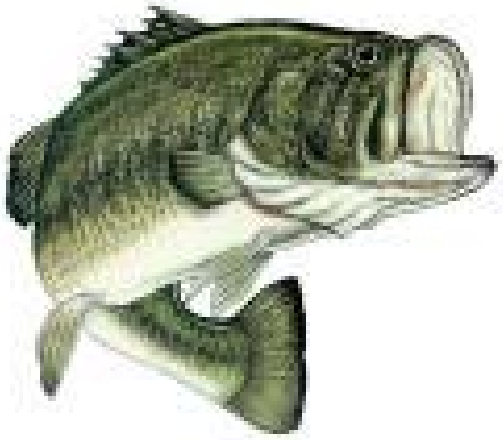
SURFACE WATER AMBIENT MONITORING PROGRAM
(SWAMP)

Chemical Concentrations in Fish Tissues from Selected Reservoirs and Coastal Areas in the San Francisco Bay Region

FINAL REPORT



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UNIVERSITY OF CALIFORNIA, DAVIS
CALIFORNIA DEPARTMENT OF FISH AND GAME
SAN FRANCISCO BAY REGIONAL WATER QUALITY CONTROL BOARD

Executive Summary

As part of the California Surface Waters Ambient Monitoring Program (SWAMP), the State Water Resources Control Board (State Board) and Regional Water Quality Control Boards (Regional Boards) have undertaken a series of studies to evaluate the condition of California's water resources. This SWAMP report describes surveys of reservoirs and coastal areas conducted by the San Francisco Bay Regional Water Quality Control Board, in which edible fish were collected and their tissues analyzed to determine the concentrations of contaminants which may affect human health. These and other data have been used by staff from the State Office of Environmental Health Hazard Assessment (OEHHA) to determine whether and what type of advisories should be issued related to the consumption of fish from the surveyed reservoirs and coastal waters.

Fish from one regional reservoir, San Pablo, were previously found to contain high concentrations of mercury, PCBs, and pesticides (Brodberg and Pollock 1999). Fish from Tomales Bay have been investigated in response to Regional Board concerns over the transport of mercury-laden sediments from the inoperative Gambonini mercury mine. These and other water quality concerns prompted the Regional Board to direct SWAMP funds to the Toxic Substances Monitoring Program and Coastal Fish Contamination Program to better characterize the potential risk to human health from consuming species caught while fishing in the Region's reservoirs and coastal waters.

Edible fish tissues were sampled and analyzed from ten reservoirs: Bon Tempe, Nicasio and Soulajule Reservoirs in Marin County; San Pablo and Lafayette Reservoirs in Contra Costa County; Lake Chabot, Shadow Cliffs and Del Valle Reservoirs in Alameda County; and Stevens Creek and Anderson Reservoirs in Santa Clara County. Fish samples were also collected and analyzed from Tomales Bay and coastal areas along the San Mateo and San Francisco County coasts, as well as near the Farallone Islands.

These studies resulted in the following findings:

1. All the reservoirs sampled yielded fish with edible tissue concentrations of mercury that exceed the OEHHA mercury Screening Value (SV) and U.S. Environmental Protection Agency (EPA) water quality criterion of 0.3 ppm (wet weight).
2. Largemouth bass accumulated higher levels of mercury than the other fish species sampled, with concentrations averaging about 3 to 5 times higher than those for carp, channel catfish, and black crappie. Largemouth bass exceeded the OEHHA SV in all nine reservoirs from which they were collected. Largemouth bass from Soulajule, Stevens Creek and Anderson Reservoirs had the highest concentrations of mercury.
3. With the exception of Nicasio Reservoir, all nine of the reservoirs surveyed for organic chemicals (pesticides and PCBs) had edible fish tissue PCB concentrations above the OEHHA SV of 20 ppb (wet weight).
4. PCB concentrations were highest in carp, followed by channel catfish, and largemouth bass. Carp in Lake Chabot had the highest mean concentrations of PCBs.
5. Dieldrin exceeded the SV of 2 ppb (wet weight) in edible fish tissues from Lake Chabot, San Pablo and Stevens Creek Reservoirs, with the highest mean concentrations in carp and channel catfish from San Pablo Reservoir.
6. Total chlordanes and total DDTs were both found above SVs in carp and channel catfish from Lake Chabot, San Pablo, and Stevens Creek Reservoirs.
7. The highest tissue concentrations of total chlordanes were found in San Pablo Reservoir, while the highest total DDTs were found in Lake Chabot.
8. OEHHA and county health officials have worked together to develop Interim Advisories for consuming fish in the sampled reservoirs, based on the data in this report and earlier data collected by OEHHA
9. Sufficient mercury data were available from Tomales Bay for OEHHA to set consumption guidelines for California halibut, redtail surfperch, shiner surfperch, jacksmelt, leopard shark, brown smoothhound shark, Pacific angel shark, bat ray, and red rock crab. Pile surfperch

were also included in the advisory, based on data for other surfperch species. The advisory is included in Appendix I.

10. It is important to note that the OEHHA mercury advisory does NOT apply to commercial oysters, clams, or mussels from Tomales Bay. Mercury concentrations have been measured in commercially grown Tomales Bay shellfish, and elevated levels have not been found.
11. Along the San Mateo coast, two of four crab samples and three of eleven fish samples had mercury concentrations above the OEHHA SV. One walleye surfperch sample exceeded the SV for PCBs.
12. Salmon composites from the San Francisco coast and the Farallone Islands did not exceed any screening values.

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Cover Image: Largemouth Bass. Courtesy of www.droppinaline.com.

1 Introduction

As part of the California Surface Waters Ambient Monitoring Program (SWAMP), the State Water Resources Control Board (State Board) and Regional Water Quality Control Boards (Regional Boards) have undertaken a series of studies to evaluate the condition of California's water resources. These studies are designed to provide information to the public and to decision makers considering questions such as:

Is the water safe to drink?

Is the water safe to swim in?

Is it safe to eat the fish?

Can the waterways support aquatic life?

This SWAMP report describes surveys of reservoirs and coastal areas in the San Francisco Bay Region, in which edible fish were collected and their tissues analyzed to determine the concentrations of contaminants which may affect human health. These and other data have been used by staff from the State Office of Environmental Health Hazard Assessment (OEHHA) to determine whether and what type of health advisories should be issued related to the consumption of fish from the surveyed reservoirs and coastal waters.

1.1 Overview of the Surface Water Ambient Monitoring Program in California

SWAMP was created to address requirements for a comprehensive surface water monitoring program under California Assembly Bill 982 (Water Code Section 13192; Statutes of 1999). Many previously existing water quality monitoring programs, such as the Toxic Substances Monitoring Program (TSMP) and the Coastal Fish Contamination Program (CFCP), have been combined under SWAMP. The program is designed to provide information necessary for water quality management in California, and to address federal Clean Water Act (CWA) requirements for water quality reporting and water body listing under Sections 305 (b) and 303 (d) of the CWA. Details of SWAMP objectives and methods can be found in the SWAMP Quality Assurance Management Plan (QAMP; Puckett 2002).

1.2 Goals and Objectives of SWAMP in the San Francisco Bay Region

In October 1999, the San Francisco Bay Regional Board developed a Regional Monitoring and Assessment Strategy (RMAS) in order to collect information on all water bodies in the San Francisco Bay Region. SWAMP is being used in this Region to implement the RMAS, which consists of activities led by the Regional Board, by collaborating partner agencies, and by the San Francisco Estuary Regional Monitoring Program (RMP). The activities led by the Regional Board under SWAMP include:

1) Monitoring watersheds to assess water quality impacts and establish regional reference sites; and
2) Monitoring edible fish tissue contaminant levels in reservoirs and coastal areas where people catch and consume fish.

This report addresses the second objective. Under SWAMP, edible fish tissue contaminant monitoring was conducted by the TSMP and CFCP in reservoirs and coastal areas popular for fishing. TSMP reservoir data were generated from fish collected between 2000 and 2002; CFCP coastal data were from fish collected between 1998 and 2001.

2 Selection and Description of Water Bodies Sampled for Contaminants in Edible Fish

In order to characterize the potential risk to human health from consuming species caught while fishing, edible fish tissues were sampled and analyzed from 10 reservoirs and four coastal areas (Figure 1): Bon Tempe, Nicasio and Soulajule Reservoirs in Marin County; San Pablo and Lafayette Reservoirs in Contra Costa County; Lake Chabot, Shadow Cliffs and Del Valle Reservoirs in Alameda County; Stevens Creek and Anderson Reservoirs in Santa Clara County; and coastal waters in Tomales Bay, along the San Mateo and San Francisco County coasts and near the Farallone Islands. These water bodies were selected for sampling based on fishing pressure and geographic balance within the Region. Concentrations of contaminants in fish from San Francisco Bay are monitored through the San Francisco Estuary Regional Monitoring Program (http://www.sfei.org). All edible fish tissue studies have been conducted in cooperation with OEHHA.

2.1 Reservoirs

Fish sampling in reservoirs was conducted through the Toxic Substances Monitoring Program (TSMP). The TSMP was initiated in 1976 by the SWRCB to provide a uniform statewide approach to the detection and evaluation of toxic substances in freshwater, estuarine, and marine waters of the State through the analysis of fish and other aquatic life. In a study conducted by OEHHA, fish from San Pablo Reservoir (located in the Wildcat/San Pablo Watershed) were previously found to contain high mercury concentrations (California Lakes Study; Brodberg and Pollock 1999). Based on those results, an interim advisory was issued by the Contra Costa County Health Services Department for the consumption of largemouth bass collected from San Pablo Reservoir (http://www.co.contra-costa.ca.us). These findings, the paucity of recent data from other reservoirs, and the knowledge that fish from Regional reservoirs are commonly caught and consumed, led the Regional Board to direct SWAMP funds towards an assessment of chemical concentrations in edible fish tissues in the ten selected reservoirs.

2.2 Coastal Waters

Fish sampling in coastal waters was conducted through the Coastal Fish Contamination Program (CFCP). Fish sampling in Tomales Bay was conducted in response to Regional Board concerns over the transport of mercury-laden sediments from the inoperative Gambonini mercury mine. The mine was located in the Walker Creek basin, the second largest watershed draining to Tomales Bay. The US EPA and the Regional Board initiated an emergency Superfund cleanup action for the Gambonini mine in 1998. The Regional Board has supported a number of studies to assess the fate, transport, and effects of mercury in the watershed and its receiving waters in Tomales Bay.

