# EXECUTIVE SUMMARY E

This report was written for the State Water Resources Control Board's Surface Water Ambient Monitoring Program (SWAMP) as a step toward the development of an improved bioaccumulation monitoring program for California. The report provides a review of bioaccumulation monitoring data generated under three historic State Board programs (the Toxic Substances Monitoring Program, the State Mussel Watch Program, and the Coastal Fish Contamination Program) and other major bioaccumulation studies since 1970. Future monitoring will be guided by assessment questions developed for the SWAMP. The objective of this report was to evaluate how well the historic data from the State Board programs and from other major monitoring efforts since 1970 address these questions. This exercise has provided a substantial amount of information about present and historical impacts of pollutant bioaccumulation on fishing and aquatic life in California, and has also highlighted areas where improved sampling approaches can better address the assessment questions.

## NET IMPACT OF POLLUTANTS ON FISHING

Present concentrations of pollutants in many California water bodies are high enough to cause concern for possible effects on human health and to have a significant impact on the fishing beneficial use. Consumption advisories, 303(d) listings, and the bioaccumulation database as a whole provide three indices of the status of this impact. Consumption advisories exist for an increasing number of water bodies, but these represent only a fraction of the areas likely to need them. Lack of suitable data is a major impediment to developing advice for additional water bodies. A USEPA evaluation of the 2002 303(d) List indicated that large portions of the state had not been assessed, especially rivers and coastline. Most of the lake area in the state (61%) had been assessed, and a relatively small percentage of the total area (6%) was classified as impaired. Assessment of lakes, however, has focused primarily on the largest lakes, leaving the vast majority of smaller lakes unsampled. Many of these small lakes are near population centers and are popular for fishing. Bays and estuaries had been thoroughly assessed (98% of the area) and 93% of the total area was impaired.

Evaluation of the most recent monitoring data (collected from 1998 – 2003) indicates that, for the locations sampled, 32% had low concentrations of pollutants, 42% had moderate concentrations, 18% had high concentrations, and 8% had very high concentrations (Figure 1). Concentrations in the low category are in a range where consumption is generally encouraged by the California Office of Environmental Health Hazard Assessment (OEHHA) (Klasing and Brodberg 2006). OEHHA is the agency responsible for managing health risks due to contaminated sport fish in California. Concentrations in the very high category are in a range where OEHHA discourages consumption (Klasing and Brodberg 2006). Lakes assigned to the moderate, high, or very high concentration categories were primarily affected by mercury, with PCBs also playing a lesser role.

