HEALTH ADVISORY AND SAFE EATING GUIDELINES FOR SAN FRANCISCO BAY FISH AND SHELLFISH

May 2011

Edmund G. Brown Jr.
Governor
State of California

Linda S. Adams
Acting Secretary for Environmental Protection
California Environmental Protection Agency

George V. Alexeeff, Ph.D.
Acting Director
Office of Environmental Health Hazard Assessment

Health Advisory and Safe Eating Guidelines for San Francisco Bay Fish and Shellfish

May 2011

Margy Gassel, Ph.D.
Robert K. Brodberg, Ph.D.
Susan A. Klasing, Ph.D.
Lizette F. Cook, M.S.

Pesticide and Environmental Toxicology Branch
Office of Environmental Health Hazard Assessment
California Environmental Protection Agency

LIST OF CONTRIBUTORS

Reviewer

Lori Lim, Ph.D.

Final Reviewers

Anna Fan, Ph.D.

David Siegel, Ph.D.

Allan Hirsch

ACKNOWLEDGMENTS

OEHHA would like to acknowledge the San Francisco Bay Regional Monitoring Program (Steering Committee and Advisory Committee), the Surface Water Ambient Monitoring Program, Moss Landing Marine Laboratories, the San Francisco Bay Regional Water Quality Control Board, and the San Francisco Estuary Institute for developing and/or implementing fish and shellfish sampling and analysis. OEHHA would also like to acknowledge the California Department of Public Health, Environmental Health Investigations Branch, for their significant contributions on risk communication, including development of advisory graphics and management of the San Francisco Bay Fish Project.

FOREWORD

This report provides guidelines for consumption of various fish and shellfish species taken from San Francisco Bay waters. This report provides an update of a previous interim state advisory for San Francisco Bay and Richmond Harbor and includes anadromous species that can also be caught in the Delta and the Sacramento and San Joaquin rivers. These guidelines were developed as a result of studies of chemical contaminants in fish and shellfish tested from San Francisco Bay, and for anadromous species, from the Delta and Sacramento and San Joaquin rivers. The guidelines are provided to fish consumers to assist them in making choices about the types of fish and shellfish and frequency of consumption considered safe to eat. Some fish tested from these water bodies showed high contaminant levels, and guidelines are provided to protect against possible adverse health effects from contaminated fish. Additionally, the guidelines provide information to aid consumers in selecting fish and shellfish that are lower in contaminants and higher in beneficial omega-3 fatty acids. This report provides background information and a description of the data and criteria used to develop the guidelines.

For further information, contact:

Pesticide and Environmental Toxicology Branch

Office of Environmental Health Hazard Assessment
California Environmental Protection Agency
1515 Clay Street, 16th Floor
Oakland, California 94612
Telephone: (510) 622-3170

Office of Environmental Health Hazard Assessment
California Environmental Protection Agency
1001 I Street, P.O. Box 4010
Sacramento, CA 95812-4010
Telephone: (916) 327-7319

TABLE OF CONTENTS

EXECUTIVE SUMMARY

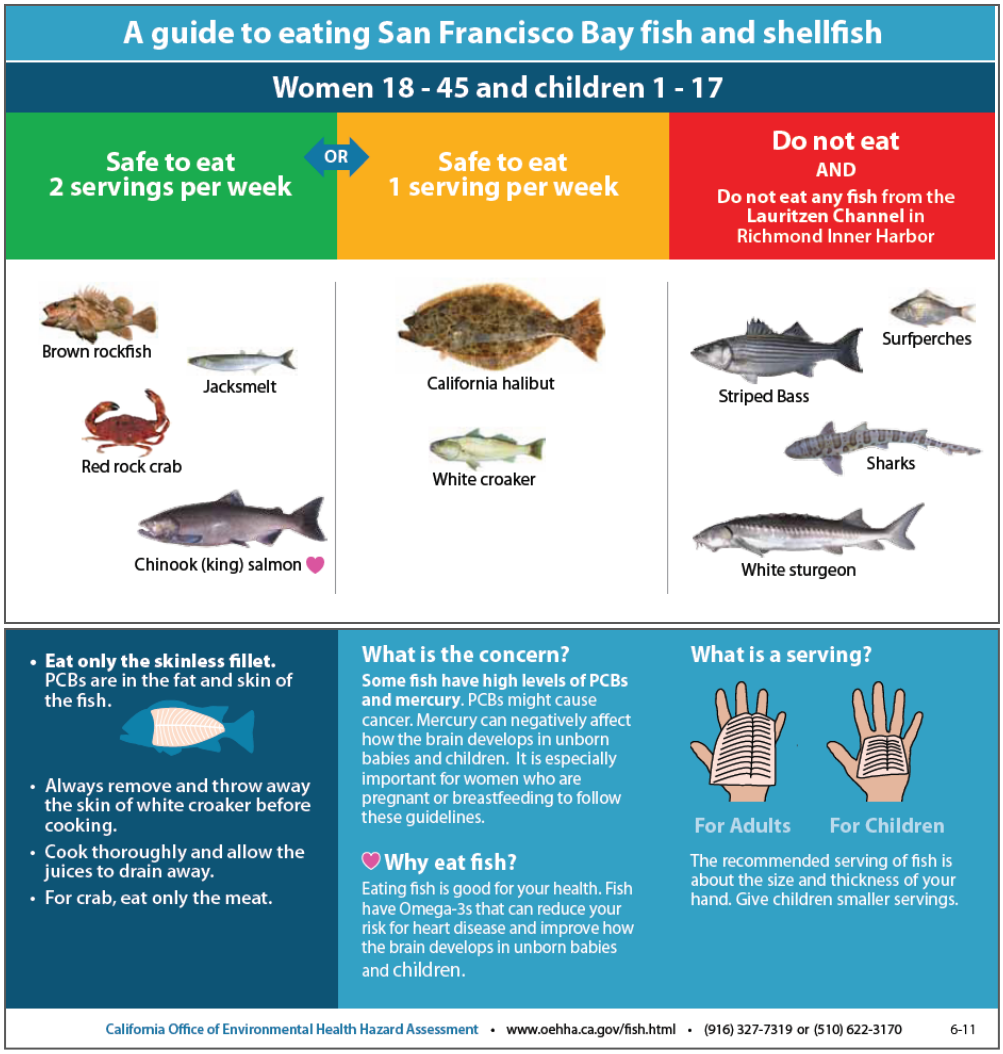
This report presents results and evaluation of studies of chemical contaminants in San Francisco Bay fish and shellfish including anadromous (migratory) species also caught in the Delta, and Sacramento and San Joaquin rivers. The dataset includes samples from 14 fish species and one shellfish species. Fish and shellfish were collected from numerous locations within San Francisco Bay or connected water bodies in one or more of the following years: 1997, 2000, 2003, 2006, and 2009. Fish and shellfish were analyzed for some or all of these contaminants of potential health concern:

- PCBs (polychlorinated biphenyls)
- Pesticides: DDTs (dichlorodiphenyltrichloroethane and its break-down products), dieldrin, and chlordane
- Metals: mercury and selenium
- Flame retardants: PBDEs (polybrominated diphenyl ethers)

The Office of Environmental Health Hazard Assessment (OEHHA) evaluated the data to determine whether consumption of certain sport fish and shellfish from San Francisco Bay could pose health risks to consumers. This effort used new data, improved analytical methods, and a protocol consistent with OEHHA's other recent advisories to update a previous interim state advisory for San Francisco Bay and Richmond Harbor. New data included species previously tested in a pilot study and additional fish and shellfish species. Sufficient numbers of samples were collected to provide consumption advice for brown rockfish, brown smoothhound shark, California halibut, Chinook salmon, jacksmelt, leopard shark, red rock crab, shiner perch, striped bass, white croaker, and white sturgeon. Smaller sample sizes were available for additional surfperch species including barred surfperch, black perch, rubberlip seaperch, and walleye surfperch. All surfperch species were considered together as one species group.

Based on the evaluation, OEHHA developed a health advisory and safe eating guidelines for San Francisco Bay fish and shellfish and fish from the Lauritzen Channel. The advisory recommends against eating certain types of fish high in contaminants. The safe eating guidelines identify fish and shellfish species with low contaminant levels that are safe to eat frequently (once a week or more). The guidelines include certain anadromous fish species that can also be caught in the Delta and the Sacramento and San Joaquin rivers.

Evaluating contaminants in fish and shellfish is OEHHA's primary responsibility. OEHHA's advisories also reflect general scientific agreement that eating fish provides health benefits. These benefits are thought to be the result of omega-3 fatty acids found in fish. The benefits include decreased rates of heart disease and stroke, decreased inflammation, and improvements in brain and visual function. Fish consumption during pregnancy has been associated with higher cognitive scores in young children. The health advisory and safe eating guidelines provide consumers information to make healthy choices in fish and shellfish consumption.



Guidelines for Chinook (king) salmon, striped bass, and white sturgeon apply to these species caught within their migratory range including the ocean, San Francisco Bay, the Delta, and rivers that flow into the Delta.

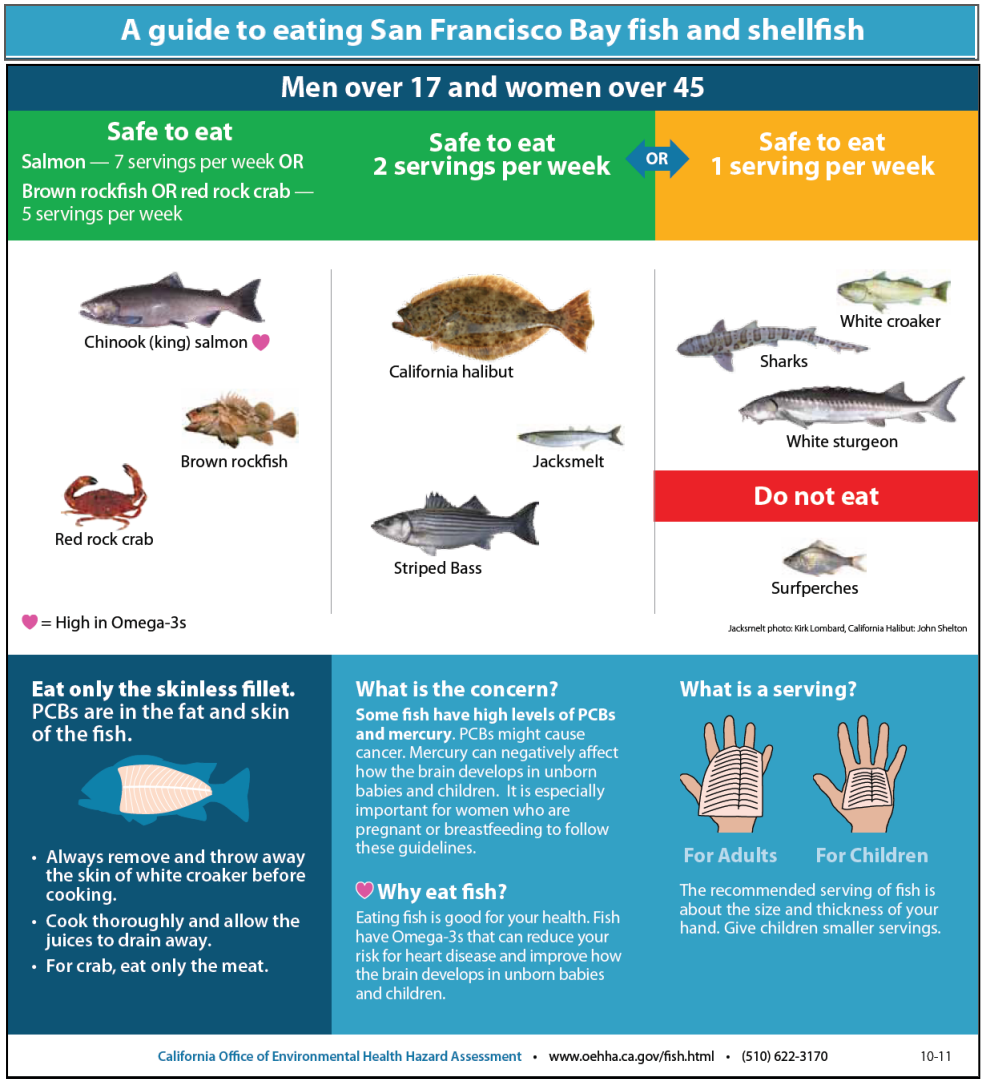
No one should eat any fish from the Lauritzen Channel in Richmond Inner Harbor.