Because shellfish aquaculture is an important economic activity in Tomales Bay, the Regional Board used state Mussel Watch funds in the late 1990s to measure mercury concentrations in commercially grown oysters. These studies found that mercury concentrations in oysters were all well below the FDA action level for commercial fish and shellfish (1.0 ppm wet wt.), as well as the OEHHA SV (0.3 ppm wet wt.), and ranged from 0.029 to 0.049 ppm wet wt. Similarly,

mercury concentrations in mussels transplanted to the Walker Creek Delta for three months during the 1996/97 rainy season, ranged from 0.044 to 0.055 ppm (wet wt.), while mussels transplanted in Tomales Bay north and south of the Delta ranged from 0.033 to 0.036 ppm. Mercury concentrations in resident bivalves (cockles) harvested from sediments in the Walker Creek Delta contained up to 0.56 ppm (wet wt.). This was an order of magnitude greater than for both the mussels and oysters, which were suspended above the sediment, and for the resident cockles harvested at the McDonald sediment sampling location 11 km south of Walker Creek. However, when methylmercury concentrations, the toxic form of mercury, were measured in the resident cockles from Walker Creek Delta the concentrations were low. In all cases, the mercury concentrations in shellfish were below the 1 ppm action level set by the US Food and Drug Administration, which oversees commercially grown shellfish. There are no OEHHA advisories in effect for Tomales Bay bivalves (OEHHA 2004).

In 1998, 1999, and 2001, CFCP funds were used to investigate mercury contamination in fish in Tomales Bay. Tomales Bay is a popular salt-water fishing area, with anglers catching a variety of species, including halibut, surfperch, jack smelt, brown smoothhound sharks, leopard sharks, bat rays, and angel sharks. The CFCP sampled edible fish tissues in these species, and detected high levels of mercury. In order to alert the fishing community to potential health risks associated with mercury, the County of Marin, in cooperation with OEHHA, issued an interim fish consumption advisory for Tomales Bay (County of Marin 2000). More tissues were sampled in 2001. These additional data allowed OEHHA to more reliably determine tissue concentrations, and to issue a Health Advisory for consumption of fish and red rock crab from Tomales Bay (Appendix I; OEHHA 2004). The methods and results of these fish tissue analyses are covered in this report.

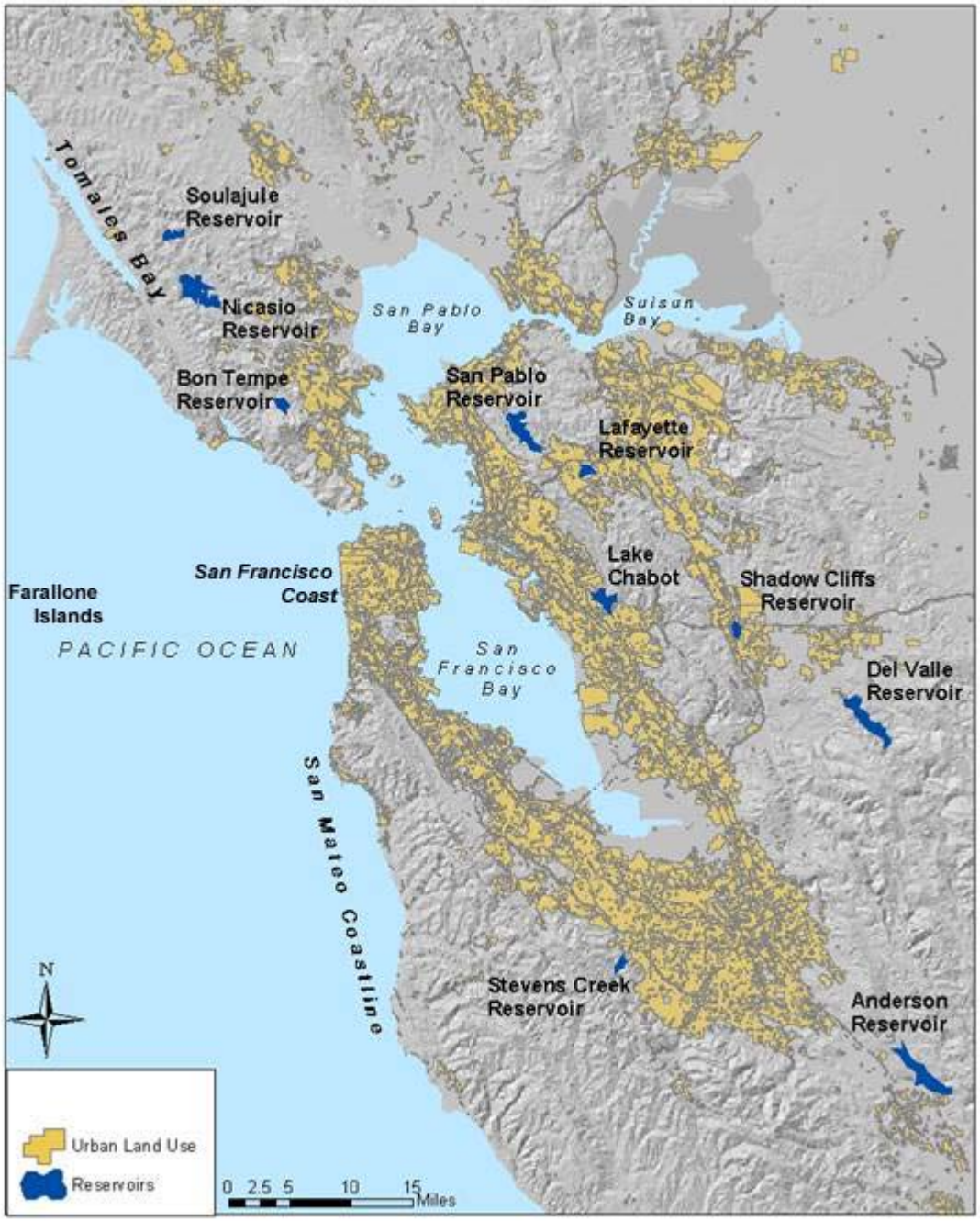
In 2000 the CFCP sampled edible fish and shellfish tissues in other coastal areas. Along the San Mateo County coast samples consisted of composites of between 3 to 13 individuals per sample of the following species: Dungeness crab, red rock crab, chinook salmon, white croaker, walleye surfperch, white surfperch, pile surfperch, rainbow surfperch, spotfin surfperch, brown rockfish, rosethorn rockfish, black rockfish, and lingcod. Crab hepatopancreas were also sampled. In

addition, two composite samples of salmon were collected; one from the San Francisco County coast and one near the Farallone Islands.

2.3 Use of Screening Values

U.S. EPA recommends that states use screening values (SVs) as part of the process of monitoring fish for contaminants and determining which target chemicals and specific fish species are of potential health concern when consumed by the public. Screening values are not regulatory and do not correspond to an advisory level. Measurements that exceed SVs in pilot or screening studies indicate where further sampling would be appropriate. They are used to determine which chemicals and fish species are most important to sample more intensively in a water body. Exceedences of SVs also serve to indicate when evaluation of human health risks should be conducted and are used to determine which chemicals and species should be considered in risk assessments to determine consumption advice.

Figure 1. Location of sampled water bodies in the San Francisco Bay Region.



3 Methods

All sampling, chain of custody procedures, and laboratory analyses were performed according to objectives and procedures outlined in the SWAMP QAMP and its appendices (Puckett 2002), unless otherwise noted. Regional Board contacts, as well as participants contracted for field and laboratory studies, are also listed in the QAMP (Puckett 2002, Appendix A). All station locations were measured using global positioning system (GPS) units.

3.1 Reservoir Sampling

Fish targeted for collection in Regional reservoirs in 2000-2002 included those species frequently caught and consumed by recreational anglers: channel catfish, carp, rainbow trout, largemouth bass, bluegill, crappie and other sunfish. Of these, all but rainbow trout were collected. Two or more species were collected in most reservoirs. Sampling effort was designed to catch enough fish to make two to four composite samples of four fish each, for each species collected. Within each composite, the smallest fish was at least 75% the length of the largest fish. Larger, older fish were targeted, with a minimum size set at the legal angling size or practical eating size for each species.

Fish collection was performed by the Department of Fish and Game (DFG) Aquatic Bioassessment Laboratory using an electrofishing boat. Fish species and length were recorded before fish were wrapped in aluminum foil or Teflon®. The heads and tails of fish larger than the wrapping material were removed prior to wrapping (gut contents were kept intact). Fish were kept on dry ice in the field, then frozen at -20º C prior to analysis. Tissues were analyzed for mercury, pesticides, polychlorinated biphenyls (PCBs), moisture, and lipids (Table 1). Details of fish sampling and analysis methods used in the TSMP can be found in their most recent data report (Rasmussen 1997). Chemical concentrations in edible fish tissues from reservoirs were compared to OEHHA screening values (SVs; Table 2). SVs were not available for all analytes.

Table 1. Analytes measured in edible tissue under the Toxic Substances Monitoring Program and the Coastal Fish Contamination Program.

Analyte	CFCP, Coastal Samples (1)	TSMP, reservoirs (2)
Organics		
Aldrin	X	X
Chlordane, cis	X	X
Chlordane, trans	X	X
Chlordane, alpha	X	X
Chlordane, gamma	X	X
Chlorpyrifos	X	X
Dacthal	X	X
DDD(o,p')	X	X
DDD(p,p')	X	X
DDE(o,p')	X	X
DDE(p,p')	X	X
DDMU(p,p')	X	X
DDT(o,p')	X	X
DDT(p,p')	X	X
Diazinon	X	X
Dichlorobenzophenone-p,p'		X
Dieldrin	X	X
Endosulfan I	X	X
Endosulfan II	X	
Endosulfan sulfate	X	
Endrin	X	X
Ethion	X	X
HCH, alpha	X	X
HCH, beta	X	X
HCH, delta	X	X
HCH, gamma	X	X

Table 1 (Continued). Analytes measured in edible tissue under the Toxic Substances Monitoring Program and the Coastal Fish Contamination Program.

Analyte	CFCP, Coastal Samples (1)	TSMP, reservoirs (2)
Heptachlor	X	X
Heptachlor epoxide	X	X
Hexachlorobenzene	X	X
Methoxychlor	X	X
Mirex	X	
Nonachlor, cis	X	X
Nonachlor, trans	X	X
Oxadiazon	X	X
Oxychlordane	X	X
Parathion, Ethyl	X	X
Parathion, Methyl	X	X
PCBs (various congeners)		X
PCBs (Aroclor 1248, 1254, 1260)	X	
Tetrachlorophenol, 2,3,5,6-	X	
Toxaphene	X	X
Inorganics		
Arsenic (Total or Inorganic)	X	
Cadmium	X	
Chromium	X	
Copper	X	
Lead	X	
Mercury (Total or Methyl-)	X	X
Nickel	X	
Selenium	X	
Silver	X	
Zinc	X	
Other analytes		
Lipid	X	X
Moisture	X	X

(1) These data are not part of the SWAMP database; see OEHHA 2004 for analysis details.
(2) These data are not part of the SWAMP database; see Rasmussen 1997 for analysis details.

