(2-Ethylhexyl)Phthalate
4-Bromophenyl Phenyl Ether
Butylbenzyl Phthalate
2-Chloronaphthalene
4-Chlorophenyl Phenyl Ether
Chrysene
Dibenzo(a,h)Anthracene
1,2-Dichlorobenzene
1,3-Dichlorobenzene
1,4-Dichlorobenzene
3,3'-Dichlorobenzidine
Diethyl Phthalate
Dimethyl Phthalate
Di-n-Butyl Phthalate
2,4-Dinitrotoluene
2,6-Dinitrotoluene
Di-n-Octyl Phthalate
1,2-Diphenylhydrazine
Fluoranthene
Fluorene
Hexachlorobenzene
Hexachlorobutadiene
Hexachlorocyclopentadiene
Hexachloroethane
Indeno(1,2,3-cd)Pyrene
Isophorone
Naphthalene
Nitrobenzene
N-Nitrosodimethylamine
N-Nitrosodi-n-Propylamine
N-Nitrosodiphenylamine
Phenanthrene
Pyrene
1,2,4-Trichlorobenzene
Aldrin
alpha-BHC
beta-BHC
gamma-BHC
delta-BHC
Chlordane
4,4'-DDT
4,4'-DDE
4,4'-DDD
Dieldrin
alpha-Endosulfan
beta-Endosulfan
Endosulfan Sulfate
Endrin
Endrin Aldehyde
Heptachlor
Heptachlor Epoxide
PCBs total
Toxaphene

The Cormorant Egg Puzzle

by Bernadette Powell

A mysterious unknown compound discovered in cormorant eggs taken from Richmond Bridge was a catalyst for the San Francisco Estuary Institute's interest in emerging contaminants. In 1996, Jay Davis discovered the compound when testing eggs for PCBs, a chemical compound known to have harmful effects on sensitive early life stages. Many cormorants nest on the large steel girders on the bridges that cross the Bay, just a few feet from constant noisy traffic. And yet these sites are relatively undisturbed and free from predators, nestled just above Bay waters where the cormorants fish. For his study, Jay reached out to the girders from the vehicle deck using a ten foot pole to net eggs. Two eggs from the same nest presented him with a puzzle.

He used a gas chromatograph (GCMS) to identify the presence of PCB's and noticed a distinctive pattern or chemical "fingerprint" that was clearly not a PCB, and yet present in much larger amounts than the PCBs. The pattern-matching software of the GCMS could not identify it. Jay consulted with Bob Risebrough of the Bodega Bay Institute. As the first person to document PCB contamination in the environment, Bob was interested in the compound. He thought he'd seen something similar in analysis of effluent water. Its presence in cormorant eggs indicated that this compound, like PCBs, was bioaccumulative, i.e. capable of passing up the food web

Orcas—The New Canaries of the Coal Mine?

Decades after they've been banned, industrial pollutants such as PCBs continue to leave behind their toxic legacy. The latest unfortunate inheritors of this legacy are Pacific Northwest orcas, or killer whales, which are currently rated by scientists who study marine mammal contamination as the most contaminated marine mammals on Earth. Exactly how this will affect orcas or the larger food web (of which humans, and orcas are "top-level" feeders) is uncertain. What is evident, however, is that what we have dumped into the marine environment decades ago, either directly or inadvertently, is still catching up with us.

According to the Marine Fisheries Service, orcas have a 50-50 chance in the next few years, of being listed as endangered, and until their recent recognition as the most chemical-laden marine mammals in the world, were only superseded in toxicity by the European harbor seals that died en masse in 1988 after their immune systems were weakened from PCB contamination.

PCBs are in a class of compounds called endocrine disrupters and can disrupt immune and reproductive systems by mimicing hormones.

Since 1995, the population of middle-aged orcas has declined 15% and nearly half of their newborn calves have been dying in the first few months after birth. Some pods, which have several females of reproductive age, haven't successfully produced a single calf in a decade.

Figuring out the exact reasons why orcas are in decline is proving complicated. Revered as superb predators, it seems that now the killer whale is falling prey to human-induced pressures such as boat traffic (whale watching), food supply and pollution. Of the three suspects, the elevated pollution levels discovered in the fatty tissues of orcas seems to suggest the most staggering risks to their health.

Subtle but insidious, PCBs and other persistent organic pollutants don't break down easily. Working from the bottom of the food chain up, PCBs collect in the fatty tissues of animals, increasing in concentration up the food web in a process called bioaccumulation. For nursing calves, this means that they're breast feeding on a lifetime dose of pollutants stored in their mother's fat.

PCBs in the aquatic food web pose a health risk to more than wildlife. Children born to mothers who were long-time consumers of fish from Lake Michigan have been shown to have developmental effects. And the EPA has associated the consumption of PCB-laden fish from the Hudson River with an increased risk of cancer.