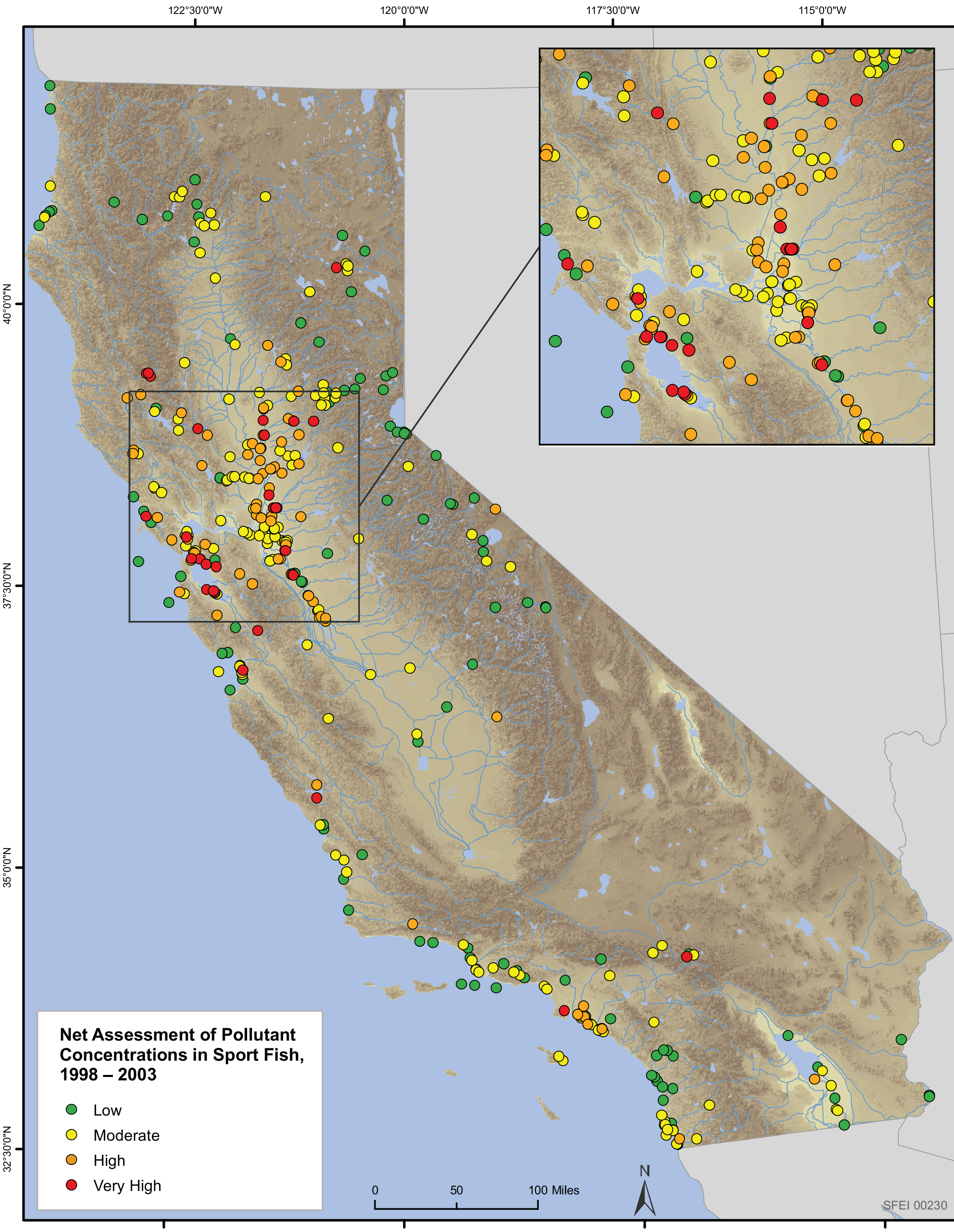


Figure 1. Net assessment of pollutant concentrations in California sport fish, 1998 – 2003. Based on measurements of several chemicals (mercury, PCBs, DDTs, dieldrin, and chlordanes) in muscle tissue from a variety of fish species. Size limits were applied for evaluation of mercury data (Appendix 1). Dots represent sampling locations. Dot colors correspond to degrees of contamination (low, moderate, high, very high) defined for each pollutant and represent the species with the highest degree of contamination at each location.

## IMPACTS OF SPECIFIC POLLUTANTS ON FISHING AND AQUATIC LIFE

### Mercury

Mercury contamination is common in California aquatic food webs, affecting both the fishing and aquatic life beneficial uses in many areas of the state, with long-term trends indicating little change over the past few decades. Large regions of the state contain fish with moderate, high, or very high concentrations of mercury. Twenty-three of the 294 locations (8%) sampled from 1998 – 2003 had a species with a median mercury concentration above 0.9 ppm, placing these sites in the very high category. Another 68% of the locations sampled from 1998 – 2003 had mercury concentrations in the moderate and high categories. Only 24% of the locations had concentrations in the low category (Figure 2). The number of locations with high or very high concentrations was greatest in the San Francisco Bay-Delta, Central Valley, and surrounding areas. The few good time series available for mercury in sport fish showed no clear trends over the past three decades. Thus, the available evidence supports the hypothesis that the mercury problem may take decades to be resolved. TMDL implementation actions, mine clean-ups, and consumption advisories are important management actions that may improve the situation over different time-scales. Large-scale wetland restoration has the potential to exacerbate the mercury problem by increasing production of methylmercury, the most toxic and readily accumulated form. In the region with the most data regarding impacts on aquatic life, the San Francisco Bay-Delta, impacts on wildlife populations, including endangered species, from mercury contamination appear likely.