Table 2. Screening Values for contaminants in edible fish tissue from reservoirs.

Constituent	OEHHA Screening Values (1)
Mercury	0.3 ppm
Total Chlordanes	30 ppb
Total DDTs	100 ppb
Dieldrin	2.0 ppb
Endrin	1,000 ppb
Lindane (gamma-HCH)	30 ppb
Heptachlor epoxide	4.0 ppb
HCB	20 ppb
Toxaphene	30 ppb
Diazinon	300 ppb
Chlorpyrifos	10,000 ppb
Total PCBs	20 ppb

(1) From Brodberg and Pollock 1999, for California reservoirs. Screening values (SVs) were calculated based on EPA guidance (1995), using the dose-response variables published in current EPA guidelines (USEPA 2000) and a consumption rate of 21 g/d for recreational fishers. The current EPA SVs (USEPA 2000) were calculated with a consumption rate of 17.5 g/d; because OEHHA used higher consumption rates and rounded their calculations, their SVs are more protective than EPA values, with the exception of chlorpyrifos (EPA = 1200 ppb).

3.2 Coastal Sampling

All methods for sampling and analysis of coastal fish were consistent under the Coastal Fish Contamination Program. Coastal fish were collected by scientists from the DFG Marine Pollution Studies Laboratory. Fish were collected using nets or by hook and line. From 1998 to 2001 fish were sampled in Tomales Bay, along the San Mateo and San Francisco coasts and near the Farallone Islands.

Information from past sampling efforts helped determine the fish species to target for collection from Tomales Bay. Where target species or numbers were not attainable, other species were collected. Species (and number of samples each) collected during one or both of the two sampling periods were California halibut (12), redtail surfperch (3), shiner surfperch (7), jacksmelt (7), leopard shark (18), brown smoothhound shark (12), Pacific angel shark (18), bat

ray (12), pile surfperch (1), red rock crab (6), and resident clams (10). Tissue samples were analyzed for organic chemicals and trace metals.

In Tomales Bay composite samples of three to five individuals each (or enough to yield 100 g of tissue) were collected for each species. Both individual fish and composite samples were analyzed. Composite samples (including tissues taken from more than one individual of a given species) were used to maximize the amount of information gained without incurring higher analytical costs from additional individual samples. Differences in the size of the smallest and largest fish in each composite were no greater than 25 percent, with the exception of two composites of shiner surfperch and one composite of bat ray, each of which exceeded the acceptable range by two to three millimeters. For some species, individual fish were analyzed in order to provide information on the relationship between size of fish and mercury concentration, and to provide additional information on the amount of variability among individual fish. The species analyzed as individuals in 1999 were leopard shark and Pacific angel shark. In 2001, individual samples were analyzed for all shark species, bat rays, and California halibut. Organisms were wrapped in Teflon® and plastic bags; some large fish were dissected in the field prior to wrapping. Samples were kept on ice in the field, then frozen at -20ºC until analysis.

Tissue samples were homogenized in the laboratory, and all samples were analyzed for total mercury. Most fish samples were also analyzed for arsenic, cadmium, and selenium. Redtail surfperch and jacksmelt were only analyzed for mercury and arsenic. California halibut and shiner surfperch were analyzed for a full suite of trace metals including silver, arsenic, cadmium, chromium, copper, mercury, lead, nickel, selenium, and zinc. Clams were also analyzed for the full suite of trace metals and for methylmercury. Red rock crabs were analyzed for mercury, methylmercury, arsenic, cadmium, and selenium (Table 1; OEHHA 2004). In 1999, California halibut and shiner surfperch were analyzed for organic contaminants. Additional details of fish sampling methods in Tomales Bay can be found in the following documents: SWAMP QAMP (Puckett 2002, Appendix D); "Health Advisory: Guidelines for Consumption of Fish and Shellfish from Tomales Bay" (Marin County 2000); and OEHHA (2004). The main OEHHA webpage for all Tomales Bay advisory information is:
http://www.oehha.ca.gov/fish/so_cal/tomales.html

In 2000 fish and crab samples were collected from the San Mateo County coast. Species included Dungeness crab, red rock crab, walleye surfperch, white surfperch, white croaker, pile surfperch, rainbow surfperch, brown rockfish, lingcod, rosethorn rockfish, black rockfish and spotfin surfperch. All samples were composites made up of from 3 to 13 individuals. Four composite samples of crab hepatopancreas were also sampled; two Dungeness and two red rock crab. In addition, two composite samples of salmon were collected; one from the San Francisco County coast and one near the Farallone Islands. All of the fish and crab muscle tissue samples were analyzed for arsenic, cadmium, mercury, selenium and organics, including PCBs and pesticides. Hepatopancreas samples were only analyzed for mercury.

3.3 Analytical Methods

Homogenized tissue from the samples was digested using acid, and analyzed for total mercury by cold vapor atomic fluorescence spectrometry using a Perkin Elmer Flow Injection Mercury System at DFG Moss Landing Marine Laboratory. Methylmercury was measured in several clam and red rock crab samples. Methylmercury was analyzed by cold vapor atomic fluorescence spectrometry at CDFG Moss Landing Marine Laboratory. For analysis of organic chemicals (including pesticides and PCBs), homogenized tissue was extracted and analyzed by capillary gas chromatography for chlorinated hydrocarbons utilizing an electron capture detector (GC/ECD), and for aromatic hydrocarbons by gas chromatography mass spectrometry (GC/MS) at the CDFG Water Pollution Control Laboratory (OEHHA 2004).

3.3.1 PCB Congeners Analysis of Fish Tissue

Digestion procedure

A 1-5 g (tissue homogenate) sample is weighed into a pre-weighed aluminum planchet and placed in a 70 ^{o}C oven for 48 hours to determine moisture content. A 10 g sample is mixed using a clean glass stirring rod with approximately 7 g of pre-extracted Hydromatrix in a 250 mL trace clean wide mouth jar until the mixture is free flowing. The mixture is then poured into a 33 mL stainless steel Dionex Accelerated Solvent Extractor (ASE 200) extractor cell and packed by tamping the mixture. A solution containing pesticide and PCB surrogate compounds is added to the cell and the cap is screwed onto the cell. The extractor cells (maximum of 24) are placed on

the ASE 200 autosampler rack and the samples are extracted with a 50/50 mixture of acetone/dichloromethane (DCM) using heat and pressure. The extracts are automatically collected in 60 mL VOA vials. The extracts are dried using sodium sulfate, evaporated to approximately 0.5 mL using Kuderna-Danish (K-D) glassware equipped with 3-ball Snyder columns and micro-Snyder apparatus and diluted to 10 mL using DCM. The extracts are then filtered through a 0.45 µm syringe filter into J2 Scientific AccuPrep 170 (GPC) autosampler tubes. (Crane, 2004)

Analytical Method

The GPC autosampler tubes are then placed on the GPC autosampler for initial sample cleanup. The cleaned-up extracts are evaporated using K-D apparatus and solvent exchanged into petroleum ether. The extracts are then fractionated using 5 grams of Florisil in a 11 mm x 300 mm column with a 250 mL reservoir. The Florisil columns are eluted with petroleum ether (PE) (Fraction 1), 6% diethyl ether/PE (Fraction 2), 15% diethyl ether/PE (Fraction 3), and 50% diethyl ether/PE (Fraction 4). The fractions are concentrated to an appropriate volume using K-D/micro K-D apparatus prior to analysis by dual column high resolution gas chromatography. A mixture of synthetic organic standards is eluted through the Florisil column to determine the recovery and separation characteristics of the column. (Crane, 2004)

3.3.2 Total Mercury Analysis of Fish Tissue

Digestion procedure

Step 1: Place approximately 1 gram of homogenized sample or 0.25 gram of SRM in a 40 mL I-Chem™ vial.

Step 2: Pipette 10.0 mL of 70:30 (v/v) HNO3/H2SO4 solution into the 40 mL vial and swirl.

Step 3: Place vial on a hot plate with a glass reflux cap.

Step 4: Heat sample to 125º C for a minimum of 2 hours after the onset of refluxing or until all organic matter is dissolved.

Step 5: After samples cool, dilute to 40 mL with a 5% (v/v) solution of 0.2 N BrCl in ASTM Type II water. (Ichikawa et al., 2001)

Analytical method

Samples were analyzed using a Perkin Elmer Flow Injection Mercury System (FIMS) with an AS-90 autosampler. Mercury concentrations were determined by analyzing 1 mL of digestate. Stannous chloride was used as the reducing agent with argon as the carrier gas. Samples, blanks, reductant, and standards were prepared using clean techniques. ASTM Type II water and ultra clean chemicals were used for all standard preparations. Continuing calibration verification was performed after every 10 samples and samples run between CCVs that drifted greater than 10% were rerun. Three blanks, a standard reference material (DORM-2), as well as a method duplicate and a matrix spike pair were run with each set of samples. Digestion batches contained 20 or less samples. Each batch has its own blank, SRM, matrix spike, matrix spike duplicate, and laboratory duplicate. (Ichikawa et al. 2001).

3.4 Quality Assurance

The CFCP and TSMP programs have defined data quality objectives (DQOs) and quality control requirements for edible fish tissue chemistry. The DQOs are summarized in Tables A1-1 and A1-2 in Appendix II. Details of the DQOs are available in recent TSMP reports (http://www.swrcb.ca.gov/programs/smw/index.html) and in the SWAMP's Quality Assurance Management Plan (Puckett 2002). All samples reported in this study were collected, analyzed and reported following CFCP and TSMP quality assurance protocols.

PCB congener samples were analyzed using high resolution gas chromatography using electron capture detection by the Water Pollution Control Laboratory in Rancho Cordova, California. Total mercury samples were analyzed using cold vapor atomic fluorescence spectrometry (a modified version of EPA 1631) by Moss Landing Marine Laboratory in Moss Landing, CA. This report presents quality control (QC) data associated with PCB congeners and total mercury (Appendix II). Recent TSMP reports detail QC data for all analytes from 1996-2002.

4 Results and Discussion

Edible fish tissue data from reservoirs are presented in Appendix III (metals) and Appendix IV (organics). Metals and organics data for the San Mateo and San Francisco County coasts and the Farallone Islands can be found in Appendix V. Data for Tomales Bay can be found in OEHHA (2004).