Consumption advice should not be combined. Fish consumers can choose one fish from the "1 serving a week" category to eat that week, or combine two types of fish or shellfish from the "2 servings a week" category in that week. Then they should not eat any other fish from any location until the next week.

For more information, check the following Web sites:

General advice on how to limit your exposure to chemical contaminants in sport fish:
http://www.oehha.ca.gov/fish.html

Guidelines for fish and shellfish from other California water bodies:
http://www.oehha.ca.gov/fish/so_cal/index.html



Guidelines for Chinook (king) salmon, striped bass, and white sturgeon apply to these species caught within their migratory range including the ocean, San Francisco Bay, the Delta, and rivers that flow into the Delta.

No one should eat any fish from the Lauritzen Channel in Richmond Inner Harbor.

Consumption advice should not be combined. Fish consumers can choose one fish from the "1 serving a week" category to eat that week, or combine two types of fish or shellfish from the "2 servings a week" category in that week. Then they should not eat any other fish from any location until the next week.

For more information, check the following Web sites:

General advice on how to limit your exposure to chemical contaminants in sport fish:
http://www.oehha.ca.gov/fish.html

Guidelines for fish and shellfish from other California water bodies:
http://www.oehha.ca.gov/fish/so_cal/index.html

FISH AND SHELLFISH SPECIES IMAGES

(not to scale)

Brown rockfish *Sebastes auriculatus*

Brown smoothhound shark *Mustelus henlei*

California halibut *Paralichthys californicus*

Photo credit: John Shelton

Chinook salmon *Oncorhynchus tshawytscha*

Jacksmelt *Atherinopsis californiensis*

Photo credit: Kirk Lombard

Leopard shark *Triakis semifasciata*

Red rock crab *Cancer productus*

Photo credit: Scott Groth, Oregon Department of Fish and Wildlife

Shiner perch *Cymatogaster aggregata*

Photo credit: Milton Love

Barred surfperch *Amphistichus argenteus*

Photo credit: John Shelton

Black perch *Embiotoca jacksoni*

Photo credit: Kirk Lombard

Rubberlip seaperch *Rhacochilus toxotes*

Photo credit: Milton Love

Walleye surfperch *Hyperprosopon argenteum*

Photo credit: John Shelton

Striped bass *Morone saxatilis*

White croaker *Genyonemus lineatus*

White sturgeon *Acipenser transmontanus*

INTRODUCTION

The San Francisco Bay and Delta region of California forms the largest estuary on the Pacific coast of the United States. It is a shallow, productive estuary that covers up to about 1,600 square miles and drains more than 40 percent of the state, or 60,000 square miles (California Academy of Sciences, 2010). San Francisco Bay consists of three parts: North, Central, and South. The northern part, San Pablo Bay, is connected to Suisun Bay by the Carquinez Strait, which receives water from the Sacramento and San Joaquin Rivers. The water then flows into the central, largest portion, San Francisco Bay itself, and joins the Pacific Ocean by the Golden Gate. Salinity and water circulation patterns in the northern and central portions of the bay are controlled by fresh water from the Sacramento and San Joaquin Rivers. Circulation patterns and salinity of the southern part of the Bay are regulated by a combination of ocean and northern bay waters (California Academy of Sciences, 2010). The entire San Francisco Bay estuary includes San Pablo Bay, Suisun Bay, San Francisco Bay, and five other bays: Honker, Richardson, San Rafael, San Leandro, and Grizzly (BCDC, 2010).

This report and advisory cover San Francisco Bay, including San Pablo Bay, the South Bay, the five other bays named above, and the Carquinez Strait, hereafter simply called "San Francisco Bay." An advisory for Lauritzen Channel (in Richmond Harbor) is also included. The Delta has separate consumption advisories in place for freshwater fish and shellfish species inhabiting that region. Delta fish and shellfish advisories cover the San Joaquin River, Sacramento River, and creeks, sloughs, and other water bodies in the Delta. For more information on Delta advisories, see the following Web pages:

- Central and South Delta (Contra Costa and San Joaquin Counties)
- San Joaquin River from Friant Dam to the Port of Stockton (Fresno, Madera, Merced, Stanislaus, and San Joaquin Counties)
- Sacramento River and Northern Delta

Anadromous species migrate between fresh and marine waters. Advice for these species in this report, striped bass, white sturgeon, and Chinook (king) salmon, therefore applies to these fish caught from San Francisco Bay, the Delta, the Sacramento River, and the San Joaquin River.

The first fish consumption advisory for San Francisco Bay and Delta was issued in 1972 for striped bass due to mercury contamination, by the predecessor entity for the Office of Environmental Health Hazard Assessment (OEHHA), then part of the Department of Health Services. OEHHA updated the striped bass advisory in 1993 and then incorporated it into the San Francisco Bay and Delta 1994 interim fish advisory. OEHHA issued the 1994 interim advisory for multiple chemical contaminants, particularly mercury and polychlorinated biphenyls (PCBs) based on data collected in a pilot study, discussed below. OEHHA developed the updated advisory presented in this report using new data, including additional species, and an advisory development

process consistent with that used in OEHHA's other current advisories. This advisory replaces the previous interim state advisory.

BACKGROUND

This section summarizes the sampling and analysis data for fish and shellfish from San Francisco Bay that OEHHA evaluated and used to develop consumption guidelines.

MONITORING SAN FRANCISCO BAY FISH AND SHELLFISH

PILOT STUDY

In 1994, the San Francisco Bay Regional Water Quality Control Board, as part of the Bay Protection and Toxics Cleanup Program[1], conducted a pilot study to measure levels of chemical contaminants in fish in San Francisco Bay (SFBRWQCB, 1995). A committee of state agency representatives, anglers, and environmental groups planned the pilot study. The study design was expanded to provide information for OEHHA to develop fish consumption advice to protect public health. The California Department of Fish and Game (DFG) collected fish from 13 sampling locations. Locations were chosen to represent all areas of the bay including frequently fished shorelines or piers, potentially contaminated areas, and areas where contamination was expected to be low. The planning committee selected target fish species consisting of fish commonly caught and eaten, and more likely to be contaminated because of their fat content and feeding habits. The 1994 target species were brown smoothhound shark, California halibut, leopard shark, shiner perch, striped bass, walleye surfperch, white croaker, and white sturgeon. The fish samples were tested for over 100 chemicals. Of these chemicals or chemical groups, six were found at levels of potential health concern: mercury; polychlorinated biphenyls (PCBs); dioxins; and the pesticides dichlorodiphenyltrichloroethane and its derivatives (DDTs), dieldrin, and chlordane.

ONGOING MONITORING

Following the pilot study, monitoring of chemicals in fish in San Francisco Bay continued every three years under the purview of the Regional Monitoring Program (RMP). Established in 1993, the RMP consists of a partnership between regulatory agencies and the regulated community in the San Francisco Bay Area. Committees comprised of waste dischargers, industry representatives, regulators, scientists, and community advocates plan and oversee the research in San Francisco Bay. The original purpose of the RMP was to provide ambient water quality data to support management decisions. The program expanded to include long-term water, sediment, and bivalve

[1] California Water Code, Division 7, Chapter 5.6, Bay Protection and Toxic Cleanup (Water Code Sections 13390-13396.5) established a comprehensive program within the State Water Resources Control Board to protect the existing and future beneficial uses of California's enclosed bays and estuaries.

monitoring and sport fish monitoring, among other studies. One of the objectives for the RMP fish contamination monitoring is to produce information needed for conducting human health risk assessments and updating human health advisories.

A Fish Committee Workgroup met prior to each sampling year to plan, and fine-tune, the sampling design. Fish Committee members included representatives from the San Francisco Bay Regional Water Quality Control Board, OEHHA, RMP Stakeholders, DFG, local universities, and San Francisco Estuary Institute (SFEI).

In years 1997, 2000, and 2003, fish sampling followed a status and trends approach. In this design, seven sport fish species (California halibut, jacksmelt, leopard shark, shiner perch, striped bass, white croaker, and white sturgeon) were collected and analyzed for mercury, PCBs, and pesticides (DDTs, chlordane, and dieldrin). Sturgeon samples were also analyzed for selenium.

The status and trends program shifted to a sport fish indicator sampling approach in 2006. Based on results from prior years, two indicator species, white croaker and shiner perch, were chosen to monitor the organochlorine contaminants PCBs, DDTs, chlordane, and dieldrin. Striped bass was chosen as the main mercury indicator species. Brown rockfish, brown smoothhound shark, black perch, Chinook salmon, and walleye surfperch were added to the 2006 target species list as a special study of other species of interest. Two non-target species were also caught: barred surfperch and rubberlip seaperch. The additional target and non-target species caught were analyzed for mercury and PCBs.

In 2009, sampled species included California halibut, jacksmelt, shiner perch, striped bass, white croaker, and white sturgeon. All species were analyzed for pesticides, PCBs, flame retardant polybrominated diphenyl ethers (PBDEs), and selenium. Mercury was analyzed in striped bass and leopard shark as individual fish and in shiner perch, halibut, and jacksmelt as composite samples.

During sampling, several additional species were collected including starry flounder, diamond turbot, Pacific herring, Pacific sardine, and northern anchovy. For these species, either the sample sizes were insufficient for providing representative data on chemical concentrations in the species; the sizes (lengths) of the fish collected were too small to meet minimum legal or “edible” size requirements, or both. For these reasons, these species were not included in this advisory.

In addition to triennial monitoring of San Francisco Bay fish, the RMP conducted occasional special studies. To determine whether consumption of Bay-caught shellfish posed a human health concern, sampling in 1998–1999 included two commonly caught shellfish species: Japanese littleneck clams and red rock crabs. Among the clams used in the composite samples, some (an unknown number) were less than the minimum legal size requirement of 38 mm. For that reason, clams were not included in

this evaluation and advisory. Both muscle tissue and hepatopancreas were analyzed in crabs. Analytes in crabs included mercury and PCBs.

Other Fish Sampling and Analysis

Fish Mercury Project

The Fish Mercury Project (FMP) was a multi-million dollar, three-year effort funded by CALFED (www.calwater.ca.gov). Monitoring of mercury in fish from the Central Valley was planned and conducted in 2005–2007 by a team of scientists and researchers from DFG, OEHHA, the California Department of Public Health (CDPH), the University of California at Davis, and SFEI. Tasks included sport fish monitoring, public outreach activities, and finally, development of consumption advice and educational materials. Members of communities most affected by fish contamination provided input into these efforts throughout the project.

The majority of FMP fish samples were evaluated as part of the advisory process for the Sacramento River, San Joaquin River, and Delta. The anadromous species striped bass and white sturgeon, however, were evaluated for this report and included in the advisory presented here. The current advisories for the Delta, Sacramento and San Joaquin rivers direct consumers to follow the San Francisco Bay advisory for striped bass and white sturgeon. Chinook (king salmon) were included in the Sacramento River and North Delta advisory. Additional data for salmon from San Francisco Bay were used in this evaluation, and this anadromous species is also included in this advisory.

Richmond Harbor

The United Heckathorn Superfund site in Richmond includes five acres of land and about 15 acres of marine sediments in the Lauritzen Channel and Parr Canal of Richmond Harbor (Figure 1). Several companies[2] used the site to formulate, package, and ship pesticides from 1947 through 1966 (U.S. EPA Region 9: Superfund, 2010). Although many pesticides were handled at the facility, DDTs accounted for approximately 95 percent of the operations. State agencies documented leaking solvent pump lines, spills, waste discharges, and dead fish in the Lauritzen Channel during the early 1960s. United Heckathorn went bankrupt in 1966. In 1980, the California Department of Health Services inspected and sampled the site as part of the Abandoned Site Project. Chlorinated pesticides and metals were detected in soil samples. The Levin-Richmond Terminal Corporation, which purchased the site in 1981, currently operates a marine shipping terminal at the location of the former United Heckathorn facility. The area was designated a State Superfund site in March 1982;

[2] Companies included R.J. Prentiss, Heckathorn and Company, United Heckathorn, United Chemetrics, and Chemwest Inc.

U.S. EPA placed the site on the National Priorities List in March 1990 and assumed lead agency status.