### PCBs

Polychlorinated biphenyl (PCB) bioaccumulation in aquatic food webs in California has declined significantly since production was banned in the 1970s, but this persistent pollutant continues to have a negative impact on fishing and aquatic life in many parts of the state. Sport fish monitoring at 251 locations from 1998 – 2003 found that 4% of the locations had a species with median concentrations above 270 ppb, placing them in the very high concentration category (Figure 3). Thirty percent of the locations sampled had PCB concentrations in the moderate or high concentration categories. Most (66%) of the locations sampled had concentrations in the low category, with median concentrations for all species analyzed below 30 ppb. PCB concentrations in some areas also appear to be high enough to cause adverse impacts in wildlife. Concentrations are highest in water bodies near major urban centers, including the Bay Area, Sacramento, Los Angeles, and San Diego. PCB concentrations in San Francisco Bay are particularly high and appear to be unusually persistent. In general, PCB concentrations are steadily declining across the state (Figure 4). The 1979 ban on PCB sale and production and other regulations relating to disposal of PCBs appear to have generally been effective at reducing the impact of PCBs in California water bodies. In some locations, however, particularly San Francisco Bay, recovery from PCB contamination may take many decades.

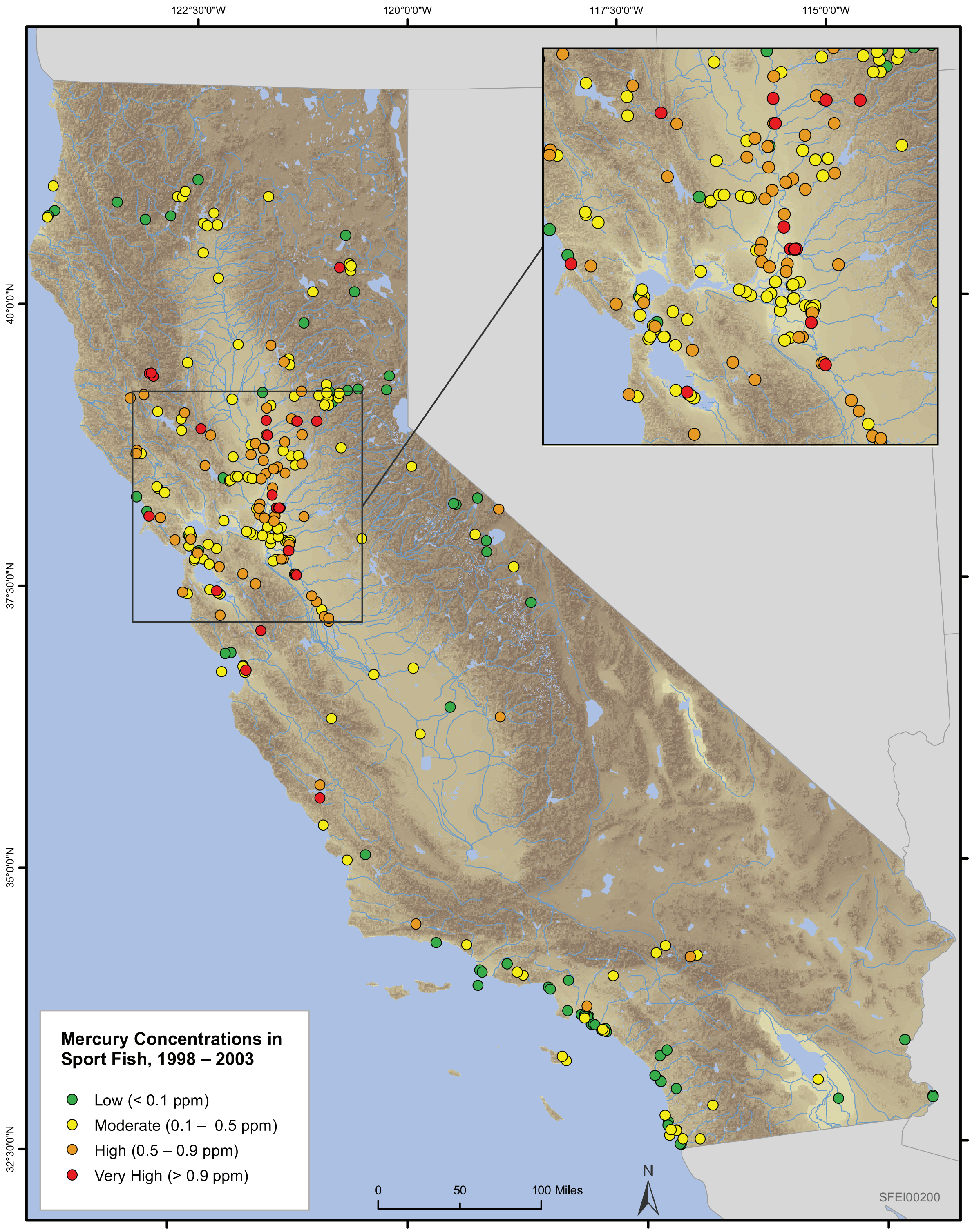


Figure 2. Mercury concentrations in California sport fish, 1998 – 2003. Based on mercury measurements (ppm wet wt) in muscle tissue from a variety of fish species. Size limits for each species were applied (Appendix 1). Dots represent sampling locations. Dot colors are based on the species with the highest median concentration at a location.