4.1 Mercury in Reservoirs

All the reservoirs sampled in this study yielded fish with edible tissue concentrations of mercury that exceed the OEHHA mercury SV and U.S. EPA water quality criterion of 0.3 ppm wet weight (Table 3). Mercury was the only trace metal analyzed in tissue samples from the reservoirs. Largemouth bass accumulated higher levels of mercury than the other fish species sampled, with concentrations averaging about 3 to 5 times higher than those for carp, channel catfish, and black crappie (Figures 2 - 5). Largemouth bass exceeded the OEHHA SV in all nine reservoirs from which they were collected. Soulajule, Stevens Creek and Anderson Reservoirs had the highest levels of mercury, based on results from largemouth bass (Table 3, Figure 2).

In this study, largemouth bass were collected from all reservoirs except San Pablo. In a previous study (Brodberg and Pollock 1999), largemouth bass were collected from San Pablo Reservoir, and had average mercury concentrations of 0.520 ppm (wet weight), a level above the OEHHA SV. At that time, largemouth bass were the only species collected from San Pablo Reservoir that exceeded the SV. Likewise in the current study, none of the carp, channel catfish, or black crappie from San Pablo Reservoir exceeded 0.3 ppm.

Fifty-four percent of all samples collected in the current study exceeded the OEHHA SV for mercury (0.3 ppm); all were tissues from largemouth bass, black crappie, channel catfish, and carp. Carp exceeded the SV in Anderson Reservoir and Lake Chabot, black crappie exceeded the SV in Soulajule, Anderson, and Stevens Creek Reservoirs, and channel catfish exceeded the SV in Stevens Creek and Del Valle Reservoirs (Table 3). Tissues from goldfish collected in

Lafayette reservoir exceeded the SV, with concentrations similar to those found in carp at other reservoirs.

No samples from redear sunfish or bluegill exceeded the SV, and numerous samples from various species had low concentrations, depending on the reservoirs from which they were collected (Table 3). Anglers may still eat some fish caught in the reservoirs if they follow the advice provided in the interim advisories available on the OEHHA website (www.oehha.ca.gov/fish.html).

Mercury concentrations tended to be higher in larger fish, as exemplified by the statistically significant trend in largemouth bass (Figure 6; $p << 0.001$). Fish age (as inferred from length) is known to be an important determinant of tissue mercury concentration. Because the biological half-life of methylmercury in fish is approximately 2 years, tissue concentrations increase with increased duration of exposure. Thus, with increasing age (length) within a given species, tissue methylmercury concentrations are expected to increase (OEHHA 2004).

Table 3. Total mercury concentrations (ppm wet weight) in fish collected from Regional reservoirs. Shaded values exceed the OEHHA Screening Value of 0.3 ppm.

Reservoir	Sampling Date	Species	Mean Length (mm)	Total Mercury
Anderson	9/13/2001	Black Crappie	139	0.090
Anderson	9/13/2001	Black Crappie	184	0.254
Anderson	9/13/2001	Black Crappie	232	0.375
Anderson	9/13/2001	Largemouth Bass	298	0.680
Anderson	9/13/2001	Largemouth Bass	361	1.170
Anderson	9/13/2001	Largemouth Bass	450	1.460
Anderson	9/13/2001	Carp	373	0.399
Anderson	9/13/2001	Carp	412	0.457
Anderson	9/13/2001	Carp	480	0.425
Bon Tempe	9/20/2001	Largemouth Bass	480	0.899
Bon Tempe	9/20/2001	Largemouth Bass	365	0.536
Del Valle	4/25/2001	Channel Catfish	445	0.393
Del Valle	4/25/2001	Channel Catfish	420	0.152
Del Valle	4/25/2001	Channel Catfish	398	0.289
Del Valle	4/25/2001	Largemouth Bass	428	0.918
Del Valle	4/25/2001	Largemouth Bass	353	0.829
Del Valle	4/25/2001	Largemouth Bass	332	0.812
Del Valle	4/25/2001	Redear Sunfish	265	0.213
Del Valle	4/25/2001	Redear Sunfish	248	0.178
Del Valle	4/25/2001	Redear Sunfish	227	0.223
Del Valle	4/25/2001	Bluegill	174	0.268
Del Valle	4/25/2001	Bluegill	153	0.193
Del Valle	4/25/2001	Bluegill	138	0.178
Lafayette	9/9/2002	Black Crappie	125.0	0.059
Lafayette	9/9/2002	Black Crappie	142.0	0.053
Lafayette	9/9/2002	Black Crappie	135.0	0.047
Lafayette	9/9/2002	Channel Catfish	485.0	0.181
Lafayette	9/9/2002	Goldfish	366.0	0.514
Lafayette	9/9/2002	Goldfish	418.0	0.302
Lafayette	9/9/2002	Goldfish	354.0	0.477
Lafayette	9/9/2002	Largemouth Bass	396.0	0.347
Lafayette	9/9/2002	Largemouth Bass	496.0	0.656
Lafayette	9/9/2002	Largemouth Bass	345.0	0.292

Table 3 (continued). Total mercury concentrations (ppm wet weight) in fish collected from Regional reservoirs. Shaded values exceed the OEHHA Screening Value of 0.3 ppm.

Reservoir	Sampling Date	Species	Mean Length (mm)	Total Mercury
Lake Chabot	4/24/2001	Channel Catfish	420	0.127
Lake Chabot	4/24/2001	Channel Catfish	393	0.050
Lake Chabot	4/24/2001	Channel Catfish	500	0.127
Lake Chabot	4/24/2001	Redear Sunfish	130	0.118
Lake Chabot	4/24/2001	Redear Sunfish	155	0.192
Lake Chabot	4/24/2001	Largemouth Bass	388	0.577
Lake Chabot	4/24/2001	Largemouth Bass	357	0.559
Lake Chabot	4/24/2001	Largemouth Bass	347	0.523
Lake Chabot	6/6/2001	Carp	478	0.662
Lake Chabot	6/6/2001	Carp	449	0.728
Lake Chabot	6/6/2001	Carp	431	0.613
Nicasio	9/19/2001	Bluegill	150	0.213
Nicasio	9/19/2001	Bluegill	158	0.163
Nicasio	9/19/2001	Bluegill	165	0.128
Nicasio	9/19/2001	Largemouth Bass	303	0.173
Nicasio	9/19/2001	Largemouth Bass	367	0.372
Nicasio	9/19/2001	Largemouth Bass	454	1.290
Nicasio	9/19/2001	Carp	394	0.213
Nicasio	9/19/2001	Carp	404	0.289
Nicasio	9/19/2001	Carp	445	0.253
San Pablo	4/17/2000	Carp	508	0.185
San Pablo	4/17/2000	Carp	530	0.182
San Pablo	4/17/2000	Carp	537	0.197
San Pablo	4/17/2000	Black Crappie	203	0.152
San Pablo	4/17/2000	Black Crappie	194	0.146
San Pablo	4/17/2000	Black Crappie	191	0.129
San Pablo	4/17/2000	Channel Catfish	494	0.114
San Pablo	4/17/2000	Channel Catfish	456	0.062
San Pablo	4/17/2000	Channel Catfish	504	0.131
Shadow Cliffs	8/13/2002	Carp	583.0	0.162
Shadow Cliffs	8/13/2002	Channel Catfish	395.0	0.029
Shadow Cliffs	8/13/2002	Largemouth Bass	487.0	0.712
Shadow Cliffs	8/13/2002	Largemouth Bass	382.0	0.693

Table 3 (continued). Total mercury concentrations (ppm wet weight) in fish collected from Regional reservoirs. Shaded values exceed the OEHHA Screening Value of 0.3 ppm.

Reservoir	Sampling Date	Species	Mean Length (mm)	Total Mercury
Soulajule	5/2/2000	Largemouth Bass	326	0.812
Soulajule	5/2/2000	Largemouth Bass	373	1.030
Soulajule	5/2/2000	Largemouth Bass	216	0.405
Soulajule	5/2/2001	Black Crappie	171	0.355
Soulajule	5/2/2001	Black Crappie	173	0.306
Soulajule	5/2/2001	Black Crappie	164	0.336
Soulajule	9/20/2001	Channel Catfish	620	0.229
Soulajule	9/20/2001	Channel Catfish	605	0.294
Soulajule	9/20/2001	Largemouth Bass	297	0.671
Soulajule	9/20/2001	Largemouth Bass	343	0.752
Soulajule	9/20/2001	Largemouth Bass	370	0.880
Soulajule	9/20/2001	Largemouth Bass	380	0.540
Soulajule	9/20/2001	Largemouth Bass	465	1.450
Soulajule	9/20/2001	Largemouth Bass	495	1.870
Stevens Creek	5/4/2001	Largemouth Bass	476	1.460
Stevens Creek	5/4/2001	Largemouth Bass	457	1.560
Stevens Creek	5/4/2001	Largemouth Bass	410	1.400
Stevens Creek	5/4/2001	Black Crappie	204	0.616
Stevens Creek	5/4/2001	Black Crappie	195	0.604
Stevens Creek	5/4/2001	Black Crappie	198	0.557
Stevens Creek	5/4/2001	Black Crappie	203	0.610
Stevens Creek	5/4/2001	Channel Catfish	475.0	0.192
Stevens Creek	5/4/2001	Channel Catfish	506.0	0.507
Stevens Creek	6/6/2001	Channel Catfish	640.0	0.455
Detection limit				0.01
Total detections				90
OEHHA Screening Value				0.3
Total exceedences				49
Percent exceedences in all samples				54%

Figure 2. Mean mercury concentrations (± sd) in Largemouth Bass from Regional reservoirs. Line indicates OEHHA Mercury Screening Value.