Remedial actions took place at the site from 1990 through 1999. They included excavation of heavily contaminated areas, dredging of the Lauritzen Channel and Parr Canal, and construction of a cap over 4½ acres of the site. Post-remediation monitoring, however, found that high levels of pesticides remained in the Lauritzen Channel. The most recent set of fish tissue data were obtained under contract for U.S. EPA in 2008. Using these data, U.S. EPA performed human and ecological health assessments for use in evaluating clean-up alternatives for remaining contamination (CH2MHill, 2008; U.S. EPA Region 9: Superfund, 2010). OEHHA reviewed the 2008 fish tissue data. The dataset included 1) many juvenile fishes, for example, one to three inches in length for anchovy and 11 to 12 inches for halibut—well below legal or edible sizes, 2) fish species not commonly consumed by humans such as bay gobies, and 3) invertebrates also not commonly consumed by humans, such as bay shrimp. In addition, samples were analyzed as whole fish, fillets, or carcasses. OEHHA selected and evaluated data for fish samples that met minimum size requirements (Table 1). These samples (and lengths approximated from reported inches) included 11 jacksmelt (200–300 mm) analyzed as fillet samples, and 12 shiner perch (100–150 mm) analyzed as whole body samples.

OEHHA Fish Consumption Advisories

OEHHA is the agency responsible for evaluating potential public health risks from chemical contamination of sport fish. This includes issuing fish consumption advisories, when appropriate, for the State of California. OEHHA's authorities to conduct these activities are based on mandates in the:

- California Health and Safety Code
  - Section 59009, to protect public health
  - Section 59011, to advise local health authorities
- California Water Code
  - Section 13177.5, to issue health advisories

OEHHA's fish advisories and safe eating guidelines are published in the California Department of Fish and Game Sport Fishing Regulations.

In response to pilot study results, OEHHA issued interim sport fish consumption guidelines in 1994 based on mercury and PCB contamination in bay fish (Appendix I). The 1994 interim advisory recommended:

- Adults eat no more than two meals per month of San Francisco Bay fish and no striped bass over 35 inches
- Women who are pregnant or may become pregnant, or who are breastfeeding, and children under 6 eat no more than one meal per month and, in addition, not eat striped bass over 27 inches or shark

The interim advisory did not apply to salmon, anchovies, herring, and smelt caught in the bay; other sport fish caught in the ocean; or commercial fish. The definitions of the two human populations cited above were updated subsequent to the release of the 1994 interim advisory. OEHHA extended its advice for young children to include children of all ages (up to and including 17 years of age) because evidence has shown that the nervous system continues to develop through adolescence (Klasing and Brodberg, 2008). In response to results from focus groups conducted by the California Department of Public Health (CDPH) on comprehension of advisory messages, OEHHA modified its wording for women of childbearing age (women who are pregnant or may become pregnant, or who are breastfeeding) to "women ages 18–45 years."

The specific advisory for the Richmond Harbor Channel area issued in 1993 remained in place when the 1994 advisory for all of San Francisco Bay was issued. OEHHA recommended that no one eat any croakers, surfperches, bullheads[3], gobies, or shellfish taken within the Richmond Harbor Channel area.

Benefits of Fish Consumption

Although evaluating contaminants in fish is of primary concern, OEHHA has also determined there is general scientific agreement that eating fish provides health benefits, including decreased mortality. The potential beneficial effects are thought to stem largely from specific omega-3 fatty acids found in significant quantities only in fish. These fatty acids are:

- Docosahexaenoic acid or DHA
- Eicosapentaenoic acid or EPA

Reported health benefits include reduced rates of cardiovascular (heart) disease and stroke, decreased inflammation, and improvements in cognitive (brain) and visual function. Fish consumption during pregnancy, in particular, has been associated with higher cognitive scores in young children (Oken et al., 2005; 2008).

The amount of fish consumption recommended to achieve health benefits is readily achievable, but well above national average fish consumption rates. A discussion on the risks and benefits of fish consumption is provided by Klasing and Brodberg (2008). In order to take these benefits into account and best promote the overall health of the

[3] Bullhead is a term commonly used to refer to staghorn sculpin, which people typically use as bait to catch larger fish (K. Hieb, pers. comm., 9/22/10).

fish consumer, OEHHA has expanded the advisory process beyond a simple identification of risks from chemical contaminants. OEHHA now emphasizes "safe eating guidelines" as part of health advisories in an effort to inform consumers of healthy choices in fish consumption in addition to those species that should be avoided or limited. OEHHA encourages people of all ages, especially women of childbearing age (18–45 years, including pregnant and breast feeding women) and children, to select and eat fish that are low in mercury or other contaminants and high in omega-3 fatty acids (DHA and EPA).

SAN FRANCISCO BAY FISH AND SHELLFISH DATA

This section summarizes the results of analysis of chemical concentrations in San Francisco Bay fish and shellfish.

Fish and shellfish were collected from various locations within San Francisco Bay (Figure 2). Table 2 shows sampling locations and years sampled. Striped bass were collected from San Francisco Bay and from freshwater locations that are shown in Figures 3 and 4, respectively, and listed in Table 2. The numbers of fish and shellfish analyzed and evaluated by analyte and by species are presented in Table 3. Fish were generally collected under the RMP in pre-determined target lengths to meet a) legal size requirements for species regulated by DFG, or b) a minimum "edible" size predetermined by OEHHA based on species size at maturity and professional judgment. Table 1 shows the minimum size requirements (and maximum, as applicable) by species. The fish and shellfish collected did not always meet size requirements. OEHHA included data for samples that were within 2% of the required legal size. Because edible sizes are not strict requirements, OEHHA used professional judgment on a case-by-case basis, as explained for relevant species under Data Evaluation.

SAMPLE ANALYSIS

The majority of RMP samples for San Francisco Bay were analyzed as composite samples of skinless fillets. Prior to 2009, shiner perch and jacksmelt were analyzed as whole fish (including skin) excluding heads, tails, and guts (internal organs), and white croaker were analyzed as fillets with skin on. Due to its small size, shiner perch continued to be analyzed as whole fish in 2009, but all other fish species were analyzed as skinless fillets to be consistent with other fish monitoring programs in California. Analysis of skinless fillet samples also provides more consistent and reliable results as skin is not readily homogenized. FMP fish were analyzed as skinless fillet samples.

The organochlorine compounds PCBs, DDTs, chlordane, and dieldrin were analyzed by gas chromatography/mass spectrometry with selective ion monitoring (GC/MS-SIM). The organochlorines were detected by gas chromatography equipped with an electron capture detector according to EPA method 8081AM. PCBs were also detected by gas chromatography, using EPA method 8082M. Mean concentrations of PCBs were calculated as the sum of congeners analyzed, which varied between species and

sampling year. The total number of PCB congeners analyzed ranged between 37 and 51 congeners. Method detection limits (MDLs) for PCB congeners ranged from 0.00012 to 3 ppb, and reporting limits (RLs) were 0.048 to 8.99 ppb. Results of analyses that failed to pass quality control were not included in the summed results for PCB congeners. In 2000, subsets of composite samples of shiner perch, striped bass, and white croaker from one to five locations in the bay, varying by species, were also analyzed for co-planar PCBs by the Hazardous Materials Laboratory (currently the Environmental Chemistry Laboratory at the California Department of Toxics Substances Control). These results, although relatively low, were included with the other PCB congeners when calculating mean values for that year. DDTs were calculated as the sum of *p,p'*-DDT, *o,p'*-DDT, *p,p'*-DDE, *o,p'*-DDE, *p,p'*-DDD, and *o,p'*-DDD. Their MDLs ranged from 0.2 to 0.66 ppb, and RLs were 0.46 to 2 ppb. Total chlordanes consisted of the sum of cis-chlordane, trans-chlordane, cis-nonachlor, trans-nonachlor, and oxychlordane. The MDLs ranged from 0.175 to 1.53 ppb, and RLs were 0.9 to 2 ppb. The MDLs for dieldrin were 0.2 to 0.66 ppb, and RLs were 0.46 to 2 ppb.

PBDEs were determined in 2009 samples using gas chromatography with an electron capture detector or GC/MS/MS. MDLs for PBDEs ranged from 0.95 to 2.65 ppb, and the RLs were 0.484 to 10 ppb. Some PBDE congeners were also analyzed in 2003 and 2006; however, OEHHA chose not to use these data because of quality control concerns about the method and recovery standards used and because the method analyzed only 12 PBDE congeners. The 2009 PBDEs data were generated using a new validated method for PBDEs, included 27 congeners, and also used isotopically labeled internal standards. OEHHA evaluated the 2009 data, which offered the best quality.

The evaluation of organochlorine contaminants included analytical results from 2000 to 2009, because analytical methods, including detection limits, have greatly improved over time and older data are considered less reliable. As indicated above, for the chlorinated compounds, total concentration for each compound (parent and congeners, or metabolites, if applicable) was the sum of detected concentrations. Since the MDLs were relatively low compared to concentrations of concern, samples with concentrations reported as non-detects were assumed to have no residue. This is a standard method of handling non-detects for PCBs and other chemical with multiple congeners (U.S. EPA, 2008).

Fish samples were combusted and analyzed for mercury by DMA (direct mercury analyzer), an integration of thermal decomposition and atomic absorption, on individual or composite samples. In most cases, more than 95% of mercury in fish occurs as the more toxic form methylmercury. A conservative assumption was made that all measured mercury was methylmercury. For ease of communication, the term “mercury” is used in this report to refer to concentrations of the metal measured in fish and shellfish as well as the health effects that result from methylmercury exposure. Mercury MDLs ranged from 0.3 to 38.6 ppb, and RLs were 9 to 36 ppb.

The samples were digested and analyzed for selenium with Inductively Coupled Plasma Mass Spectrometry (ICP/MS). MDLs for selenium ranged from 17 to 150 ppb, and RLs were 16.7 to 400 ppb.

RICHMOND HARBOR FISH DATA

Fish tissue samples were analyzed as whole fish, composites of multiple specimens, fillets, or carcasses by Test America for organochlorine pesticides by EPA Method 8081A and percent lipids and percent moisture using laboratory specific methods (CH2MHill, 2008).

ANALYTICAL RESULTS FROM THE RMP AND FMP

Chemical concentrations are reported in wet weight. Arithmetic means, rather than geometric means, were used to represent the central tendency (average) of chemical concentrations for all species in this report. In general, arithmetic means for environmental chemical exposures are more health-protective than geometric means, and are commonly used in human health risk assessments (Parkhurst, 1998). In addition to chemical concentrations, the RMP reported mean total lengths and/or the ranges of lengths in composite samples. Data for samples that did not include the mean length or the range of lengths were excluded from evaluation because it was not possible to determine whether the fish in these samples met legal or edible size requirements. Much of the data OEHHA received for earlier sampling years, particularly 1994, were missing the needed length data and thus are not included in this report.

DATA EVALUATION

As a first step in interpreting contaminant levels in fish and shellfish, OEHHA has developed advisory tissue levels (ATLs) for PCBs, DDTs, mercury, PBDEs, and other contaminants found in fish (Klasing and Brodberg, 2008; 2011). ATLs are similar to risk-based consumption limits recommended by U.S. EPA (2000). ATLs relate the number and size of recommended fish servings to contaminant concentrations found in fish (Table 4). These values were designed so that individuals consuming no more than a preset number of servings should not exceed:

a) the reference dose (RfD) for non-cancer hazards associated with chemical contaminants, on average, or

b) a risk level of $1x10^{-4}$ for carcinogens (no more than one additional case of cancer for every 10,000 people exposed over a lifetime).

ATLs for mercury for women over 45 years and men are approximately three times higher than for sensitive populations because of the three-fold higher RfD (3×10^{-4} mg/kg-day) used for women over 45 years and men compared to the RfD (1×10^{-4}

mg/kg-day) for sensitive populations, women ages 18–45 years and children 1–17 years. Serving sizes are based on a standard eight-ounce (227 grams) portion of uncooked fish, which is approximately six ounces after cooking, for adults who weigh roughly 70 kilograms (approximately equivalent to 160 pounds). OEHHA recommends that serving sizes be adjusted according to body weight such that people who weigh less than 70 kilograms eat smaller portions of fish. Serving size can be adjusted to add one ounce of fish for every 20 pounds of body weight above, or subtract one ounce of fish for every 20 pounds of body weight below, the average weight of 160 pounds. A description of the process of developing ATLs, including toxicological information on methylmercury and other chemical contaminants can be found in Klasing and Brodberg (2008 and 2011). In this report, OEHHA evaluated those chemical contaminants for which ATLs have been developed.