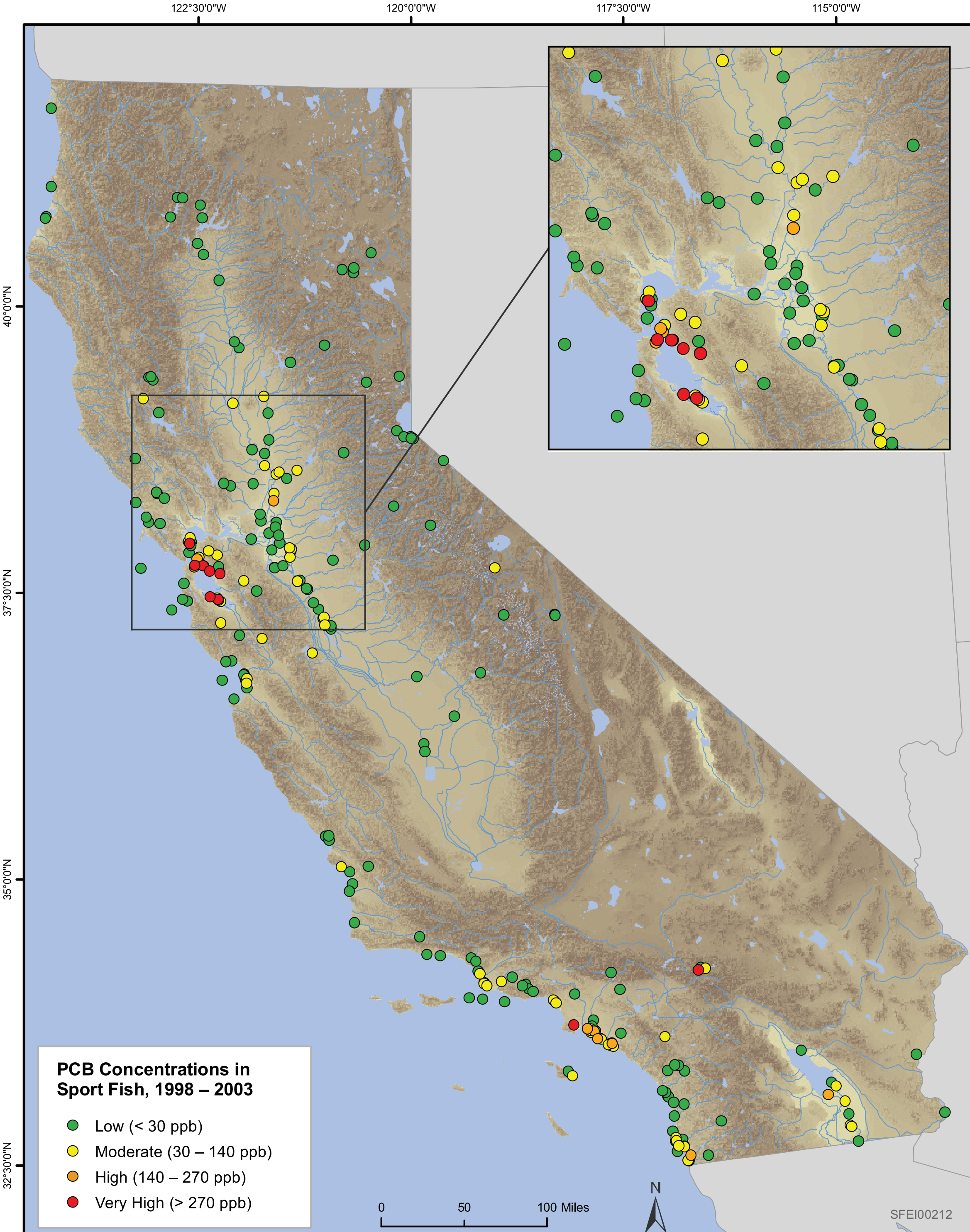


Figure 3. PCB concentrations in California sport fish, 1998 – 2003. Based on PCB measurements (ppb wet wt) in muscle tissue from a variety of fish species. Dots represent sampling locations. Dot colors indicate the highest median concentration among species at each location.