The level of PCB contamination in the Puget Sound, where many of the orcas reside, is considered "average" for an urban area. According to NOAA, San Francisco Bay's PCB levels, in contrast, are twice as high.

The recent plight of the orcas seems a stark reminder that the real story about the unintended side effects of synthetic chemicals may sometimes take decades to unfold. In the case of persistent and bioaccumulative substances, it may be a scenario of "too little-too late" before we have irrefutable proof—the canary in the cage—to take action. —PC

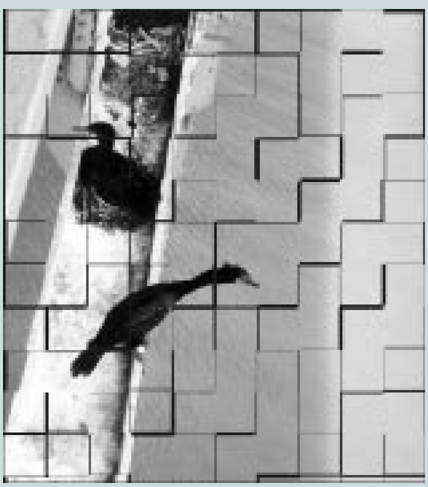


Photo by Jay Davis

from water to fish to birds. Jay checked his other egg samples and found the unknown compound present in smaller amounts, but generally barely detectable. The egg shells were not thinned. The eggs appeared normal. There was no "smoking gun." And so the mystery rested.

Until, at a Toxicology and Environmental Chemistry meeting, Jay attended a presentation that discussed brominated flame retardants as a potential contaminant problem. Dr. Rob Hale of the Virginia Institute of Marine Science showed a sample GCMS pattern which Jay recognized as the same one in the cormorant eggs. Flame retardants are already somewhat restricted in Europe. They are persistent, nonvolatile, insoluble and, as Jay's work shows, bioaccumulative.

Products treated with flame-retardants are found in most public spaces. Within the home, flame retardants are most likely to be found in urethane foam cushions in upholstery. There is not yet good information on their effects. Scientists in Sweden have studied one class of brominated flame retardants called polybrominated diphenyl ethers (PBDEs) and characterize them as "similar to the well-known environmental contaminants such as PCBs."

Jay's discovery highlighted the fact that the Regional Monitoring Program's analyte list consists of contaminants that have been of concern for 20 to 30 years. This list likely needs to be updated. Nobody yet knows whether flame retardants will be on it. Certainly, they have already helped promote a more proactive Regional Monitoring Program.

Through pilot studies, the San Francisco Estuary Institute will look for and quantify compounds such as PBDEs before large-scale environmental damage has been identified. Thus, resource managers will have data on status and trends in hand, and will be able to act faster should the need arise.

SFEI held the eighth Annual RMP Meeting on March 9, 2001 to provide highlights of results from the 1999 monitoring year and to stimulate discussion on how RMP monitoring information is used by regulatory agencies and dischargers. The meeting also called upon other relevant monitoring and research efforts to share their views. The notes below outline the key points made during the one-day session.

The Evolving RMP: A Brief Refresher of Where We Are After Eight Years

Rainer Hoenicke, manager of the Regional Monitoring Program, provided a short introduction to the organization and function of the RMP. A major RMP objective is providing answers to the management questions posed by its participants. Endowment of monitoring data with relevance and purpose is one way the RMP works to achieve this goal. The RMP is adaptive and in the future will place more focus on contaminant inputs (Sources, Pathways and Loadings) and impairment assessment (Biological Effects).

The value of RMP data in the TMDL and NPDES programs

Loretta Barsamian, executive director of the Regional Water Quality Control Board, emphasized the importance of the RMP to the Regional Board. A more cooperative partnership has developed between the RMP and the Board. The RMP redesign will play a key role in answering management questions. RMP data has been used by the Regional Board for the development of TMDL's, in the permit process, and in assessments.

Questions to the presenters highlighted:

- The need to get the message out about the RMP. Currently, the majority of funding and resources is going to Southern California.
- The impact of state budget cuts due to the current power crisis was briefly discussed.
- Upstream issues are driving the RMP redesign process.
- The change in focus from using chemical to biological indicators of pollution.

Highlights of Recent RMP Results

Summary of the 1999 *Pulse of the Estuary* Report

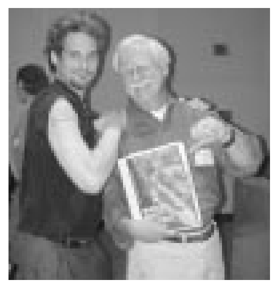
Mike May, SFEI, opened the session after the break by presenting a summary of the latest edition of the *Pulse of the Estuary*. Mike stated that the intended audience of the *Pulse* was decision-makers and the interested public. Mike noted that *The Pulse of The Estuary* is an attempt to address in a single publication, and in a summarized yet meaningful way the contamination issues in the San Francisco Estuary.