Because a variety of fish and shellfish species were collected from different locations within a large geographic area, OEHHA evaluated the data in several ways. First, OEHHA calculated grand mean concentrations for each chemical by species. Grand means were calculated as the weighted average of all samples obtained from all sampling locations in the bay in all years for which data were available. Sample sizes were assessed to exclude species with insufficient data. OEHHA compared the grand mean chemical concentrations for each species with adequate sample sizes to ATLs. Concentrations of DDTs, chlordane, dieldrin, PBDEs, and selenium were below levels of concern (see Klasing and Brodberg, 2008; 2011) in all samples analyzed under the RMP. Therefore, this report focuses primarily on mercury and PCBs. Discussion of DDTs and dieldrin is included for samples analyzed from Inner Richmond Harbor. A summary of grand mean concentrations of all chemicals analyzed by species is presented in Table 5. Mean total lengths and the ranges of fish lengths for each species, as available, are shown in Table 6.

OEHHA next compared mean chemical concentrations by geographic location for each species sampled from at least three locations. The mean concentrations by sampling location were also compared to ATLs, and the extent of variation was summarized for each species. Shiner perch, which had a relatively large number of samples across locations and years, reflected the greatest difference in concentrations of PCBs (and corresponding advice) among sampling locations. No consistent patterns in geographic variation were found across species. To avoid complicating communication of advice, consumption recommendations were based on bay-wide grand mean chemical concentrations for each species or, in the case of surfperches, species group.

The most restrictive consumption advice resulting from evaluation of concentrations of mercury and PCBs in each species was used to determine the recommended number of servings for that species. The potential effect of co-exposure to mercury and PCBs was also considered before consumption advice was finalized. For women ages 18–45 years and children 1–17 years, the recommended number of servings was reduced for striped bass and white sturgeon based on the combination of mercury and PCBs in these species.

Results by Species or Species Groups

The following section provides summaries of the data for each species used in the evaluation. The results are also shown in Table 2 (sampling locations and years sampled), Table 3 (sample sizes), Table 5 (analytical results for all chemicals), and Table 6 (length measurements).

Brown Rockfish

Three composite samples of five brown rockfish each were collected in 2003 and 2006 from the Central Bay for a total of six composite samples of 30 fish. Brown rockfish were analyzed as skinless fillet samples for mercury and PCBs. Mean concentrations were 129 ppb mercury and 5 ppb PCBs. The minimum and mean lengths of brown rockfish samples (200 mm and 247 mm, respectively) were less than OEHHA's minimum length determination for this species based on size at maturity (300 mm). The samples, however, are likely to be representative of what is typically caught inside San Francisco Bay and were therefore included in the evaluation.

Brown Smoothhound Shark

Nine brown smoothhound shark were collected in 2003, three each from near Berkeley, the South Bay, and San Pablo Bay. They were analyzed as skinless fillet samples for mercury and analyzed as three composite samples (one per location) for PCBs. Mean concentrations were 677 ppb mercury and 9 ppb PCBs.

California Halibut

Forty-six California halibut were collected in years 1997, 2000, 2003, and 2009 and analyzed for chemicals as skinless fillet samples. Eight individual halibut were analyzed for mercury in 1997, nine individual halibut in 2000, and six individual halibut in 2003; three composite samples of three fish each were analyzed for mercury in 2009. One to three composite samples comprised of two to three of the individual halibut were analyzed for PCBs, DDTs, chlordane, and dieldrin in 2000, 2003, and 2009. Additionally, three composite samples of three halibut each were analyzed for PBDEs in 2009. Mean concentrations for the years sampled were 329 ppb mercury, 18 ppb PCBs, 5 ppb DDTs, 1 ppb chlordane , <1 ppb dieldrin, 2 ppb PBDEs, and 397 ppb selenium.

Chinook (King) Salmon

Five composite samples of three salmon each were collected from San Pablo Bay or Berkeley, two composite samples in 2003 and three composite samples in 2006. The skinless fillet samples were analyzed for mercury and PCBs. Mean concentrations were 78 ppb mercury and 5 ppb PCBs.

Additionally, FMP samples collected in 2005 and 2006 included seven Chinook (king) salmon from the Sacramento River at River Mile 44, and one salmon each from the Sacramento River at Tisdale Boat Ramp and the Merced River at Hatfield State Park. The salmon were analyzed individually for mercury, and the mean concentration was 71 ppb. Under the FMP, five Chinook salmon each were also collected as they returned to each of five hatcheries: Coleman, Feather River, Merced River, Mokelumne River, and Nimbus. The mean mercury concentration for these fish was 99 ppb.

To complete the evaluation of Chinook (king) salmon, OEHHA considered eight salmon collected in 2000 from the San Francisco coast, Marin coast and Farallon Islands and analyzed for mercury under the Coastal Fish Contamination Program[4]. The mean mercury concentration in these salmon was 58 ppb.

The overall mean concentration for all Chinook (king) salmon was 83 ppb mercury.

JACKSMELT

Fifteen composite samples of jacksmelt were collected in 2000 from Berkeley, Oakland, San Francisco Waterfront, San Pablo Bay, and the South Bay (three composite samples per location). Four composite samples of five fish each were collected in 2003 from Berkeley, Oakland Inner Harbor, San Francisco Waterfront, and the South Bay (one composite sample per location). In 2009, four composite samples of five fish each were collected from Oakland, San Francisco Waterfront, San Pablo Bay, and the South Bay (one composite sample per location). Jacksmelt were analyzed as whole body without head, tail, and guts in 2000 and 2003 and as skinless fillet samples in 2009. They were analyzed for mercury, PCBs, DDTs, chlordane, and dieldrin (only one composite was analyzed for dieldrin in 2009) in all three years of sampling, and PBDEs and selenium were also analyzed in 2009. Mean concentrations in whole body samples were 60 ppb mercury, 38 ppb PCBs, 27 ppb DDTs, 3 ppb chlordane, and < 1 ppb dieldrin. Mean concentrations in 2009 fillet samples were 84 ppb mercury, 22 ppb PCBs, 13 ppb DDTs, 2 ppb chlordane, < 1 ppb dieldrin, 2 ppb PBDEs, and 322 ppb selenium.

LEOPARD SHARK

Leopard sharks were collected in 1997, 2000, 2003, and 2009 and analyzed as skinless fillet samples. Mercury was analyzed either in individual sharks or in composite samples of three fish. Analysis of chlorinated hydrocarbon contaminants was performed on composite samples. Leopard sharks were collected mainly from Berkeley, San Pablo Bay, and the South Bay, and occasionally from Oakland and the Central Bay. Mean concentrations were 951 ppb mercury, 827 ppb methylmercury, 14

[4] The Coastal Fish Contamination Program was initiated as a result of legislation in 1998 to develop a comprehensive monitoring program of chemical contamination in sport fish and shellfish in nearshore waters (marine and estuarine) in California. This effort now falls under the Surface Water Ambient Monitoring Program.

ppb PCBs, 5 ppb DDTs, 1 ppb chlordane, and < 1 ppb dieldrin. Mean concentrations of PBDEs and selenium analyzed in 2009 were 5 ppb and 300 ppb, respectively.

Red Rock Crab

In 1999, two composite samples each of red rock crab were collected from each of three locations: Pier 7 (San Francisco Waterfront), Municipal Pier (San Francisco Waterfront), and Fort Baker. Composite samples of muscle tissue were analyzed for mercury and PCBs, and the hepatopancreas from each of the two composite samples per location were combined and analyzed for mercury and PCBs. The mean concentrations for muscle tissue were 133 ppb mercury and 4 ppb PCBs. The mean concentrations for hepatopancreas were 59 ppb mercury and 126 ppb PCBs.

Surfperch Species

Samples from the surfperch family were mostly shiner perch, which has also been the more common surfperch species caught in San Francisco Bay (California Recreational Fisheries Survey, 2005–2010). Smaller numbers of other surfperch species were also collected and are reported here. Chemical concentrations differed between species. Concentrations of PCBs were highest in shiner perch compared to all other surfperch species sampled. Shiner perch were analyzed as whole body samples, however, and the other surfperch species were analyzed as skin-off fillet samples. This difference makes it difficult to compare species, including water column-feeding species (shiner perch and walleye surfperch) with benthic-feeding species (barred surfperch, black perch, and rubberlip seaperch). Mercury concentrations, however, which differ less between skin-on and skin-off samples than do fat-soluble PCBs, were higher in the benthic-feeding surfperch species (271 ppb) compared to the water column-feeding species (104 ppb). Chemical concentrations also show variability among sampling locations. For example, mean concentrations of PCBs in shiner perch were two to four times higher in samples from Oakland, San Leandro Bay, and the South Bay compared to samples from San Pablo Bay and the Central Bay near Berkeley. Because the data set does not include sufficient and comparable samples for surfperch species other than shiner perch, and because of the different methods of sample preparation, it was not feasible to develop location-based advice for all surfperch species. It is also uncertain whether many fishermen distinguish among the large variety of surfperch species. For these reasons, consumption advice was developed for all surfperch species as a group, which is likely to be more health-protective for species other than shiner perch.

Shiner Perch

Eighteen composite samples of shiner perch were collected in 2000. Three composite samples each were collected from the following locations: Berkeley, Oakland, San Francisco Waterfront, San Leandro Bay, San Pablo Bay, and the South Bay. All samples contained 20 fish except for one with 19 fish. Whole body samples without head, tail, and guts were analyzed for PCBs, DDTs, chlordane, and dieldrin in 2000,

2003, 2006, and 2009. In addition, mercury was analyzed in 2000, 2003, and 2009. PBDEs and selenium were analyzed in samples from 2009. Mean concentrations for the years sampled were 103 ppb mercury, 137 ppb PCBs, 28 ppb DDTs, 8 ppb chlordane, 1 ppb dieldrin, 9 ppb PBDEs, and 421 ppb selenium. The minimum length of shiner perch collected (90 mm) was slightly under OEHHA's minimum "edible" size requirement for this species (100 mm). Because OEHHA's minimum "edible" requirement is an estimate of what would be consumed and size at maturity for the species, and shiner perch were typically caught in groups of likely similarly aged individuals, all samples were included in the evaluation.

Barred Surfperch

Two composite samples of three barred surfperch each were analyzed for mercury and PCBs as skinless fillet samples. One composite sample was caught in the South Bay in 2003 and one in the Central Bay in 2006. Mean concentrations of mercury and PCBs were 346 ppb and 21 ppb, respectively.

Black Perch

Three composite samples of five black perch each were collected in the Central Bay in 2003. Six composite samples of three back perch each were collected from the Central Bay in 2006. Composite samples were analyzed as skinless fillet samples for mercury and PCBs. Mean concentrations were 118 ppb mercury and 8 ppb PCBs.

Rubberlip Seaperch

Three composite samples of three rubberlip seaperch each were collected from the Central Bay in 2006 and analyzed as skinless fillet samples for mercury and PCBs. Mean concentrations were 349 ppb mercury and 9 ppb PCBs.

Walleye Surfperch

Two composite samples of five walleye surfperch each were collected in 2003 from the San Francisco Waterfront. Two composite samples of three walleye surfperch each were collected in 2006 from the Central Bay. The skinless fillet samples were analyzed for mercury and PCBs. Mean concentrations were 155 ppb mercury and 59 ppb PCBs.

Striped Bass

The following samples of striped bass collected under the RMP were used in this evaluation. All samples were analyzed as skinless fillet samples. In 1997, striped bass were collected near Berkeley (two composite samples of two and three striped bass, respectively), from San Pablo Bay (two composite samples of three bass each), and from Suisun Bay (one composite sample of three bass). These composite samples were analyzed for mercury. In addition, ten individual striped bass near Davis Point (in

San Pablo Bay) and eight bass from the South Bay were collected and analyzed for mercury. In 2000, 11 striped bass collected near Berkeley, 12 striped bass from San Pablo Bay, and nine striped bass from the South Bay were analyzed as individuals for mercury. Nine of the striped bass from Berkeley, nine from the South Bay, and 12 from San Pablo Bay were composited (three fish per composite sample) for analysis of PCBs, DDTs, chlordane, and dieldrin. In 2003, three individual striped bass collected near Berkeley were analyzed for mercury and then composited for analysis of PCBs, DDTs, chlordane, and dieldrin. Likewise, two striped bass from the San Francisco Waterfront were analyzed for mercury and composited for analysis of PCBs, DDTs, chlordane, and dieldrin. Twelve striped bass from San Pablo Bay were analyzed for mercury and made into four composite samples of three fish each for analysis of PCBs, DDTs, chlordane, and dieldrin. Seven striped bass were collected from the South Bay, analyzed for mercury, and of these, two composite samples of three fish each were analyzed for PCBs, DDTs, chlordane, and dieldrin. In 2006, one striped bass collected from the Central Bay, 14 striped bass from San Pablo Bay, and one striped bass from the South Bay were analyzed for mercury. In 2009, six striped bass from the Central Bay and 12 striped bass from San Pablo Bay were collected and analyzed for mercury. These fish were also made into composite samples of three fish each for analysis of PCBs, DDTs, chlordane, dieldrin, PBDEs, and selenium.