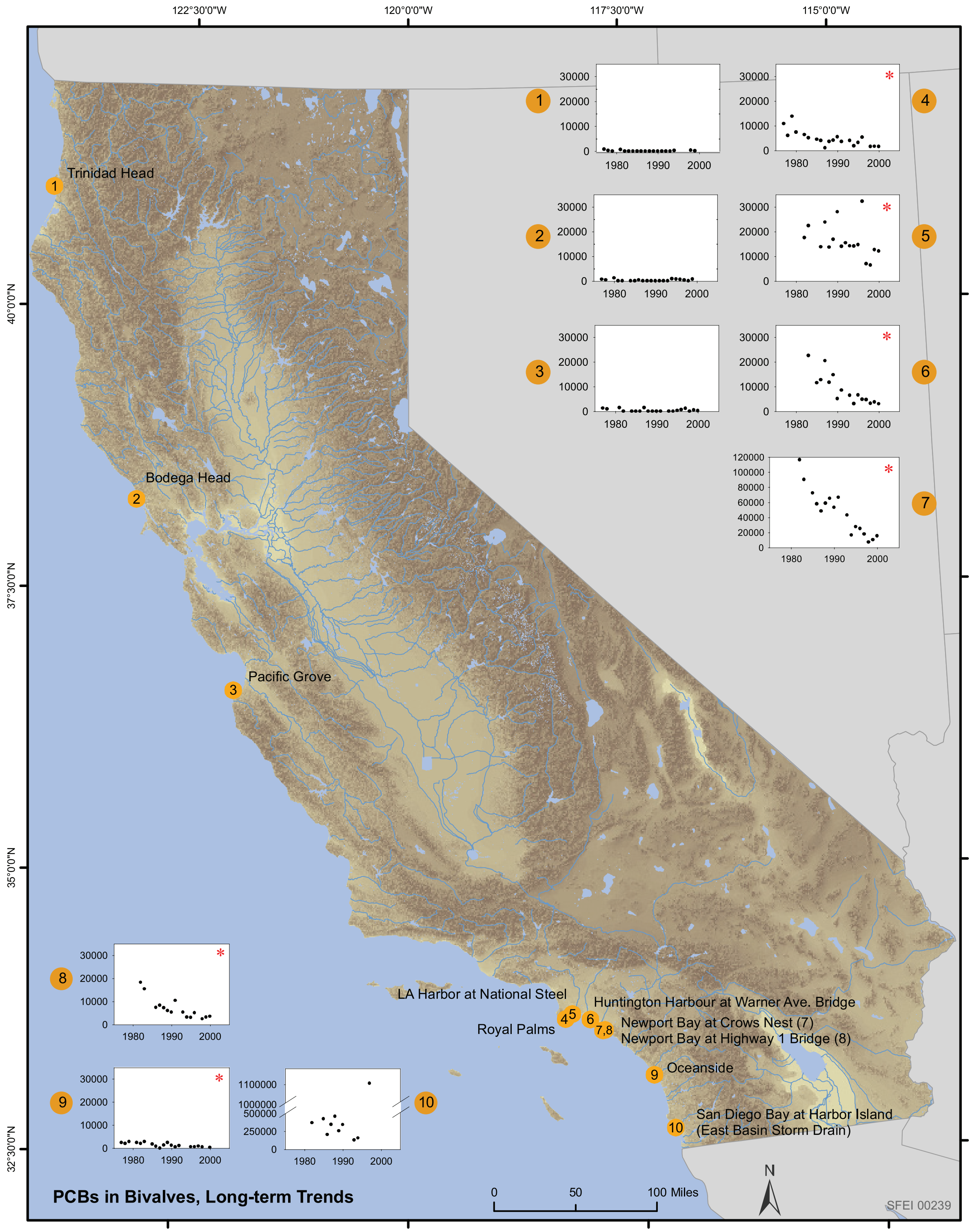


Figure 4. Long-term trends in PCB concentrations in California mussels measured by the State Mussel Watch Program. Locations shown represent the best time series available for different parts of the state. The red asterisk indicates a significant trend. Concentrations are given in ppb lipid weight.

## DDT

Recent sport fish monitoring data (1998 – 2003) indicated that DDT concentrations in the vast majority of the state (248 of 252 locations sampled) were in the low concentration category, and thus, are having little impact on fishing. Concentrations of DDT in aquatic food webs across the state have generally shown significant declines over the past 30 years in response to the use restrictions and federal ban in 1972. Prior to these management actions, DDT had severe impacts on populations of aquatic birds on the California coast, including brown pelicans and double-crested cormorants. These populations have rebounded in response to the decline in DDT contamination, though concentrations still remain above thresholds for concern in some cases. Long-term trends in sport fish from the Imperial Valley (Salton Sea) region indicate consistently high DDT concentrations during the last 20 years. The DDT ban has not been as successful in reducing concentrations in this region. Agricultural and urban runoff were the primary historical sources to California water bodies.