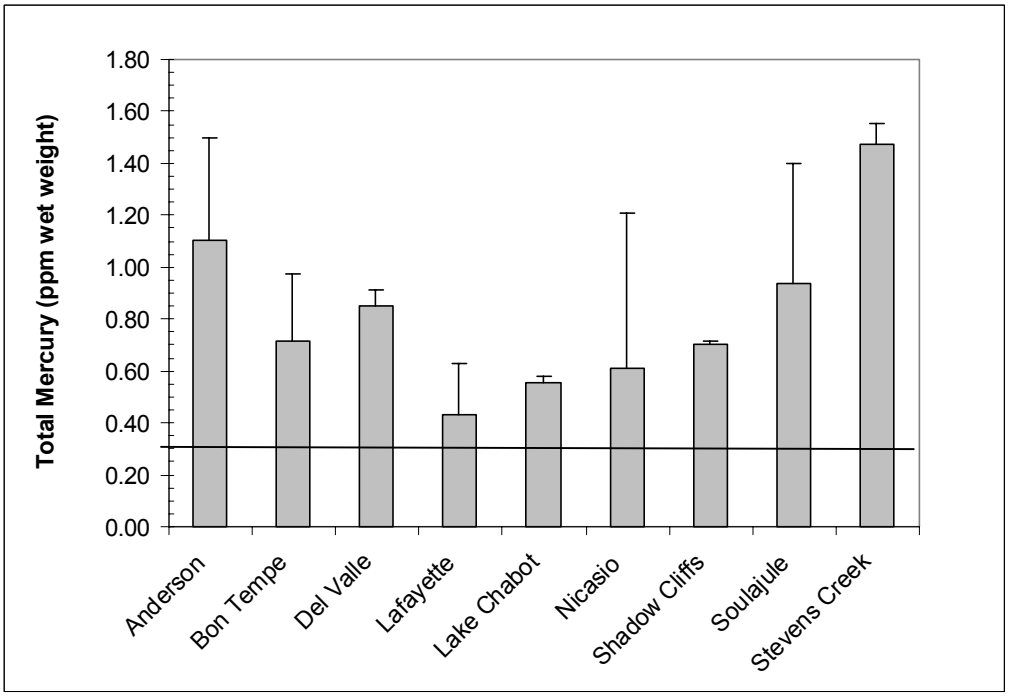


Figure 3. Mean mercury concentrations (± sd) in Carp from Regional reservoirs. Line indicates OEHHA Mercury Screening Value. * Lafayette values are for goldfish.

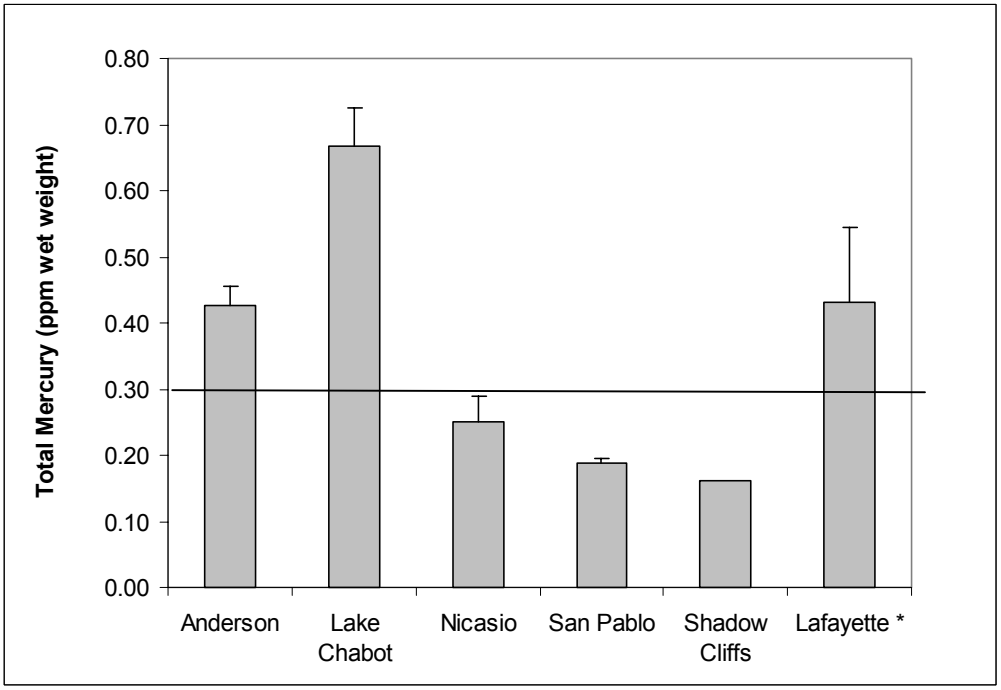


Figure 4. Mean mercury concentrations (± sd) in Black Crappie from Regional reservoirs. Line indicates OEHHA Mercury Screening Value.

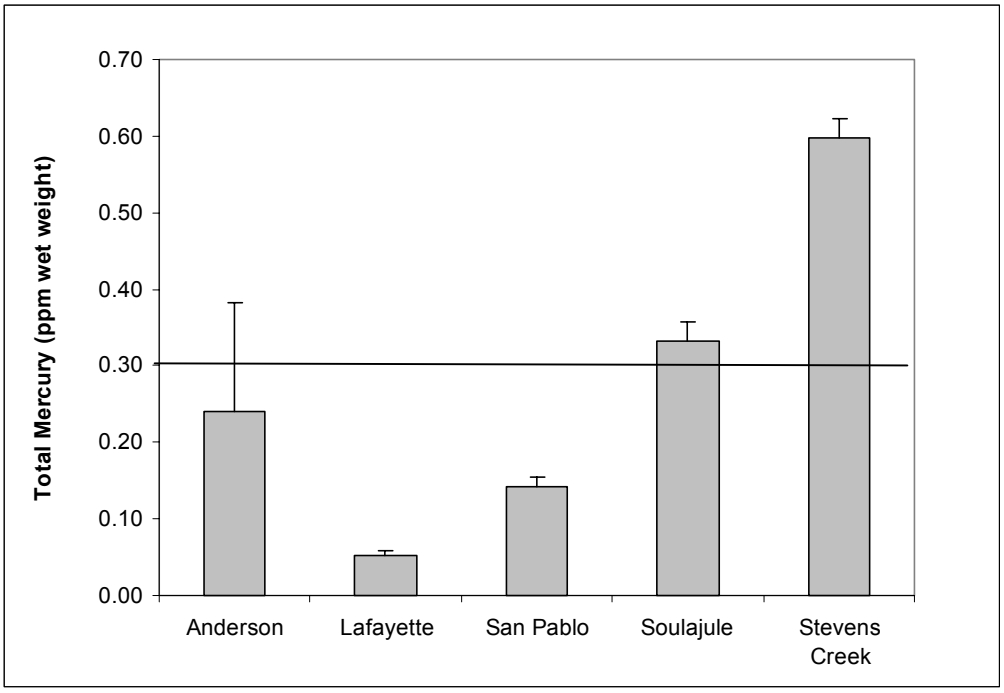


Figure 5. Mean mercury concentrations (± sd) in Channel Catfish from Regional reservoirs. Line indicates OEHHA Mercury Screening Value.

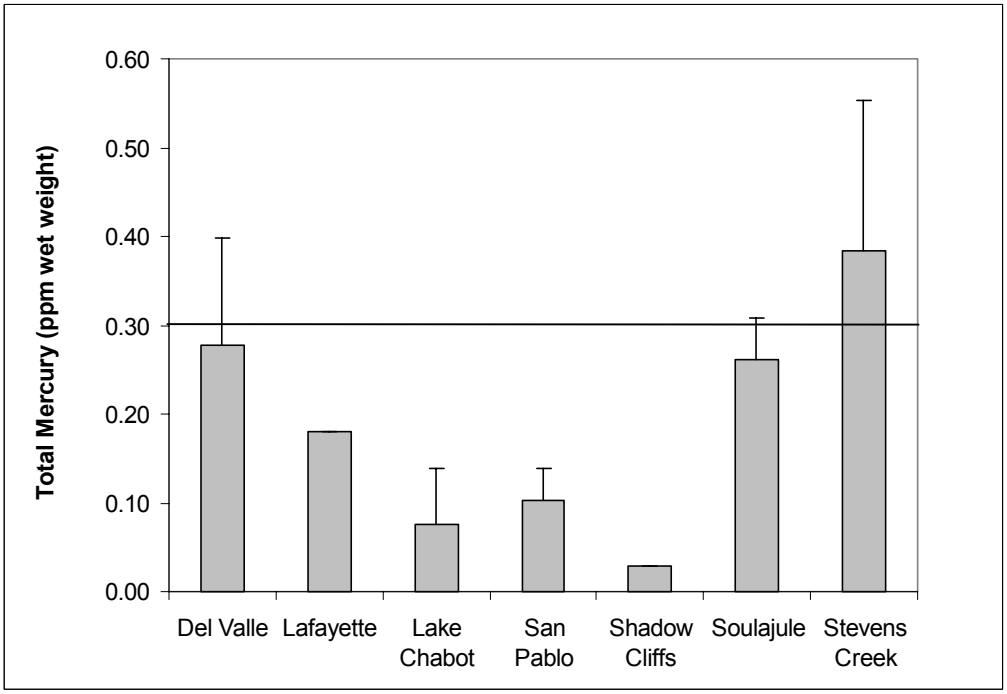
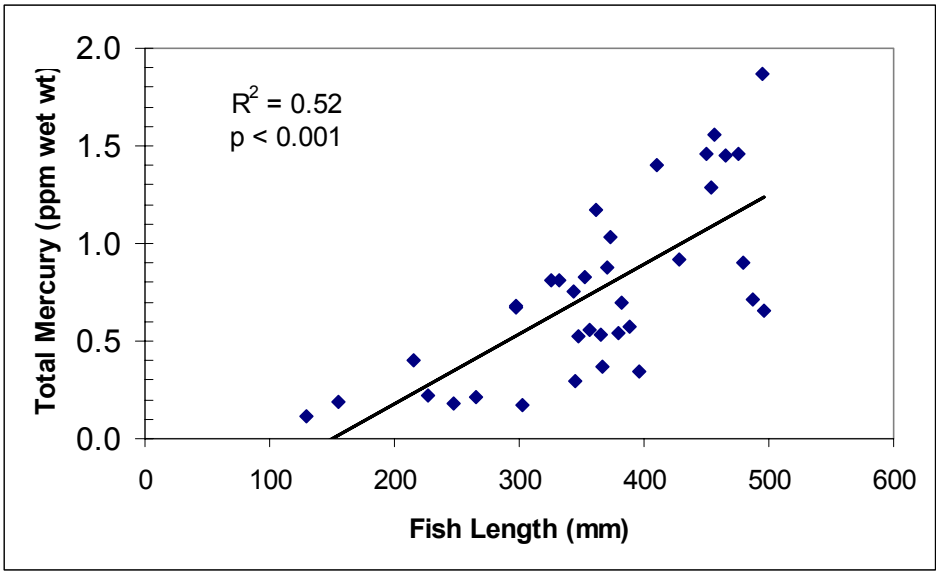


Figure 6. Relationship between fish length and mercury concentration in largemouth bass.



4.2 PCBs and Pesticides in Reservoirs

With the exception of Nicasio Reservoir, all of the reservoirs surveyed and tested for organic chemicals had edible fish tissue PCB concentrations above the OEHHA SV of 20 ppb (wet weight; Table 4). PCB concentrations were highest in carp (Figure 7), followed by channel catfish (Figure 8), and largemouth bass (Figure 9). Carp from Lake Chabot had the highest mean PCB concentrations measured (406 ppb wet wt.). Channel catfish from seven reservoirs had mean PCB tissue concentrations exceeding the SV. Stevens Creek Reservoir was the only reservoir in which largemouth bass were found to contain PCBs above the SV. Fish collected from Bon Tempe Reservoir were not analyzed for organic chemicals.