Under the FMP, striped bass from the Delta were collected and analyzed as follows. In 2006, 26 striped bass from Fremont Weir, 12 from Liberty Island, 10 from Old River at Clifton Court Forebay, 11 from the Sacramento River at Knights Landing, two from the Sacramento River Rio Vista Fish Derby, one each from Cache Slough and Cache Slough at Miner Slough[5], two from the Sacramento River near Tisdale Boat Ramp, one from the Sacramento River near Hamilton, and three from Toe Drain were analyzed for mercury. One striped bass from the Sacramento River at Liberty Island, one from Clifton Court Forebay, two from Knights Landing, two from the Rio Vista Fish Derby, and two from Toe Drain were also analyzed for PCBs, DDTs, chlordane, and dieldrin. In 2007, ten striped bass from the Sacramento River at Liberty Island, five from the Lower Mokelumne River, ten from Old River at Clifton Court Forebay, nine from O'Neal Forebay, ten from the Sacramento River at Knights Landing, five from San Luis Reservoir at San Luis Creek, four from Toe Drain, two from Prospect Slough, one from the Sacramento River at Rio Vista, one from the Cosumnes River, and one from Dead Horse Slough were analyzed for mercury. Of these, three striped bass each from the Sacramento River at Knights Landing, Liberty Island, and Clifton Court Forebay were also analyzed for PCBs, DDTs, chlordane, and dieldrin.

Mean concentrations for all striped bass analyzed were 419 ppb mercury, 40 ppb PCBs, 26 ppb DDTs, 2 ppb chlordane, 1 ppb dieldrin, 5 ppb PBDEs, and 462 ppb selenium.

[5] These two Cache Slough locations were reported in the database as "Sacramento River at Cache Slough" and "Sacramento River at Miner Slough," respectively, but the GPS coordinates for them indicate they are located as named here.

In the 1993 striped bass advisory and the 1994 interim advisory, consumption advice for mercury contamination in striped bass was issued according to the size (length) of the fish based on linear regression analysis of the striped bass data from the 1980s (Figure 5a). This analysis showed a significant relationship between mercury concentration (dependent variable) and total length (independent variable) with length accounting for about 47 percent of the mercury variance ($p < 0.001$, $R^2 = 0.4648$). To determine whether size-based advice would be appropriate for the current striped bass data and to identify the size threshold for issuing different consumption recommendations, OEHHA conducted a simple linear regression analysis including data from the sampling years between 1997 and 2009. Because the t-statistic for the slope was significant at the 0.5 critical alpha level [$t(272)=6.01$, $p < 0.001$], OEHHA concluded there is a likely and significant positive relationship between mercury concentration and length. However, length only accounted for about 12 percent of the variability in observed mercury concentrations (Figure 5b). The lengths of striped bass shown in the graphs in Figures 5a and 5b are displayed in inches because the original regression analysis was conducted this way, and DFG regulations for striped bass are also given in inches. All other measurements are in millimeters (mm), the way samples are measured when collected. Because striped bass collected in the 1980s were obtained from freshwater locations (the Sacramento River at Antioch and Clarksburg) and were 530 mm total length or more, OEHHA selected comparable data from the 1990s and 2000s—striped bass from freshwater habitat equal to or greater than 530 mm total length. OEHHA conducted a regression analysis of this subset of the recent data to investigate whether length would be a stronger predictor of mercury concentration when striped bass comparable to those from the 1980s were evaluated. The relationship between mercury concentration and length was not significant ($p = 0.227$, $R^2 = 0.014$).

OEHHA concluded that the results do not support size-based advice for striped bass because the variability of the mercury data reflected in the plot (Figure 5b) is too great to assign advice based on length.

White Croaker

Sixty white croaker were collected in 2009 and analyzed as skinless fillets. Composite samples made of five fish each were collected from Oakland (eight composite samples), the Central Bay (one composite sample), and the South Bay (three composite samples). These samples were analyzed for PCBs, DDTs, chlordane, dieldrin, PBDEs, and selenium; skin-on fillet samples of white croaker were analyzed for mercury. The mean concentrations were 222 ppb mercury, 52 ppb PCBs, 9 ppb DDTs, 2 ppb chlordane, < 1 ppb dieldrin, 4 ppb PBDEs, and 393 ppb selenium.

White Sturgeon

Thirteen white sturgeon collected in 1997, 12 from 2000, seven from 2003, 12 from 2006, and 12 from 2009 were analyzed for selenium as individual skinless fillet samples. Mercury was analyzed in the individual sturgeon samples from 2000 and

2003; PCBs, DDTs, chlordane, and dieldrin were analyzed in four composite samples made from three individual sturgeon each in 2000, and two composite samples of two and three sturgeon from 2003. In 2006, four composite samples of three sturgeon each were analyzed for mercury, PCBs, DDTs, and chlordane, and three of these composite samples were analyzed for dieldrin. In 2009, four composite samples of three sturgeon each were analyzed for PCBs, DDTs, chlordane, dieldrin, and PBDEs. The mean concentrations for the samples analyzed were 347 ppb mercury, 76 ppb PCBs, 30 ppb DDTs, 6 ppb chlordane, 1 ppb dieldrin, 3 ppb PBDEs, and 1,413 ppb selenium[6].

Twelve white sturgeon were collected under the FMP. One sturgeon was collected in 2006 from the Sacramento River at Channel Marker 33. In 2007, three were caught from the Sacramento River at Channel Marker 33, and the other eight were collected as part of the McAvoy Derby from the Sacramento River at Ryer Island, Suisun Bay, Cache Slough, and Honker Bay. The sturgeon were analyzed as individuals for mercury, and the mean concentration was 221 ppb. The overall mean mercury concentration for white sturgeon was 312 ppb.

The Effects of Skinning on PCBs Concentrations in Fish

In 2009, white croaker fillet samples were analyzed both with the skin on and with the skin removed. The mean concentration of PCBs in the samples with skin was 219 ppb, compared to 52 ppb without skin, representing a 76 percent reduction of contaminant. The difference in contaminant levels measured in white croaker with skin intact and skin removed indicates the large contribution to contamination of the fish by the presence of skin, which contains a fatty layer. OEHHA recommends that fish consumers eat only the fillet portions of fish (and skin, trim the fat, and cook them in ways, such as grilling, that allow the juices to drain from the fish) to reduce exposure to lipophilic contaminants such as PCBs. In a geographic area such as San Francisco Bay where PCBs levels are elevated in certain species, such as white croaker, this advice is even more important to follow. OEHHA also recognizes that some people prefer to prepare and eat white croaker (or other species) in different ways such as using the whole body in soups, or with the skin intact. For example, in the San Francisco Bay Seafood Consumption Study (SFEI, 2000), about 26 percent of white croaker consumers reported eating the skin and a similar percentage reporting eating white croaker prepared as soup. These practices varied by ethnicity with a greater percentage of Asians and African Americans than Latinos and Caucasians reporting consumption of the skin (SFEI, 2000). Because exposure to PCBs is likely to be much greater if skin or whole bodies are consumed, OEHHA strongly recommends that consumers either eat the fillet only or do not eat white croaker at all.

Richmond Harbor Data

[6] Although below a level of concern for human health, the mean selenium concentration in sturgeon is higher than in other fish species tested. This is likely due to sturgeon feeding on the invasive and prevalent bivalve *Potamocorbula amurensis*. This clam is an effective bioaccumulator of selenium, which is efficiently transferred and biomagnified in predators (Linville et al., 2002).

Very few of the samples from Richmond Inner Harbor were appropriate for OEHHA to evaluate potential human health exposure due to the small size of most of the fish collected and hence small sample sizes of fish. The few samples OEHHA considered for evaluation were obtained from different parts of Richmond Inner Harbor. Although sample sizes were insufficient, the results suggested that only the samples from the Lauritzen Channel were highly contaminated with dieldrin or DDTs. Three shiner perch had very high concentrations of dieldrin (380 ppb) and DDTs (9,600 ppb). Five jacksmelt had a relatively high level of dieldrin (56 ppb) but a relatively low level of DDTs (194 ppb). Because the concentrations in these few fish from the Lauritzen Channel were exceptionally high in dieldrin or DDTs or both, OEHHA recommends that no one eat fish from the Lauritzen Channel.

The 1994 San Francisco Bay Pilot Study included sampling of shiner perch and brown smoothhound shark in the portion of Richmond Harbor known as “Marina Bay” (Figure 1). The mean concentrations in three composite samples of shiner perch with 20 fish per composite were 1.6 ppb dieldrin and 101 ppb DDTs. The concentrations in one composite sample of three brown smoothhound shark were < 1 ppb dieldrin and 12 ppb DDTs. A comparison of the 1994 fish tissue results with the data obtained by U.S. EPA suggests that extremely high levels of contamination are limited to the inner channels in Richmond Harbor, specifically the Lauritzen Channel, and are not occurring in fish collected in nearby areas such as Marina Bay.

COMPARISON OF INTERIM ADVISORY AND CURRENT UPDATED ADVICE

The 1994 interim advisory for San Francisco Bay issued general advice for all fish species from the bay, excluding salmon, anchovies, herring, and smelt, with specific advice for striped bass and shark. The updated advisory and safe eating guidelines presented in this report were based on evaluation of chemical concentrations for each species with sufficient data, including more species than considered for the interim advisory. The new guidelines also emphasize which species can be eaten safely at recommended frequencies of one to seven servings per week, and indicate species with beneficial levels of omega-3 fatty acids.

GUIDELINES FOR EATING SAN FRANCISCO BAY FISH AND SHELLFISH

OEHHA generally issues consumption advice beginning at a consumption frequency of one eight-ounce serving per week (a total of six ounces of cooked fish per week), which is similar to two 3.5-ounce servings or the minimum weekly fish consumption rate recommended by the American Heart Association (AHA, 2011). Fish that can be eaten at this frequency are those fish species with relatively low levels of mercury, PCBs, DDTs, or other contaminants. If, based on very low contaminant concentrations, fish

can be consumed even more frequently than a total of six ounces (after cooking) per week, advice for consumption of two or three meals per week, or more, as appropriate, may also be provided. ATLs for four, five, six, and seven servings per week can be calculated, as in Klasing and Brodberg (2008), using consumption rates of 128, 160, 192, and 224 grams per day, respectively. In addition, because of the potential beneficial effects from regular fish consumption, thought to stem largely from specific omega-3 fatty acids found in significant quantities only in fish, OEHHA encourages people of all ages, especially women 18–45 years and children, to eat fish that are low in mercury or other contaminants and high in omega-3 fatty acids. OEHHA recommends that consumers avoid regular consumption of fish that cannot safely be eaten at a minimum of one six-ounce serving (after cooking) a week.

Consumption advice should not be combined. Fish consumers can choose one fish from the "1 serving a week" category to eat that week. Then they should not eat any other fish until the next week. If they choose fish that can be eaten two servings a week, for example, they can combine fish species from that group for a total of two servings in that week. Then they should not eat any other fish until the next week.

Recommendations for women 18–45 years, including pregnant and breastfeeding women, and children 1–17 years for eating San Francisco Bay fish and shellfish:

- Eat a total of **two servings a week** of brown rockfish, Chinook (king) salmon, jacksmelt, or red rock crab, OR
- Eat a total of **one serving a week** of California halibut or white croaker
- Do **not eat** brown smoothhound shark, leopard shark or other sharks, shiner perch or other surfperches, striped bass, or white sturgeon

Recommendations for women over 45 years and men for eating San Francisco Bay fish and shellfish:

- Eat a total of **seven servings a week** of Chinook (king) salmon, OR
- Eat a total of **five servings a week** of brown rockfish or red rock crab, OR
- Eat a total of **two servings a week** of jacksmelt, California halibut, or striped bass, OR
- Eat a total of **one serving a week** of brown smoothhound shark, leopard shark, or other sharks, white croaker, or white sturgeon
- **Do not eat** shiner perch or other surfperch species

RECOMMENDATIONS FOR ALL SAN FRANCISCO BAY FISH AND SHELLFISH CONSUMERS:

Note: Guidelines for Chinook (king) salmon, striped bass, and white sturgeon apply to these species caught within their migratory range including the ocean, San Francisco Bay, the Delta, and rivers that flow into the Delta.