## Dieldrin

Recent sport fish data indicated that dieldrin concentrations in most areas of the state (238 of 244 locations sampled) were in the low category and having little impact on fishing. Concentrations of dieldrin in aquatic food webs across the state have generally shown gradual declines over the past 30 years in response to use restrictions and the federal ban in 1987. Dieldrin concentrations in food webs have also generally been below thresholds for concern for impacts on aquatic life. Long-term trend monitoring in sport fish from the Imperial Valley (Salton Sea) region indicates only a recent decline. Overall, the dieldrin ban has been successful in reducing concentrations and impacts across the state, with locations of higher historical contamination improving more recently. Agricultural runoff into California water bodies has been the primary historical source of this pollutant.

## Chlordane

Chlordane concentrations in all areas of the state (238 locations sampled) were low in recent sport fish sampling, and thus, not impacting fishing. Chlordane concentrations measured in food webs have also been below thresholds for concern for impacts on aquatic life. Chlordanes have not been as persistent as other legacy pesticides. Dramatic declines in chlordanes were evident immediately after the 1988 ban. Long-term trend monitoring in sport fish across the state also indicates declines in chlordane concentrations. The chlordane ban has been quite effective in reducing impacts of this insecticide. Agricultural and urban runoff were the most prominent pathways for transport into California water bodies.