Dieldrin exceeded the SV of 2 ppb (wet weight) in edible fish tissues from Lake Chabot, San Pablo and Stevens Creek Reservoirs (Figures 10 – 12); with the highest mean concentrations in carp and channel catfish from San Pablo Reservoir. Black crappie from San Pablo Reservoir also exceeded the dieldrin SV (Figure 10).

Total chlordanes and total DDTs had similar distributions, with both found above SVs in carp and channel catfish from Lake Chabot, San Pablo, and Stevens Creek Reservoirs (Table 4). The highest

concentrations of total chlordanes were found in San Pablo Reservoir, while the highest total DDTs were found in Lake Chabot. Patterns of SV exceedence for heptachlor epoxide and toxaphene were identical: both were found in carp and channel catfish from San Pablo Reservoir (Table 4). Hexachlorobenzene (HCB) was the only other detected pesticide for which SVs were available, and it was not found above its SV of 20 ppb.

As in the current study, tissues sampled from San Pablo reservoir for the California Lakes Study (Brodberg and Pollock 1999) contained concentrations of chlordanes, DDTs, dieldrin, PCBs, heptachlor epoxide, and toxaphene in exceedence of OEHHA SVs. Because sample size was low in that study, tissues collected from San Pablo Reservoir for the current study were analyzed for these and other organic chemicals, and concentrations of the same six analytes exceeded OEHHA SVs (Table 4). It is important to note that there are no SVs for some organic analytes, because they are not on the list of target analytes recommended by EPA for screening studies in fish; these analytes were not evaluated here. Data from the present study, the California Lakes Study (Brodberg and Pollock 1999), and additional data have been used by OEHHA to establish interim advisories for human health related to consumption of fish from regional reservoirs (www.oehha.ca.gov/fish.html).

Table 4. Concentrations of detected pesticides and PCBs (ppb wet weight) in fish collected from Regional reservoirs. Shaded values exceed the OEHHA Screening Values.

Reservoir	Sampling Date	Species	Total Chlordanes	Total DDTs	Dieldrin	Heptachlor Epoxide	HCB	Total PCBs	Toxaphene
Anderson	9/13/2001	Black Crappie	ND	ND	ND	ND	ND	ND	ND
Anderson	9/13/2001	Black Crappie	ND	3.1	ND	ND	ND	10	ND
Anderson	9/13/2001	Black Crappie	ND	ND	ND	ND	ND	ND	ND
Anderson	9/13/2001	Carp	5.9	17.9	ND	ND	ND	38	ND
Anderson	9/13/2001	Carp	13.3	30.2	ND	ND	ND	46	ND
Anderson	9/13/2001	Carp	8.0	26.5	ND	ND	19.5	40	ND
Del Valle	4/25/2001	Channel Catfish	1.6	51.5	ND	ND	0.3	28	ND
Del Valle	4/25/2001	Channel Catfish	2.0	44.3	ND	ND	0.4	21	ND
Del Valle	4/25/2001	Channel Catfish	1.9	46.7	ND	ND	0.4	21	ND
Lafayette	9/9/2002	Black Crappie	NA	-99.0	ND	ND	ND	NA	ND
Lafayette	9/9/2002	Channel Catfish	1.9	16.8	0.8	ND	ND	41.0	ND
Lafayette	9/9/2002	Goldfish	10.8	24.7	1.4	ND	0.4	59.0	ND
Lafayette	9/9/2002	Largemouth Bass	NA	3.3	ND	ND	ND	12.0	ND
Lake Chabot	4/24/2001	Channel Catfish	8.6	17.2	3.6	ND	0.4	15	ND
Lake Chabot	4/24/2001	Channel Catfish	27.3	42.3	5.7	1.5	0.6	75	ND
Lake Chabot	4/24/2001	Channel Catfish	15.8	31.1	3.7	ND	0.4	42	ND
Lake Chabot	4/24/2001	Largemouth Bass	ND	ND	ND	ND	ND	ND	ND
Lake Chabot	4/24/2001	Largemouth Bass	ND	ND	ND	ND	ND	ND	ND
Lake Chabot	4/24/2001	Largemouth Bass	1.8	5.6	ND	ND	ND	15	ND
Lake Chabot	6/6/2001	Carp	92.4	166.4	13.7	1.6	1.1	406	ND
Lake Chabot	6/6/2001	Carp	99.9	159.9	13.5	1.8	1.3	354	ND
Lake Chabot	6/6/2001	Carp	58.9	91.6	7.0	ND	0.8	253	ND
Nicasio	9/19/2001	Carp	ND	12.5	ND	ND	ND	10	ND
Nicasio	9/19/2001	Carp	ND	12.6	ND	ND	ND	10	ND
Nicasio	9/19/2001	Carp	ND	7.4	ND	ND	ND	ND	ND
San Pablo	4/17/2000	Carp	101.0	86.2	111.0	4.1	1.1	127	33.5
San Pablo	4/17/2000	Carp	100.7	86.9	95.2	4.1	0.9	121	34.5

Table 4 (continued). Concentrations of detected pesticides and PCBs (ppb wet weight) in fish collected from Regional reservoirs. Shaded values exceed the OEHHA Screening Values.

Reservoir	Sampling Date	Species	Total Chlordanes	Total DDTs	Dieldrin	Heptachlor Epoxide	HCB	Total PCBs	Toxaphene
San Pablo	4/17/2000	Carp	84.0	75.8	62.7	2.7	0.8	105	21.0
San Pablo	4/17/2000	Black Crappie	1.8	3.6	5.3	ND	ND	ND	ND
San Pablo	4/17/2000	Black Crappie	1.7	3.5	5.2	ND	ND	ND	ND
San Pablo	4/17/2000	Black Crappie	1.6	3.0	5.3	ND	ND	ND	ND
San Pablo	4/17/2000	Channel Catfish	82.1	72.0	120.0	4.1	0.8	110	40.4
San Pablo	4/17/2000	Channel Catfish	30.5	27.5	63.1	2.2	0.5	43	ND
San Pablo	4/17/2000	Channel Catfish	148.0	125.8	110.0	4.4	1.1	198	61.1
Shadow Cliffs	8/13/2002	Carp	6.4	38.7	1.1	ND	ND	95.0	ND
Shadow Cliffs	8/13/2002	Channel Catfish	2.1	14.7	1.1	ND	ND	24.0	ND
Soulajule	9/20/2001	Channel Catfish	1.6	19.5	ND	ND	0.5	24	ND
Soulajule	9/20/2001	Channel Catfish	1.6	13.5	ND	ND	0.4	23	ND
Stevens Creek	5/4/2001	Largemouth Bass	14.6	47.2	ND	ND	ND	48	ND
Stevens Creek	5/4/2001	Largemouth Bass	4.5	30.8	ND	ND	ND	59	ND
Stevens Creek	5/4/2001	Largemouth Bass	4.6	29.8	ND	ND	ND	30	ND
Stevens Creek	5/4/2001	Channel Catfish	39.5	100.3	5.2	1.6	0.5	95.0	ND
Stevens Creek	5/4/2001	Channel Catfish	37.4	85.1	5.6	1.2	0.4	74.0	ND
Stevens Creek	6/6/2001	Channel Catfish	31.7	73.5	4.7	1.1	0.3	100.0	ND
Detection limit			none	none	2.0	1.0	0.3	none	20.0
Total detections			27	31	15	9	18	27	5
Percent detections			77%	89%	43%	26%	51%	77%	14%
*OEHHA Screening Value			30	100	2.0	4.0	20	20	30
Total exceedences			9	3	15	4	0	22	4
Percent exceedences in all samples			26%	9%	43%	11%	0%	63%	11%

Shaded values exceed OEHHA Screening Values.
ND = not detected; replaced by 0 for summation calculations. none = no detection limit applicable to summed data
Total Chlordanes includes cis-Chlordane, trans-Chlordane, cis-Nonachlor, trans-Nonachlor, and Oxychlordane
Total DDTs includes o,p- and p,p- homologues of DDD, DDE, DDT Total PCBs includes Aroclors 1248, 1254 and 1260

Figure 7. Mean total PCB concentrations (± sd) in Carp from Regional reservoirs. Line indicates OEHHA PCB Screening Value. * Lafayette values are for goldfish.

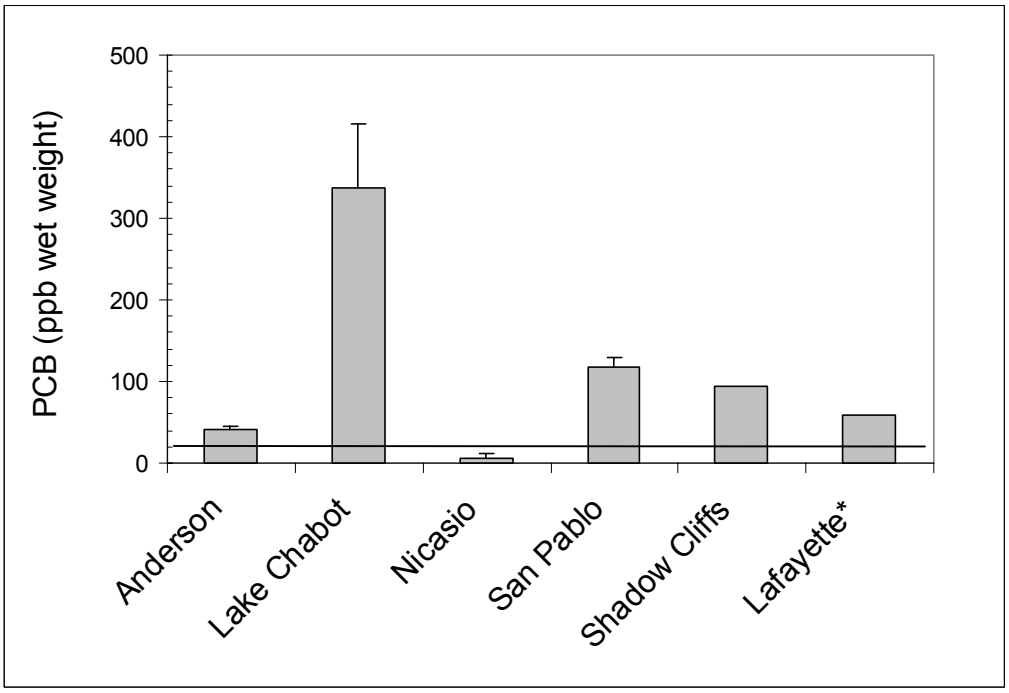


Figure 8. Mean total PCB concentrations (± sd) in Channel Catfish from Regional reservoirs. Line indicates OEHHA PCB Screening Value.