Eat only the skinless fillet portion. Skin and trim all visible fat. Thoroughly cook before eating, preferably using a method that allows the juices to drain away. OEHHA also recommends eating only the meat of crabs and avoiding the internal organs.

The recommended serving is about the size and thickness of your hand. Give smaller servings to children. Serving size can be adjusted to add one ounce of fish for every 20 pounds of body weight above, or subtract one ounce of fish for every 20 pounds of body weight below, the average weight of 160 pounds.

Consumption advice should not be combined. Fish consumers can choose one fish from the "1 serving a week" category to eat that week, or combine two types of fish or shellfish from the "2 servings a week" category in that week. Then they should not eat any other fish until the next week.

Because of high concentrations of dieldrin or DDTs or both, OEHHA recommends that no one eat fish from the Lauritzen Channel in Richmond Inner Harbor.

For general advice on how to limit your exposure to chemical contaminants in sport fish (e.g., eating smaller fish of legal size), and a fact sheet on methylmercury and PCBs in sport fish, see the California Sports Fish Consumption Advisories available online at the OEHHA home page (http://www.oehha.ca.gov/fish/chems/index.html). Guidelines for other California water bodies are also posted online (http://www.oehha.ca.gov/fish/so_cal/index.html). Unlike the case for PCBs, various cooking and cleaning techniques will not reduce the methylmercury content of fish. Additionally, there are no known ways to prepare fish (such as soaking in milk) that will reduce the methylmercury content of fish.

REFERENCES

AHA. 2011. American Heart Association. Available at: http://www.americanheart.org/presenter.jhtml?identifier=4632

BCDC. San Francisco Bay Conservation and Development Commission. 2010. Accessed at http://www.bcdc.ca.gov/bay_estuary.shtml

California Academy of Sciences. 2010. Accessed at http://research.calacademy.org/redirect?url=http://researcharchive.calacademy.org/research/izg/SFBay2K/sfbayfacts.htm

California Recreational Fisheries Survey. 2005-2010. http://www.dfg.ca.gov/marine/crfs.asp; Database available at: http://www.dfg.ca.gov/marine/crfs.asp#database or http://data.recfin.org/forms/est2004.html

CH2MHill. 2008. Technical memorandum from Tamara Frank, E2 CH2M HILL, to Sharon Lin, U.S.EPA, October 21, 2008: Summary of Fish Tissue Sampling and Analysis, United Heckathorn Superfund Site, Richmond, California, May–June 2008.

Klasing, S.; Brodberg, R. 2008. Development of Fish Contaminant Goals and Advisory Tissue Levels for Common Contaminants in California sport fish: Chlordane, DDTs, dieldrin, methylmercury, PCBs, selenium, and toxaphene. Office of Environmental Health Hazard Assessment, California Environmental Protection Agency.

Klasing, S.; Brodberg, R. 2011. Development of Fish Contaminant Goals and Advisory Tissue Levels for Common Contaminants in California sport fish: Polybrominated diphenyl ethers (PBDEs). Office of Environmental Health Hazard Assessment, California Environmental Protection Agency.

Linville, R.G.; Luoma, S.N.; Cutter, L.; Cutter, G.A. 2002. Increased selenium threat as a result of invasion of the exotic bivalve *Potamocorbula amurensis* into the San Francisco Bay-Delta. Aquatic Toxicology **57**:51–64.

Oken, E.; Radesky, J.S.; Wright, R.O.; Bellinger, D.C.; Amarasiriwardena, C.J.; Kleinman, K.P.; Howard Hu, H.; Gillman, M.W. 2008. Maternal Fish Intake during Pregnancy, Blood Mercury Levels, and Child Cognition at Age 3 Years in a US Cohort. American Journal of Epidemiology **167**(10):1171-1181.

Oken, E.; Wright, R.O.; Kleinman, K.P.; Bellinger, D.C.; Amarasiriwardena, C.J.; Howard Hu, H.; Rich-Edwards, J.W.; Gillman, M.W. 2005. Maternal Fish Consumption, Hair Mercury, and Infant Cognition in a U.S. Cohort. Environmental Health Perspectives **113**(10):1376-1380.

Parkhurst, D.F. 1998. Arithmetic versus geometric means for environmental concentrations data. Environmental and Science Technology 32(3): 92A-98A.

SFBRWQCB. 1995. Contaminant Levels in Fish Tissue from San Francisco Bay. Final Report, June, 1995. San Francisco Bay Regional Water Quality Control Board; California Department of Fish and Game, Marine Pollution Studies Laboratory; State Water Resources Control Board.

SFEI. 2000. San Francisco Bay Seafood Consumption Study. San Francisco Estuary Institute, Richmond, CA.

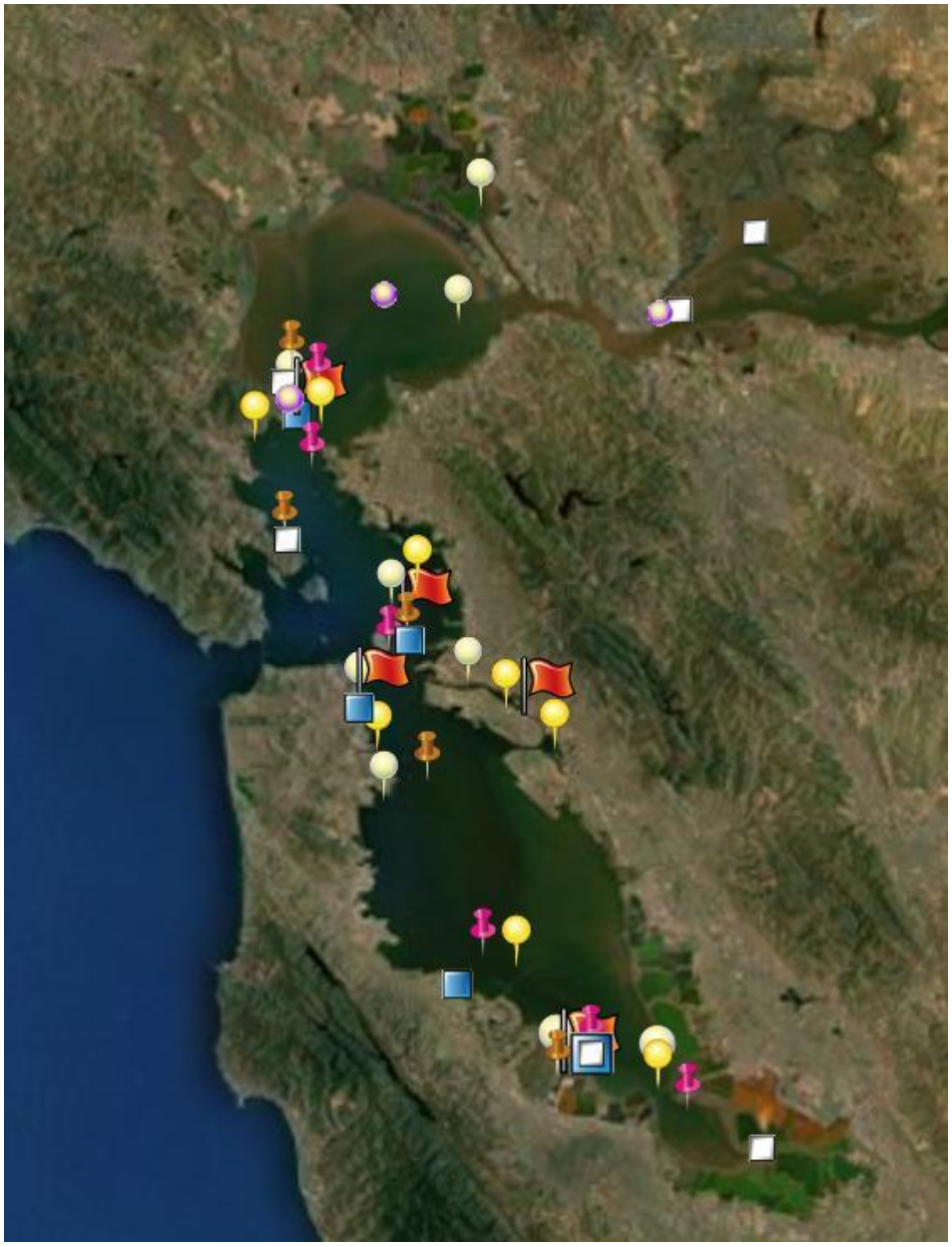
U.S. EPA Region 9: Superfund. 2010. Accessed at: http://yosemite.epa.gov/r9/sfund/r9sfdocw.nsf/84e3d3f74809433788257233007 94f02/809066aa6131970088257007005e9450!OpenDocument

U.S. EPA. 2008. Framework for Application of the Toxicity Equivalence Methodology for Polychlorinated Dioxins, Furans, and Biphenyls in Ecological Risk Assessment. EPA/100/R-08/004, June 2008. Office of the Science Advisor, Risk Assessment Forum, U.S. Environmental Protection Agency, Washington, D.C.

U.S. EPA. 2000. Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories. Vol. 2. Risk Assessment and Fish Consumption Limits. Third Edition. U.S. Environmental Protection Agency, Washington, DC.

FIGURE 1. MAP OF RICHMOND INNER HARBOR AND MARINA BAY

FIGURE 2. MAP OF RMP FISH SAMPLING AREAS

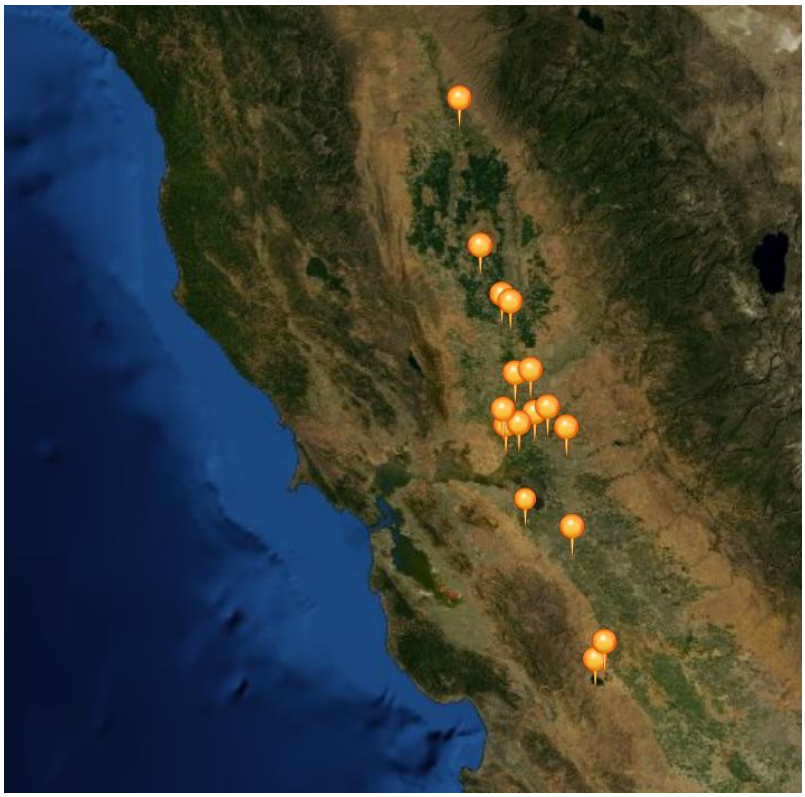


Markers represent different species collected. Blue squares indicate California halibut, and white squares signify white sturgeon. Push pins represent leopard shark (pink) and brown smoothhound shark (brown). Purple balls are Chinook (king) salmon. Jacksmelt are represented by red-orange flags. Yellow balloons show shiner perch and whitish balloons represent white croaker.

Not all sampling sites are shown. Only a few sampling locations are shown for species collected frequently; duplicates or nearby locations were omitted.