## SUMMARY AND RECOMMENDATIONS

The State Board bioaccumulation monitoring programs documented the successful management of many pollutants that posed serious threats to wildlife and human health in the 1970s and 1980s. These programs were instituted just in time to document the rapid improvements in water quality that resulted from bans on PCBs and legacy pesticides, reductions in metals due to wastewater treatment, and other improvements. Many instances of severe contamination were identified, leading to cleanup actions and fish advisories to reduce exposure of humans and wildlife. These programs and other studies greatly advanced scientific understanding of bioaccumulation in California.

However, the dataset generated by the State Board bioaccumulation monitoring programs has several limitations with regard to answering the questions that are currently high priorities for water quality managers:

- many areas were not sampled adequately, including areas with significant fishing activity;
- the distribution of sampling locations varied over time;
- most of the sampling, though focused on sport fish, was not tailored to the development of consumption advice;
- the dataset was also not tailored to evaluation of risks to piscivorous wildlife through monitoring of prey species;
- long-term time series for detecting trends in sport fish or other wildlife contamination were lacking; and
- much of the sampling was biased toward characterization of polluted areas.

The evaluation performed in this report makes it evident that a sampling design that includes spatial randomization would be better suited to answering the SWAMP assessment questions related to statewide condition. Such a design would allow for an unbiased overall assessment of the condition of California water bodies. Indices of net impact during different time intervals would be directly comparable, since all areas would be sampled in a representative manner. A randomized design could be developed that samples different locations in proportion to the amount of fishing activity, an important feature with regard to development of consumption advice. A randomized design could also be augmented by other approaches, such as targeted sampling for long-term trends in particular locations or focused efforts to sample water bodies of particularly high interest. A combination of randomized and targeted sampling would provide an optimal approach for providing the information that water quality managers need from a bioaccumulation monitoring program in California.

# SECTION 1
# INTRODUCTION

In the 1970s, the California State Water Resources Control Board (State Water Board) initiated two statewide monitoring programs employing the new technique of "bioaccumulation monitoring" – measuring the concentrations of pollutants in fish and bivalves residing in California water bodies. Bioaccumulation monitoring offers several advantages over monitoring of water or sediment, including:

- Measuring the degree to which pollutants are actually entering the food web, which for some pollutants can be quite different from the total concentrations present in water and sediment;
- Yielding a strong signal of contamination, since many pollutants reach concentrations that are much higher and easier to measure than concentrations in water and sediment;
- Providing an integrative measure of pollutant concentrations over time and a cost-effective tool for obtaining information on average concentrations; and
- Especially for fish, providing information that is directly linked to the impacts of pollutants on human and wildlife health.

The Toxic Substances Monitoring Program (TSMP), initiated in 1976, was a statewide program that employed a uniform approach for monitoring pollutants in fish and invertebrates in freshwater and estuarine habitats (SWRCB 1986, Rasmussen 1995, 1997). The TSMP primarily targeted water bodies with known or suspected water quality impairments, and successfully identified and documented many hotspots of contamination.

The State Mussel Watch Program (SMWP) was initiated in 1977 to provide information on long-term trends in water quality in coastal marine waters and to identify specific areas with elevated concentrations (Hayes et al. 1985, Hayes and Phillips 1986, Rasmussen 2000). Bivalves have some advantages compared to fish as indicator species: they are less mobile than fish and therefore good indicators of conditions at specific locations, and they can be transplanted into locations where bioaccumulation monitoring is desired.

Over the years, these two programs yielded a wealth of information on water quality in California. The chemical analyses were performed by top laboratories with excellent quality assurance and the data they generated are considered to be highly reliable. Hundreds of locations were sampled. Many instances of severe contamination were identified, leading to cleanup actions and fish advisories to reduce exposure of humans and wildlife. In addition, many areas with low concentrations (below past or present thresholds of concern) were identified. As described in this report, these programs have documented the successful management of many pollutants that posed serious threats to wildlife and human health in the 1970s and 1980s. These programs were instituted just in time to document the rapid improvements in water quality that resulted from bans on PCBs and legacy pesticides, reductions in metals due to wastewater treatment, and other improvements.