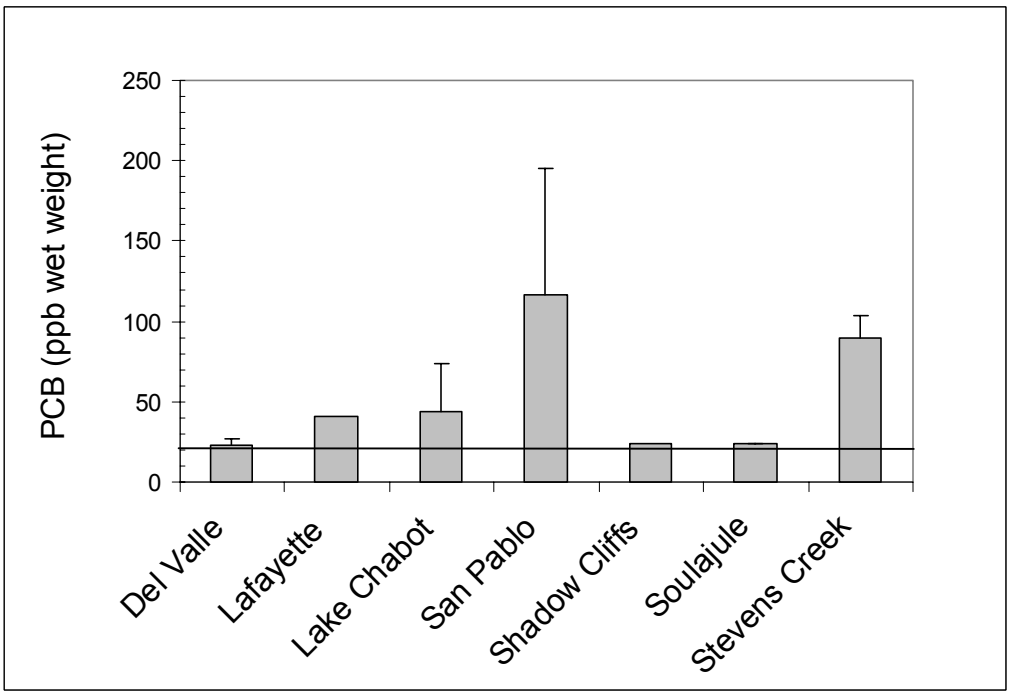


Figure 9. Mean total PCB concentrations (± sd) in Largemouth Bass from Regional reservoirs. Line indicates OEHHA PCB Screening Value.

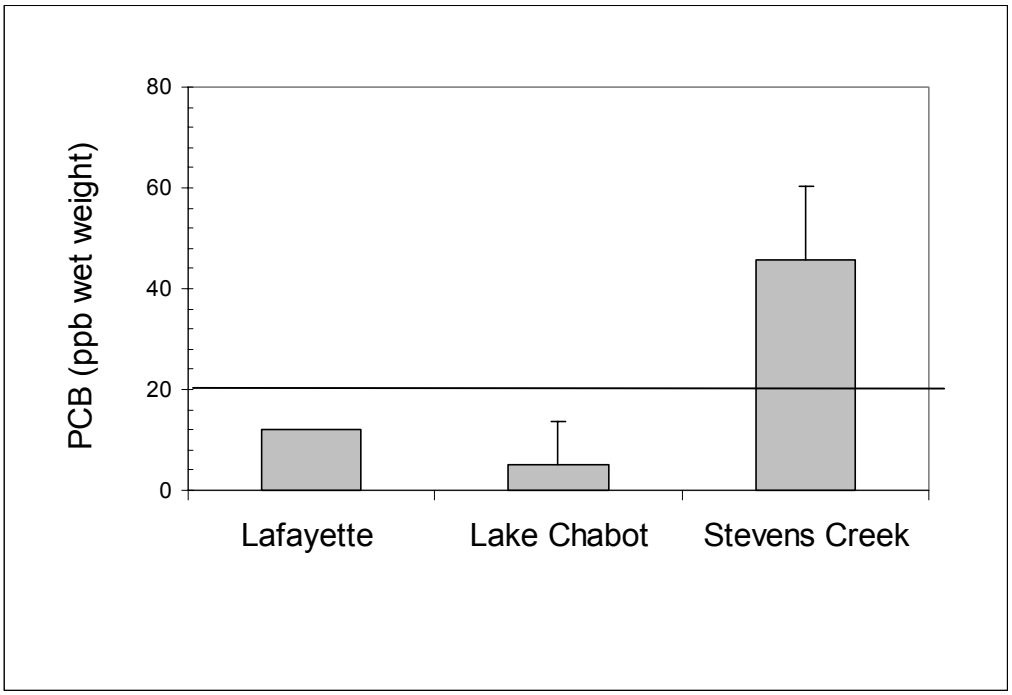


Figure 10. Mean total Dieldrin concentrations (± sd) in Black Crappie from Regional reservoirs. Line indicates OEHHA Dieldrin Screening Value. ND = Not Detected.

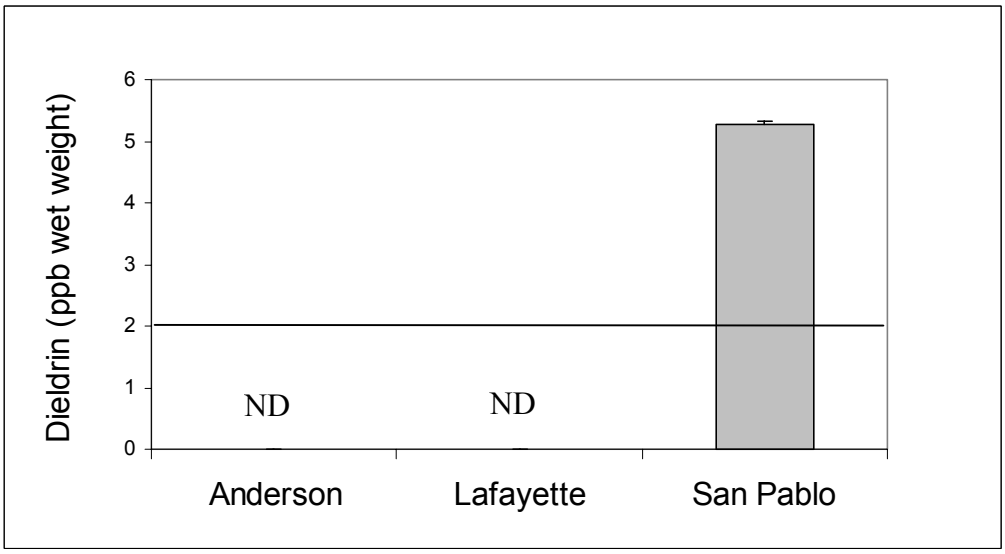


Figure 11. Mean total Dieldrin concentrations (± sd) in Carp from Regional reservoirs. Line indicates OEHHA Dieldrin Screening Value. ND = Not Detected.

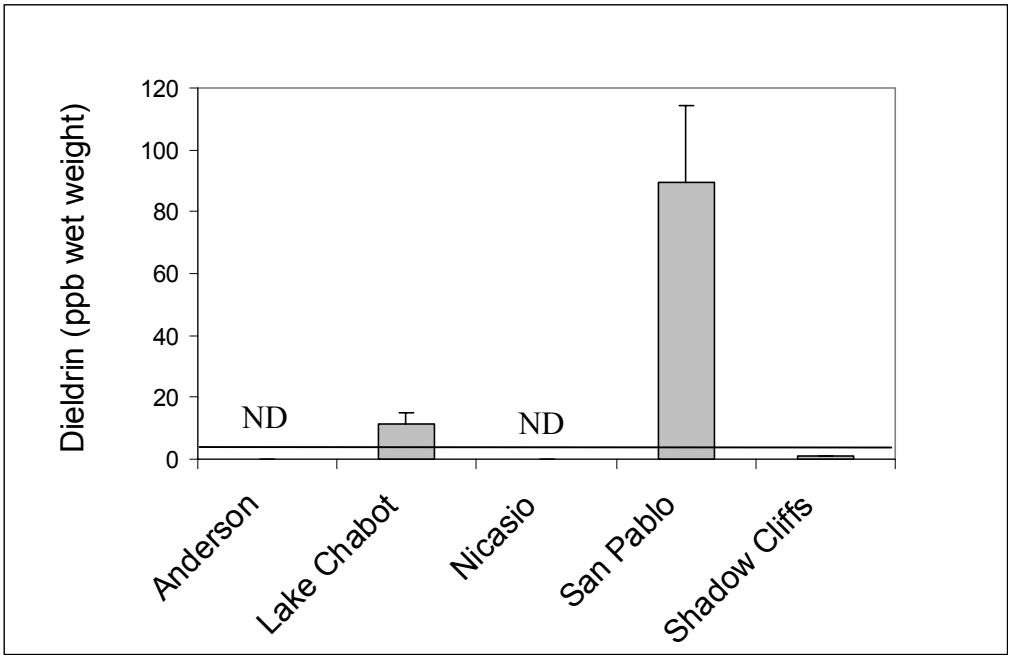
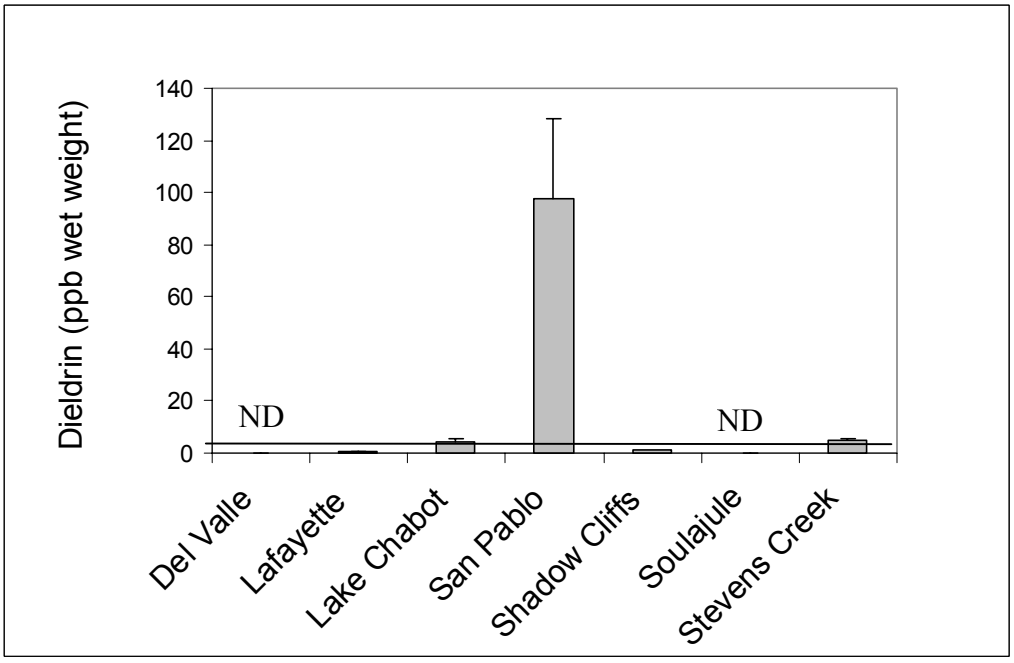


Figure 12. Mean total Dieldrin concentrations (± sd) in Channel Catfish from Regional reservoirs. Line indicates OEHHA Dieldrin Screening Value.