Models and Supermodels in the PCB, TMDL and the RMP

Fred Hetzel, Regional Water Quality Control Board, presented the Regional Board's perspective on models and the role of the RMP mass budget model in the PCB TMDL.

Jay Davis, SFEI, presented models from the RMP perspective. Jay discussed his recent work on a one-box PCB model of the whole bay, which he described as a "supermodel." Jay reported that a key prediction of his model was the achievement of a steady-state condition after an extended period of time, no matter what constant PCB starting input was assumed. Jay notified the meeting attendees that the draft report on his PCB mass budget model is now available.

The San Francisco Bay Seafood Consumption Study Highlights



Rainer Hoenicke, SFEI, presented findings from the survey designed to gather information on the anglers who fish in San Francisco Bay and their seafood consumption habits. Rainer pointed out that 1 in 10 individuals identified as consumers in the study ate above the health advisory limit for seafood caught in San Francisco Bay. High-risk behavior was not related to income or education level, however, African Americans and Asians did have higher consumption rates. A surprising 39% of anglers were not aware of the current health advisory. Rainer highlighted the need for a survey on the consumption habits of family members of Bay anglers, and recommended actions to increase the public awareness of the current health advisory.

Highlights from Other Relevant Monitoring and Research Efforts

Regional Board monitoring efforts and special studies related to 303(d) listing and TMDLs

Karen Taberski, Regional Water Quality Control Board, talked about the work of the Monitoring and Assessment Integration Team (MAIT) in updating the Regional Board and identifying data gaps in the current programs. Karen continued with an overview of the Statewide Surface Water Ambient Monitoring Program (SWAMP) and how the RMP data satisfies the needs of the Board.

Karen discussed studies on mercury in the eggs of 17 species of birds in San Francisco Bay, PCBs in San Francisco Bay, copper and nickel speciation, and stormdrain mapping. She stressed that some state funding is now available for the Regional Board to pick up the tab for a number of assessments needed for TMDL implementation.

Karen observed that Oakland Harbor and San Leandro Bay are high in total mercury concentrations. High methylmercury concentrations are generally, but not always associated with the high total mercury concentrations depending on the methylation environment, e.g. concentrations are higher where fresh and saltwater interface.

Status Report on EPA's EMAP Activities in San Francisco Bay

Terry Fleming, U.S. EPA Region 9, presented a status report on the EPA's Western Pilot Study. The study is a probability-based survey using multiple indicators to provide an unbiased estimate of the ecological conditions. The Coastal Monitoring Program is a component of the study that focuses on creating an integrated comprehensive program for monitoring the coastal areas (estuaries) of the west coast of the United States. The Coastal Monitoring Program is designed to allow for comparisons between different regions. To meet this goal data need to be collected in similar ways. Information management challenges associated with the collection, storage, and exchange of data are considerable, requiring cooperation with other monitoring programs.

Mercury and PCB Characterization in Bay Area Watersheds

Marty Stevenson, Kinnetic Laboratories, talked about mercury and PCB contamination in storm drain sediments. PCBs and Hg are ubiquitous in urban storm drains, and concentrations are significantly higher in urban versus open land use areas. Evidence suggests that the PCBs found in storm drain sediments are recent rather than historical deposits. Marty emphasized that cleanups need to be focused on small industrial sites and areas since these present the greatest potential for achieving reductions in contaminant levels.

Bioassessment and Contaminant Effects

Towards Improved Biological Effects Monitoring

Bruce Thompson, SFEI, discussed the use of biological effects, defined as measurable changes in a biological "compartment" due to exposure to contaminants, in the RMP. Bruce noted that aquatic toxicity in the San Francisco Estuary is frequently related to storm runoff events. Estuary sediments are often toxic to test organisms under laboratory conditions, with toxicity apparently due to mixtures of contaminants. Bruce pointed out that biological effects observed in the laboratory have not been conclusively linked to any particular contaminant in the Estuary.

Bruce observed that what we really care about is biological effects, the effect of contaminants on the biological community/ecosystems, and as a consequence we can expect to see an increased use of biocriteria in monitoring programs. Bruce recommended an expansion of the biological effects component of the RMP by implementing the monitoring of a "suite" of the best available bioeffects indicators.

Aquatic Bioassessment Approaches

Jim Harrington, California Department of Fish and Game, described the freshwater assessment work conducted by the CDFG. He pointed out that bioassessments put the biology into water quality monitoring. Jim noted that the aquatic assessment approach integrates effects over time, and makes monitoring more "appealing and understandable" to the general public. Jim concluded by saying that the establishment of "reference streams" is the backbone for future freshwater assessment work.