FIGURE 3. MAP OF STRIPED BASS SAMPLING AREAS FROM SAN FRANCISCO BAY

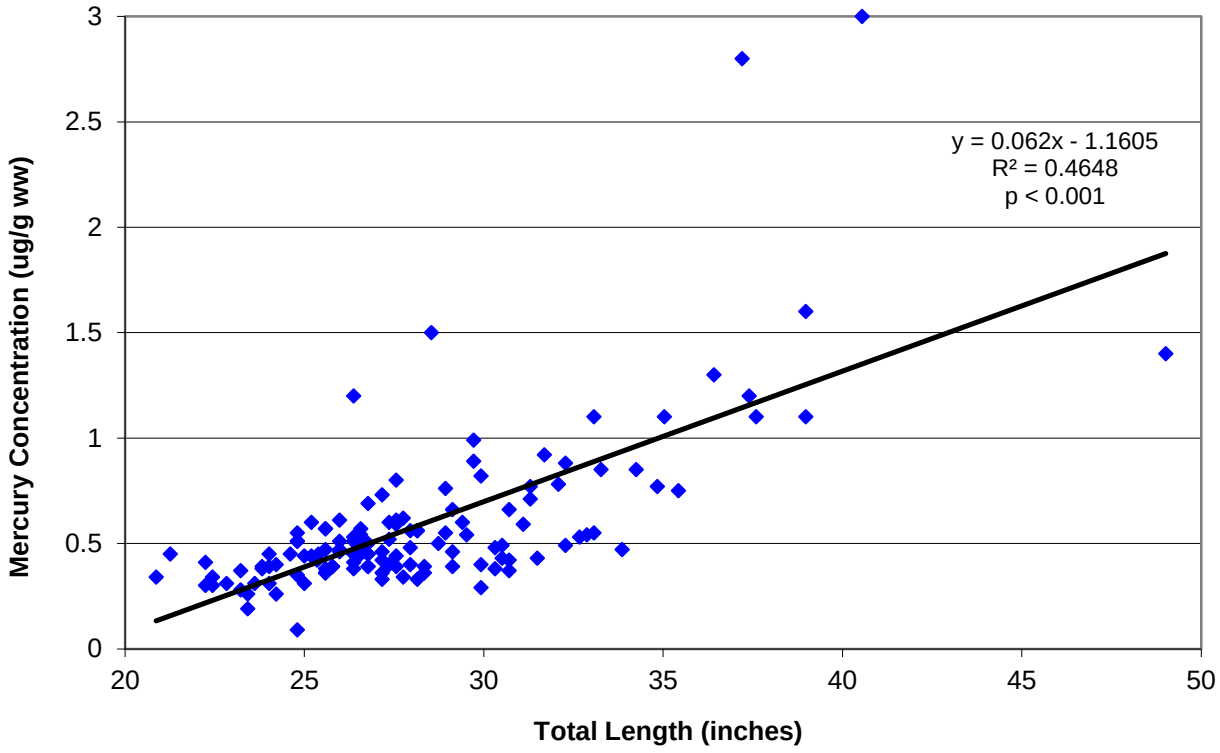
FIGURE 4. MAP OF STRIPED BASS SAMPLING AREAS FROM THE SACRAMENTO RIVER, SAN JOAQUIN RIVER, AND DELTA



Striped bass sampling locations are listed in Table 2. This map reflects areas sampled (generally from north to south) including:

Sacramento River near Hamilton
Sacramento River near Tisdale
Sacramento River near Knights
Fremont Weir
Sacramento River Mile 44
Toe Drain
Cosumnes River Mile 1
Cache Slough
Sacramento River near Rio Vista
Dead Horse Slough
Lower Mokelumne River
Old River at Clifton Court Forebay
San Joaquin River near Vernalis
O'Neal Forebay
San Luis Reservoir at San Luis Creek

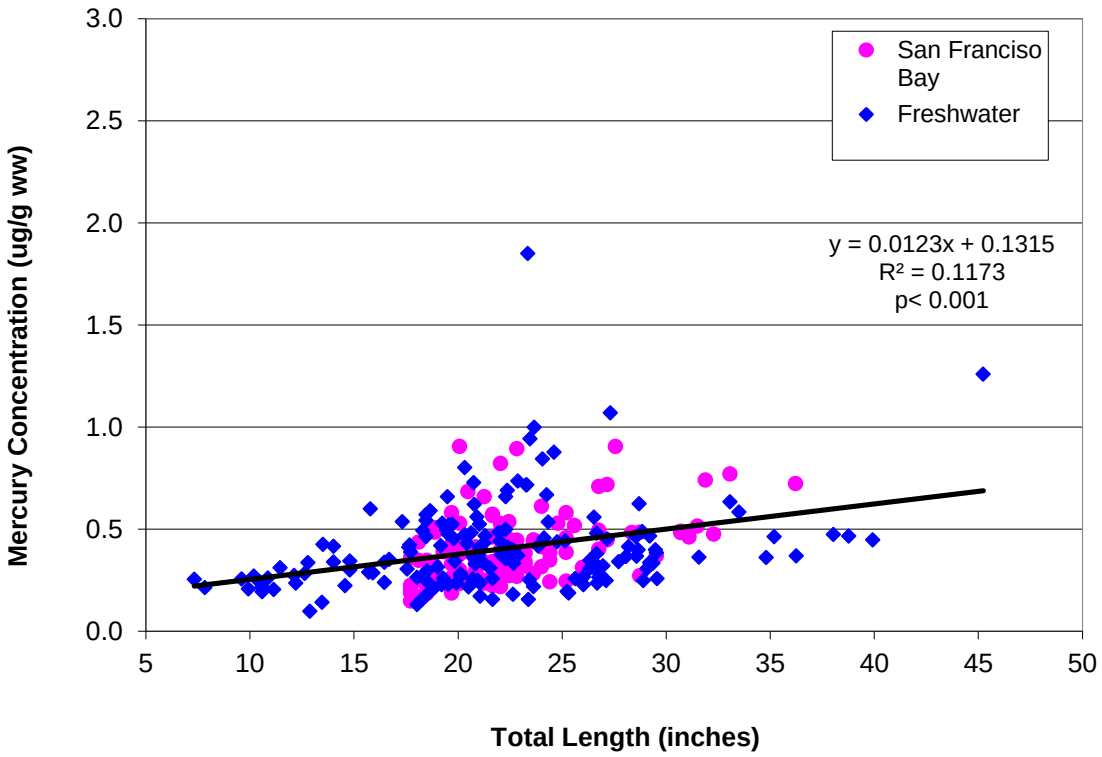
FIGURE 5A. MERCURY AND LENGTH RELATIONSHIP IN STRIPED BASS (1986–1988)



Regression Statistics						
Multiple R	0.682					
R Square	0.465					
Adjusted R Square	0.461					
Standard Error	0.287					
Observations	130					

ANOVA						
	df	*SS*	*MS*	*F*	*Significance F*	
Regression	1	9.152	9.152	111.179	0.000	
Residual	128	10.537	0.082			
Total	129	19.688				
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	-1.160	0.168	-6.920	0.000	-1.492	-0.829
Total Length (Inches)	0.062	0.006	10.544	0.000	0.050	0.074

FIGURE 5B. MERCURY AND LENGTH RELATIONSHIP IN STRIPED BASS (1997–2009)



Regression Statistics						
Multiple R	0.342					
R Square	0.117					
Adjusted R Square	0.114					
Standard Error	0.186					
Observations	274					

ANOVA						
	df	*SS*	*MS*	*F*	*Significance F*	
Regression	1	1.251	1.251	36.146	0.000	
Residual	272	9.414	0.035			
Total	273	10.665				
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	0.132	0.047	2.820	0.005	0.040	0.223
Total Length (Inches)	0.012	0.002	6.012	0.000	0.008	0.016

TABLE 1. MINIMUM (AND MAXIMUM) SIZE REQUIREMENTS BY SPECIES

Species Common Name	Minimum Legal or Edible Size (mm)	Maximum Legal Size (mm)
Barred surfperch	200	
Black perch	150	
Brown rockfish	300	
Brown smoothhound shark	600	
California halibut	**559**	
Chinook (king) salmon	**610**	
Jacksmelt	150	
Leopard shark	**914**	
Red rock crab	**102**	
Rubberlip seaperch*		
Shiner perch	100	
Striped bass	**457**	
Walleye surfperch	114	
White croaker	100	
White sturgeon	**1168**	**1676**

Note: sizes in **bold** are legal requirements per DFG

* No minimum size established; the lengths of the rubberlip seaperch collected were adequately large ($\geq$ 350 mm).

TABLE 2. RMP AND FMP SAMPLING LOCATIONS BY YEAR SAMPLED AND SPECIES

Year	Species Common Name	Station Name
1997	California Halibut	Berkeley
1997	California Halibut	San Pablo Bay
1997	California Halibut	South Bay
1997	Leopard Shark	Berkeley
1997	Leopard Shark	San Pablo Bay
1997	Leopard Shark	South Bay
1997	Striped Bass	Berkeley
1997	Striped Bass	Davis Point
1997	Striped Bass	San Pablo Bay
1997	Striped Bass	South Bay
1997	Striped Bass	Suisun Bay
1997	White Croaker	Berkeley
1997	White Croaker	Oakland
1997	White Croaker	San Francisco Waterfront
1997	White Croaker	San Pablo Bay
1997	White Sturgeon	San Pablo Bay
1997	White Sturgeon	South Bay
1999	Red Rock Crab	Fort Baker
1999	Red Rock Crab	Municipal Pier (SF Waterfront)
1999	Red Rock Crab	Pier 7 (SF Waterfront)
2000	California Halibut	San Francisco Waterfront
2000	California Halibut	San Pablo Bay
2000	Chinook Salmon	Marin coast/Farallon Islands
2000	Chinook Salmon	San Francisco coast
2000	Jacksmelt	Berkeley
2000	Jacksmelt	Oakland
2000	Jacksmelt	San Francisco Waterfront
2000	Jacksmelt	San Pablo Bay
2000	Jacksmelt	South Bay
2000	Leopard Shark	Berkeley
2000	Leopard Shark	San Pablo Bay
2000	Leopard Shark	South Bay
2000	Shiner Perch	Berkeley
2000	Shiner Perch	Oakland

Year	Species Common Name	Station Name
2000	Shiner Perch	San Francisco Waterfront
2000	Shiner Perch	San Leandro Bay
2000	Shiner Perch	San Pablo Bay
2000	Shiner Perch	South Bay
2000	Striped Bass	Berkeley
2000	Striped Bass	San Pablo Bay
2000	Striped Bass	South Bay
2000	White Croaker	Berkeley
2000	White Croaker	Oakland
2000	White Croaker	Oakland
2000	White Croaker	San Francisco Waterfront
2000	White Croaker	San Pablo Bay
2000	White Croaker	South Bay
2000	White Sturgeon	San Pablo Bay
2000	White Sturgeon	South Bay
2003	Barred Surfperch	South Bay
2003	Black Perch	Central Bay
2003	Brown Rockfish	Central Bay
2003	Brown Smoothhound Shark	Berkeley
2003	Brown Smoothhound Shark	San Pablo Bay
2003	Brown Smoothhound Shark	South Bay
2003	California Halibut	Berkeley
2003	California Halibut	San Francisco Waterfront
2003	Chinook Salmon	Berkeley 3/San Pablo Bay
2003	Chinook Salmon	San Pablo Bay
2003	Jacksmelt	Berkeley
2003	Jacksmelt	Oakland Inner Harbor
2003	Jacksmelt	San Francisco Waterfront
2003	Jacksmelt	South Bay
2003	Leopard Shark	Berkeley
2003	Leopard Shark	San Pablo Bay
2003	Leopard Shark	South Bay
2003	Shiner Perch	Berkeley
2003	Shiner Perch	Oakland Inner Harbor
2003	Shiner Perch	San Francisco Waterfront
2003	Shiner Perch	San Pablo Bay
2003	Shiner Perch	South Bay
2003	Striped Bass	Berkeley