In 1998, a third statewide bioaccumulation monitoring program, the Coastal Fish Contamination Program (CFCP), was implemented (Gassel et al. 2002). This program was developed to assess the health risks of consumption of sport fish and shellfish from nearshore waters along the entire California coast. The CFCP was considered to be a critical component of a comprehensive coastal water quality protection program, and an important opportunity to build a long-term coastal monitoring database for water quality and contaminants in fish.

In 2000, the State Water Board, responding to a bill passed by the California legislature, developed a plan to restructure their existing water quality monitoring programs (including TSMP, SMWP, and CFCP) and create a Surface Water Ambient Monitoring Program (SWAMP) for water quality that addresses all hydrologic units of the state using consistent and objective monitoring, sampling and analytical methods; consistent data quality assurance protocols; and centralized data management (SWRCB 2000). Sampling under the three monitoring programs ended in 2003, as SWAMP began to take shape.

This report was written for the SWAMP as a step toward the development of an improved bioaccumulation monitoring program for California. This report provides a review of bioaccumulation monitoring data generated under the three State Board programs. Future monitoring will be guided by assessment questions developed for the SWAMP (Table 1.1). The objective of this review was to evaluate how well the historic data from the State Water Board programs and from other major monitoring efforts since 1970 address these questions. This exercise has provided a substantial amount of information about present and historical impacts of pollutant bioaccumulation on beneficial uses in California, and also highlights areas where different sampling approaches can better address the assessment questions of current interest.

**Table 1.1**
**Draft objectives and assessment questions for the SWAMP.**

| FISHING BENEFICIAL USE SUPPORT | | | |
|---|---|---|---|
| D.1. Determine the status of the fishing beneficial use throughout the state without bias to known impairment<br><br>D.1.1 What is the extent and location of water bodies not supporting any fishing beneficial use?<br><br>D.1.2 What is the extent and location of water bodies partially supporting the fishing beneficial use?<br><br>D.1.3 What is the extent and location of water bodies fully supporting the fishing beneficial use?<br><br>D.1.4 What is the proportion of water bodies in the state and each region falling within the three levels of support of the fishing beneficial use? | D.2. Assess trends in the fishing beneficial use throughout the state<br><br>D.2.1 Are water bodies improving or deteriorating with respect to the fishing beneficial use?<br><br>D.2.2 Have water bodies fully supporting the fishing beneficial use become impaired?<br><br>D.2.3 Has full support of the fishing beneficial use been restored to previously impaired water bodies? | D3. Evaluate sources and pathways of factors impacting the fishing beneficial use<br><br>D3.1 What is the relative importance of different pollutant sources and pathways in terms of impact on the fishing beneficial use on a regional and statewide basis? | D4. Evaluate effectiveness of management actions in improving the fishing beneficial use<br><br>D4.1 How is the fishing beneficial use affected by remediation, source control, or pollution prevention actions and policies regionally and statewide? |
| **AQUATIC LIFE BENEFICIAL USE SUPPORT** | | | |
| A.1. Determine the status of aquatic life use support throughout the state without bias to known impairment<br><br>A.1.1 What is the extent and location of water bodies with limited support of the aquatic life beneficial use?<br><br>A.1.2 What is the extent and location of water bodies fully supporting the aquatic life beneficial use?<br><br>A.1.3. What is the proportion of water bodies in the state and each region in each level of support of the aquatic life beneficial use? | A.2. Assess trends in support of the aquatic life beneficial use throughout the state<br><br>A.2.1 Are water bodies improving or deteriorating with respect to the fishing beneficial use?<br><br>A.2.2 Have water bodies fully supporting the aquatic life beneficial use become impaired?<br><br>A.2.3 Has full support of the aquatic life beneficial use been restored to previously impaired water bodies? | A.3. Evaluate sources and pathways of factors impacting the aquatic life beneficial use<br><br>A.3.3 What is the relative importance of different pollutant sources and pathways in terms of impact on the aquatic life beneficial use? | A.4. Evaluate effectiveness of management actions improving the aquatic life beneficial use<br><br>A.4.1 How is the aquatic life beneficial use affected by remediation, source control, or pollution prevention actions and policies regionally and statewide? |

## *Literature Cited*

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