Biomarkers in Action: Examining the Effects of Dormant-season Pesticide Runoff on Resident Fish Species

Andrew Whitehead, UC Davis, presented results from his dissertation work on the use of biomarkers to examine the effects of pesticide run-offs on the Sacramento sucker. Andrew discussed the strengths and weaknesses of biomarkers. Biomarkers are useful because they (1) link exposure to effects, (2) show additive effects, (3) integrate effects over space and time, and (4) can be used for native and nonnative species.

Biomarkers coupled with chemistry represent a strong approach to link contaminants to exposure. Andrew pointed out that although biomarkers are indicative of some kind of stress on the organism, debate continues as to how this relates to biological effects.

Pollutant Pathways and Loadings

A Brief History of Sources, Pathways and Loadings in the RMP

Jay Davis, SFEI, gave an overview of the Sources, Pathways, and Loadings component in the Regional Monitoring Program. Jay mentioned that this is a relatively new component of the RMP with the focus of examining sources and contaminant loadings to the San Francisco Estuary. Jay stated that an information review will be undertaken in earnest during 2001, along with the development of a long-range plan. Pilot studies will start in 2002.

The View from Downstream

Khalil Abu-Saba pointed out that 80% of the precipitation in California flows into San Francisco Bay, connecting the downstream to the upstream. For example, Khalil noted that the story of mercury in California is recorded in the sediments of San Francisco Bay. Khalil discussed the use of RMP data to establish the current background levels of mercury in San Francisco Bay. Special studies, like the RMP Air Deposition Study, address key areas of uncertainty, such as the importance and relevance of contemporary air deposition of mercury versus historical mining sources.

Challenges in Designing an Effective Loadings Monitoring Program

Lester McKee, environmental scientist at SFEI, described the major challenges to the design of an effective loadings monitoring program. Lester listed the challenges as being (1) data gathering, (2) coordination of effort, (3) getting comparable and consistent results, (4) quality assurance, and (5) data and information management. Lester discussed the High-Resolution National Hydrographic Data Set (NHD) currently being developed at SFEI. Future uses of the NHD include: improving estimates of storm water loads to the SF Bay, prioritizing of sampling, and the placement of storm water loads in the proper context.

Summary

Recommendations for the future of the RMP included: improving communication (getting the message out), moving more into biological effects, doing more data mining of existing data sets.

Meet the Staff

Daniel R. Oros—Environmental Organic Chemist

Daniel received a Ph.D. in Environmental Sciences with a Biogeochemistry emphasis from Oregon State University in 1999, under the supervision of Professor Bernd R.T. Simoneit. He conducted postdoctoral study at Washington State University where he researched the chemical causes of cancer, its prevention and treatment. Daniel joined SFEI in May and is the principal investigator of a new study to identify unknown organic contaminants and emerging pollutants of concern in the San Francisco Estuary. His research centers on interpreting the RMP's archived gas chromatographic-mass spectrometric (GCMS) charts to determine organic compound structures, and concentrations in past RMP water samples.

Daniel's interests are in the distribution and fate of organic matter in the geo and biospheres (organic geochemistry and biogeochemistry) and analytical organic chemistry applied to environmental and human toxicology. His experiences have included researching the chemistry and biology of deep-sea hydrothermal vent systems using the deep submergence vehicle "Alvin"; research on the chemical composition of combusted fuels such as biomass and coal and their contribution to atmospheric chemistry; and research on petroleum hydrocarbon contamination in surface waters. Daniel is a member of the American Chemical Society and is a Sequoia Fellow in the American Indian Science and Engineering Society.

Calendar of Events

October 9-11, 2001
5th Biennial State of the Estuary Conference 2001
Palace of Fine Arts Theater, San Francisco.
For more information contact the San Francisco Estuary Project at (510) 622-2465.

November 4-8, 2001
16th Biennial Conference
Estuarine Research Federation
St. Pete Beach, Florida.
For more information visit www.erf.org.

November 11-15, 2001
Society of Environmental Toxicology and Chemistry (SETAC) 22nd Annual Meeting. Baltimore, Maryland. For more information visit http://www.setac.org.

Announcements

- The results of the San Francisco Bay Seafood Consumption Report have been published and are available from SFEI at <http://www.sfei.org/rmp/sfcindex.html>. Paper copies of the Public Summary and the Technical Report can be ordered by contacting Linda Russio at 510-231-9539.

- The 1999 Annual Results of the Regional Monitoring Program are available on CD-ROM, please contact Linda Russio 510-231-9539, or on-line <http://www.sfei.org/rmp/1999/1999_RMP_RESULTS.htm>

WWW.SFEI.ORG

Address Correction Requested

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