4.3 Tomales Bay

Mercury and arsenic were measured in all samples of fish and shellfish collected from Tomales Bay in 1998, 1999, and 2001. Other trace metals were measured in selected samples during those surveys, and organic chemicals were measured in a subset of samples from 1998 and 1999 (Appendix II).

Concentrations of total mercury were found above the OEHHA screening value (0.3 ppm wet weight) in edible tissues of four elasmobranch fish species: smoothhound shark, leopard shark, Pacific angel shark, and bat rays (Figure 13). Based on a preliminary review of initial data from the 1998 and 1999 Tomales Bay surveys, an interim health advisory was issued by the Marin County Department of Health and Human Services, in consultation with OEHHA, on December 4, 2000 (OEHHA 2004).

Further evaluation of data on Tomales Bay edible fish tissues, including those from the 2001 survey, as well as consideration of representative consumption rates and established reference doses for two distinct human populations, led OEHHA to issue a Health Advisory for fish consumption in Tomales Bay (OEHHA 2004). The Health Advisory can be found in Appendix I, and online at:
http://www.oehha.ca.gov/fish/so_cal/tomales.html (OEHHA 2004).

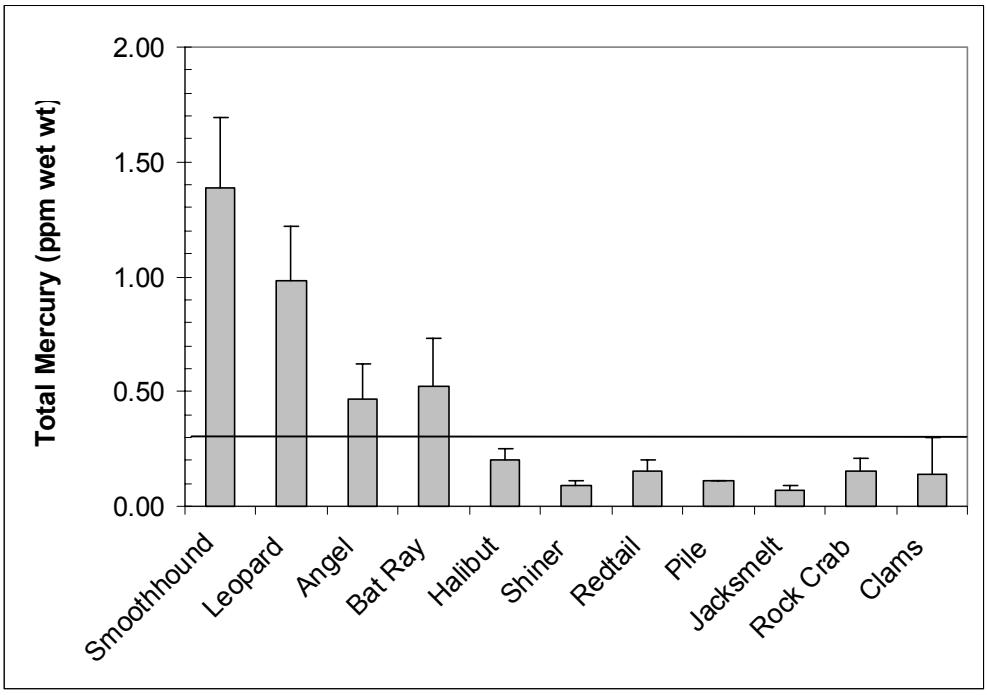
It is important to note that the OEHHA advisory does NOT apply to commercial oysters, clams, or mussels from Tomales Bay. Mercury concentrations have been measured in commercially grown Tomales Bay shellfish, and elevated levels have not been found (OEHHA, 2004).

Trace metals other than mercury were analyzed selectively for different fish species. The analysis of trace elements showed relatively high concentrations of total arsenic in several shark species. However, most of the arsenic in marine fish and shellfish tissues is present in the organic form as arsenobetaine, arsenocholine, and organosugars (Balin *et al.*, 1994), not as inorganic arsenic (the most toxic form). Samples of species exceeding the total arsenic SV were

subsequently analyzed for inorganic arsenic. Inorganic arsenic was not detected in any of the fish samples that exceeded the SV (OEHHA 2004). No other trace metals were measured at concentrations of concern for human health.

PCBs and pesticides analyzed in California halibut and shiner surfperch collected from Tomales Bay in 1999 were all below detection limits (OEHHA 2004), indicating that organic contaminants do not pose a health risk when these species are consumed.

Figure 13. Mean mercury concentrations (± sd) in fish and shellfish species collected from Tomales Bay. Line indicates OEHHA Mercury Screening Value.



4.4 Other Coastal Studies

Mercury was detected in all samples of fish and shellfish collected from the San Mateo Coast in the year 2000. Dungeness crab claw tissue from the Devil's Slide and Pacifica Pier areas, and fish tissues collected from the Pillar Point area (San Mateo Coast), had mercury concentrations above the OEHHA screening value of 0.3 ppm wet weight (Table 5; Figure 14). In total 3 of 11 fish composites had mercury exceedences above the SV. Tissue concentrations of organic compounds were generally low along the coast, with one exceedence of the screening value for total PCBs, in walleye surfperch from the Pacifica Pier. Crab hepatopancreas showed no mercury exceedences. Salmon composites from the San Francisco County coast and the Farallone Islands had no screening value exceedences (Table 5; Figure 14).

Table 5. Concentrations of mercury and PCBs in fish and shellfish collected in coastal studies. Shaded values exceed the OEHHA Screening Values.

Station Name	Species Name	Collection Date	Individuals per Sample	Mercury (ppm) wet weight	Total PCBs (ppb) wet weight
Marin/Farallone	Chinook Salmon	10-May-00	5	0.061	5.0
San Francisco Coast	Chinook Salmon	23-May-00	3	0.052	5.0
Devils Slide	Dungeness Crab-Claw	9-May-00	5	0.398	5.0
Devils Slide	Dungeness Crab - Hep	9-May-00	5	0.234	NA
Pacifica Pier	Dungeness Crab-Claw	18-Apr-00	5	0.429	10.8
Pacifica Pier	Red Rock Crab-Claw	3-May-00	5	0.140	5.0
Pacifica Pier	Dungeness Crab - Hep	18-Apr-00	5	0.141	NA
Pacifica Pier	Red Rock Crab-Hep	3-May-00	5	0.087	NA
Pacifica Pier	Walleye Surfperch	18-Apr-00	7	0.087	25.0
Pacifica Pier	White Surfperch	13-Jun-00	6	0.066	5.0
Princeton Jetty	White Croaker	8-May-00	5	0.261	5.0
Princeton Jetty	Red Rock Crab-Claw	3-May-00	5	0.133	5.0
Princeton Jetty	Pile Surfperch	10-May-00	3	0.121	5.0
Princeton Jetty	Red Rock Crab-Hep	3-May-00	5	0.125	NA
Princeton Jetty	Rainbow Surfperch	11-May-00	9	0.067	5.0
Princeton Jetty	White Surfperch	10-May-00	6	0.056	11.1
San Mateo Coast	Brown Rockfish	23-May-00	4	0.518	5.0
San Mateo Coast	Lingcod	23-May-00	4	0.334	5.0
San Mateo Coast	Rosethorn Rockfish	9-May-00	5	0.301	5.0
San Mateo Coast	Black Rockfish	9-May-00	5	0.064	5.0
San Mateo Coast	Spotfin Surfperch	22-May-00	13	0.038	5.0

Total PCBs is the sum of aroclors 1248, 1254 & 1260;
if none of the 3 aroclors were detected, the value entered was 5.0 (1/2 the lowest MDL).
Hep = hepatopancreas

Figure 14. Map of the San Mateo County coast between the San Francisco County line and the Half Moon Bay City limit. Fish tissues were collected from the four labeled locations. The symbols 'H' and 'P' indicate collection locations where some tissue concentrations exceeded OEHHA screening levels for mercury or total PCBs, respectively.

5 Conclusions

The data described in this report address a key question of the SWAMP program: Is it safe to eat the fish from water bodies in the San Francisco Bay Region? The results indicate that some types of fish in some water bodies must be consumed with caution, following advice available in interim and final health advisories developed by OEHHA in cooperation with county agencies. These results will also be useful for watershed management, Clean Water Act §305(b) reporting, CWA §303(d) listing of impaired water bodies, and development of total maximum daily load (TMDL) allocations to limit pollutants to acceptable levels.

6 References

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APPENDIX I

PUBLIC HEALTH ADVISORY

FOR TOMALES BAY

APPENDIX II

QUALITY CONTROL DATA

FOR ANALYTICAL CHEMISTRY

OF RESERVOIR FISH TISSUE SAMPLES

APPENDIX III

EDIBLE FISH TISSUE

TRACE METAL CHEMISTRY DATA

FOR RESERVOIRS

Database Notes:
The database description is identical to that found in reports by the Toxic Substances Monitoring Program (TSMP), which can be found at: http://www.swrcb.ca.gov/programs/smw/index.html. Negative numbers: -888 indicates the sample was not analyzed. Other negative numbers indicate that the measurement was below the detection limit, with each detection limit being equal to the absolute value of the negative number indicated.

APPENDIX IV

EDIBLE FISH TISSUE

TRACE ORGANIC CHEMISTRY DATA

FOR RESERVOIRS

Database Notes:
The database description is identical to that found in reports by the Toxic Substances Monitoring Program (TSMP), which can be found at: http://www.swrcb.ca.gov/programs/smw/index.html. Negative numbers: -888 indicates the sample was not analyzed. Other negative numbers indicate that the measurement was below the detection limit, with each detection limit being equal to the absolute value of the negative number indicated.

APPENDIX V

EDIBLE FISH AND SHELLFISH TISSUE

TRACE METAL AND ORGANIC CHEMISTRY DATA

FOR THE SAN MATEO COUNTY COAST