Year	Species Common Name	Station Name
2003	Striped Bass	San Francisco Waterfront
2003	Striped Bass	San Pablo Bay
2003	Striped Bass	South Bay
2003	Walleye Surfperch	San Francisco Waterfront
2003	White Croaker	Berkeley
2003	White Croaker	Oakland Inner Harbor
2003	White Croaker	San Francisco Waterfront
2003	White Croaker	San Pablo Bay
2003	White Croaker	South Bay
2003	White Sturgeon	San Pablo Bay
2003	White Sturgeon	South Bay
2005	Chinook Salmon	Coleman Hatchery
2005	Chinook Salmon	Feather River Hatchery
2005	Chinook Salmon	Merced River at Hatfield State Park
2005	Chinook Salmon	Merced River Hatchery
2005	Chinook Salmon	Mokelumne River Hatchery
2005	Chinook Salmon	Nimbus Hatchery
2005	Chinook Salmon	Sacramento River at River Mile 44
2005	Chinook Salmon	Sacramento River at Tisdale Boat Ramp
2005	Striped Bass	Prospect Slough (mid-Prospect)
2005	Striped Bass	Sacramento River @ RM44
2005	Striped Bass	Sacramento River @ RM44
2005	Striped Bass	San Joaquin River @ Vernalis
2006	Barred Surfperch	Central Bay
2006	Black Perch	Central Bay
2006	Brown Rockfish	Central Bay
2006	Chinook Salmon	San Pablo Bay
2006	Rubberlip Seaperch	Central Bay
2006	Shiner Perch	Berkeley
2006	Shiner Perch	Oakland
2006	Shiner Perch	San Francisco Waterfront
2006	Shiner Perch	San Pablo Bay
2006	Shiner Perch	South Bay
2006	Striped Bass	Central Bay
2006	Striped Bass	Cosumnes River at River Mile 1
2006	Striped Bass	Fremont Weir
2006	Striped Bass	Liberty Island
2006	Striped Bass	Old River at Clifton Court Forebay

Year	Species Common Name	Station Name
2006	Striped Bass	Rio Vista Fish Derby
2006	Striped Bass	Sacramento River at Cache Slough
2006	Striped Bass	Sacramento River at Knights Landing
2006	Striped Bass	Sacramento River at Miner Slough
2006	Striped Bass	Sacramento River at Tisdale Boat Ramp AKA River Bend Marina
2006	Striped Bass	Sacramento River Near Hamilton (Scotty's Boat Landing)
2006	Striped Bass	San Pablo Bay
2006	Striped Bass	South Bay
2006	Striped Bass	Toe Drain
2006	Walleye Surfperch	Central Bay
2006	White Croaker	Oakland
2006	White Croaker	San Pablo Bay
2006	White Croaker	South Bay
2006	White Sturgeon	San Pablo Bay
2006	White Sturgeon	Sacramento River at Channel Marker 33
2006	White Sturgeon	South Bay
2007	Striped Bass	Dead Horse Slough
2007	Striped Bass	Liberty Island
2007	Striped Bass	Lower Mokelumne River
2007	Striped Bass	Old River at Clifton Court Forebay
2007	Striped Bass	O'Neal Forebay
2007	Striped Bass	Prospect Slough (mid-Prospect)
2007	Striped Bass	Sacramento River @ Rio Vista
2007	Striped Bass	Sacramento River at Knights Landing
2007	Striped Bass	San Luis Reservoir @ San Luis Creek
2007	Striped Bass	Toe Drain
2007	White Sturgeon	Cache Slough
2007	White Sturgeon	Honker Bay
2007	White Sturgeon	Sacramento River at Channel Marker 33
2007	White Sturgeon	Sacramento River at Ryer Island
2007	White Sturgeon	Suisun Bay
2009	California Halibut	Central Bay
2009	California Halibut	San Francisco Waterfront
2009	California Halibut	San Pablo Bay
2009	Jacksmelt	Oakland
2009	Jacksmelt	San Francisco Waterfront
2009	Jacksmelt	San Pablo Bay
2009	Jacksmelt	South Bay

Year	Species Common Name	Station Name
2009	Leopard Shark	Central Bay
2009	Leopard Shark	San Pablo Bay
2009	Leopard Shark	South Bay
2009	Shiner Perch	Berkeley
2009	Shiner Perch	Oakland
2009	Shiner Perch	San Francisco Waterfront
2009	Shiner Perch	San Pablo Bay
2009	Shiner Perch	South Bay
2009	Striped Bass	Central Bay
2009	Striped Bass	San Pablo Bay
2009	White Croaker	Central Bay
2009	White Croaker	Oakland
2009	White Croaker	South Bay
2009	White Sturgeon	San Pablo Bay
2009	White Sturgeon	South Bay

TABLE 3. NUMBER OF FISH OR SHELLFISH ANALYZED BY SPECIES AND ANALYTE

Species	Mercury	PCBs	DDTs	Chlordane	Dieldrin	PBDEs	Selenium
Barred surfperch	6	6	-	-	-	-	-
Black perch	33	33	-	-	-	-	-
Brown rockfish	30	30	-	-	-	-	-
Brown smoothhound shark	9	9	-	-	-	-	-
California halibut	32	23	23	23	17	9	9
Chinook (king) salmon	57	24	-	-	-	-	-
Jacksmelt (whole body)	95	95	95	95	95	-	-
Jacksmelt (fillet)	20	20	20	20	10	20	20
Leopard shark	76	54	54	54	51	9	9
Red rock crab (muscle)	60	60					
Red rock crab (hepatopancreas)	60	60					
Rubberlip seaperch	9	9	-	-	-	-	
Shiner perch	902	1202	1202	1202	1009	263	263
Striped bass	253	85	85	85	79	18	18
Walleye surfperch	16	16	-	-	-	-	-
White croaker (skin on)	190	279	279	279	264	60	-
White croaker (skin off)	-	60	60	60	55	60	-
White sturgeon	43	43	43	43	40	12	56

TABLE 4. ADVISORY TISSUE LEVELS (ATLS)

Contaminant	Three 8-ounce Servings* a Week	Two 8-ounce Servings* a Week	One 8-ounce Serving* a Week	No Consumption
Methylmercury (Women aged 18-45 years and children aged 1-17 years)	≤70	>70-150	>150-440	>440
Methylmercury (Women over 45 years and men)	≤220	>220-440	>440-1,310	>1,310
PCBs	≤21	>21-42	>42-120	>120
DDTs	≤520	>520-1,000	>1,000-2,100	>2,100
Dieldrin	≤15	>15-23	>23-46	>46
Chlordane	≤190	>190-280	>280-560	>560
Selenium	≤2,500	>2,500-4,900	>4,900-15,000	>15,000
PBDEs	≤100	>100-210	>210-630	>630

ATLs are shown in parts per billion (ppb). For each chemical, ATLs were calculated separately for cancer and non-cancer risk, if appropriate, for consumption frequency categories of one, two, and three 8-ounce servings per week. Values for cancer and non-cancer risk were then compared to determine whether the cancer or non-cancer value was the most health-protective. For methylmercury, PCBs, DDTs, and selenium, consumption advice was based on non-cancer risk.

*Serving sizes are based on an average 160 pound person. Individuals weighing less than 160 pounds should eat proportionately smaller amounts (for example, individuals weighing 80 pounds should eat one 4-ounce serving a week when the table recommends eating one 8-ounce serving a week).

Tabled values are rounded based on laboratory reporting of three significant digits in results, where the third reported digit is uncertain (estimated). Tabled values are rounded to the second digit, which is certain. When data are compared to this table they should also first be rounded to the second significant digit as in this table.

TABLE 5. CHEMICAL CONCENTRATIONS BY SPECIES

All chemical concentrations represent weighted mean values in parts per billion (wet weight)

Species Common Name	Mercury	PCBs	DDTs	Chlordane	Dieldrin	PBDEs	Selenium
All surfperch	112	131	-	-	-		-
Barred surfperch	346	21	-	-	-	-	-
Black perch	118	8	-	-	-	-	-
Brown rockfish	129	5	-	-	-	-	-
Brown smoothhound shark	677	9	-	-	-	-	-
California halibut	329	18	5	1	< 1	2	397
Chinook (king) salmon	83	5	-	-	-	-	-
Jacksmelt (whole body)	60	38	27	3	< 1	-	-
Jacksmelt (fillet)	84	22	13	2	1	2	322
Leopard shark	951	14	5	1	< 1	5	300
Red rock crab (muscle)	133	4	-	-	-	-	-
Red rock crab (hepatopancreas)	59	126	-	-	-	-	-
Rubberlip seaperch	349	9	-	-	-	-	-
Shiner perch	103	137	28	8	1	9	421
Striped bass	419	40	26	2	1	5	462
Walleye surfperch	155	59	-	-	-	-	-
White croaker (skin on)	222	219	56	10	2	11	-
White croaker (skin off)	-	52	9	2	< 1	4	393
White sturgeon	312	76	30	6	1	3	1,413

TABLE 6. SIZE MEASUREMENTS OF SAN FRANCISCO BAY FISH AND SHELLFISH

Species Common Name	Mean Total Length (mm)	Minimum Length (mm)	Maximum Length (mm)
Barred Surfperch	262	180	310
Black Perch	252	200	300
Brown Rockfish	247	200	360
Brown Smoothhound Shark	719		
California Halibut	732		
Chinook (King) Salmon	814	559	1040
Jacksmelt		200	300
Leopard Shark	1041		
Northern Anchovy	90	65	130
Pacific Herring	73	70	80
Pacific Sardine	211	190	220
Red Rock Crab*	117	100	150
Rubberlip Surfperch	378	350	400
Shiner Perch		90	199
Striped Bass		448	1149
Walleye Surfperch	268	170	340
White Croaker		190	340
White Sturgeon	1337		

* Crab size measured by the shortest distance through the body, from edge of shell to edge of shell at the widest part

APPENDIX I: 1994 INTERIM ADVISORY OF SAN FRANCISCO BAY

December 1994

HEALTH ADVISORY ON CATCHING AND EATING FISH
INTERIM SPORT FISH ADVISORY FOR SAN FRANCISCO BAY

The California Environmental Protection Agency's Office of Environmental Health Hazard Assessment (OEHHA) has performed a preliminary review of the data from the 1994 San Francisco Bay pilot study, "Contaminant Levels in Fish Tissue from San Francisco Bay." The results of the study showed elevated levels of chemical contaminants in the fish tissues. Based on these results, OEHHA is issuing an interim consumption advisory covering certain fish species from the bay as follows:

- **Adults should limit their consumption of San Francisco Bay sport fish to, at most, two meals per month.***
- **Adults should not eat any striped bass over 35 inches.**
- **Women who are pregnant or may become pregnant, or who are breast-feeding, and children under 6, should not eat more than one meal per month and, in addition, should not eat any meals of large shark (over 24 inches) or large striped bass (over 27 inches).**
- **This advisory does not apply to salmon, anchovies, herring, and smelt caught in the bay; other ocean caught sport fish; or commercial fish.**

This advisory supersedes the existing advisory on striped bass in the bay, but does not revoke the recent advisory issued for the Richmond Harbor Channel Area.

Individuals who follow these interim guidelines will protect themselves from potential adverse effects caused by the levels of the chemicals found in fish by the study. OEHHA scientists also have the following simple suggestions for catching and eating fish from San Francisco Bay: (1) fish in a variety of locations, (2) eat smaller amounts of several species of fish rather than large amounts of a single species that may have a higher level of contamination, (3) clean and gut fish, eat only the fillet portion, (4) skin and trim fat from fish, (5) bake, broil or steam fish on a rack, and (6) discard the juices from cooked fish.

This interim consumption advice is being issued due to health concerns based on exposure to sport fish from the bay contaminated with methyl mercury, polychlorinated biphenyls (PCBs), dioxins, and pesticides like DDT. The principal effects of concern (from long-term consumption of fish) are possible neurotoxicity to developing fetuses, infants, and small children (e.g., impaired mental and motor development), mainly associated with excessive methyl mercury or PCBs exposure, and potential increased risks for cancer due to exposure to PCBs, dioxins, and pesticides. There is some indication of greater sensitivity of the nervous system in fetuses, infants, and young children. Because of this sensitivity, more restrictive consumption advice is given for young children and pregnant or breast-feeding women who may pass the contamination on to their fetus or child.

Although this advisory is based only on a preliminary review of the data from the study, OEHHA felt it would be prudent to issue interim guidelines at this time. More specific advisories and recommendations will be issued when a thorough evaluation of the study data is completed by OEHHA in conjunction with other public agencies.

More information can be obtained by calling OEHHA at (916) 327-7319 or (510) 622-3170.

Office of Environmental Health Hazard Assessment

1001 I Street, P.O. Box 4010
Sacramento, CA 95812-4010

1515 Clay Street, 16th Floor
Oakland, CA 94612

* A fish meal for a 154-pound (70 kilogram) person is considered to be an 8 oz. portion of fish prior to cooking. Meal size should be adjusted according to body weight, with roughly 1 ounce of fish per 20 pounds body weight. For a 40-pound child, for example, a fish meal would be 2 ounces of fish.