HEALTH ADVISORY AND SAFE EATING GUIDELINES FOR AMERICAN SHAD, CHINOOK (KING) SALMON, STEELHEAD TROUT, STRIPED BASS, AND WHITE STURGEON CAUGHT IN CALIFORNIA RIVERS, ESTUARIES, AND COASTAL WATERS

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Health Advisory and Safe Eating Guidelines for American Shad, Chinook (King) Salmon, Steelhead Trout, Striped Bass, and White Sturgeon Caught in California Rivers, Estuaries, and Coastal Waters

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PREFACE

The Office of Environmental Health Hazard Assessment (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.

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EXECUTIVE SUMMARY

This report provides safe eating guidelines for certain types of fish that live in and swim between rivers, estuaries, and coastal waters in California. The safe eating guidelines were based on findings of mercury or PCBs (polychlorinated biphenyls). The fish species are American shad, Chinook (king) salmon, steelhead trout, striped bass, and white sturgeon. They are called "anadromous species," a term that means fish that swim from the ocean to rivers to spawn. The guidelines do not apply to these same species caught in lakes or reservoirs. The samples evaluated here were caught in one of the following water bodies: the ocean along the San Francisco coast, San Francisco Bay, the Delta, or rivers that flow into the San Francisco Bay/Estuary including the Sacramento, San Joaquin, American, Feather, Cosumnes, and Mokelumne rivers. Fish samples were collected in the following years: 1997, 2000, 2003, 2005, 2006, 2007, and 2009. Some of these fish species were included in previous health advisories and safe eating guidelines issued for one or more of the following locations: San Francisco Bay, the Delta, or the Sacramento, San Joaquin, American, or Feather rivers. The purpose of issuing a separate species-specific advisory is to highlight and clarify the advice for fish species that travel between these water bodies. The advice applies to all of the water bodies where these species are caught, except for lakes and reservoirs.

The Office of Environmental Health Hazard Assessment (OEHHA) evaluates the risks from exposure to contaminants in fish and develops advisories that also reflect general scientific agreement that eating fish promotes significant health benefits. These benefits are believed to be the result of omega-3 fatty acids found in fish. The health benefits include decreased rates of heart disease and stroke, increased anti-inflammatory response, 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 consumption.

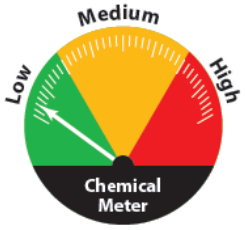
For more general and specific information on OEHHA's fish advisories, check the following Web sites:

> 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

SAFE EATING GUIDELINES

A guide to eating American shad, Chinook (king) salmon, steelhead trout, striped bass, and white sturgeon caught in California rivers, estuaries, and coastal waters

Women ages 18 - 45 and children ages 1 - 17 years old

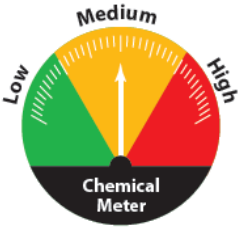


Steelhead Trout* ♥

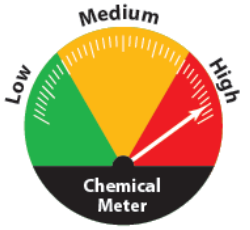
American Shad ♥

Chinook (King) Salmon ♥

♥ = High in Omega-3s



There are no fish with medium levels of chemicals



Striped Bass

White Sturgeon

Safe to eat 2-3 servings per week	Safe to eat 1 serving per week	Do not eat

Men over age 17 and women over age 45 can safely eat more fish

- **Safe to eat 7 servings per week** — American shad, Chinook (king) salmon, or steelhead trout **OR**
- **Safe to eat 2 servings per week** — striped bass **OR**
- **Safe to eat 1 serving per week** — white sturgeon

Why eat fish?

Eating fish is good for your health. Fish have Omega-3s that can reduce your risk for heart disease and improve how the brain develops in unborn babies and children.

What is the concern?

Some fish have high levels of mercury and PCBs. Mercury can negatively affect how the brain develops in unborn babies and children. It is especially important for women who are pregnant or breastfeeding to follow these guidelines. PCBs might cause cancer.

What is a serving?

For Adults For Children

The recommended serving of fish is about the size and thickness of your hand. Give children smaller servings.

These guidelines do not apply to these fish caught in lakes or reservoirs.

* Note: It is only legal to keep hatchery steelhead and only in selected waters. Hatchery steelhead are identified by a missing adipose fin and healed scar in the location of the missing fin. All wild steelhead must be released unharmed.

Check California Department of Fish and Game Regulations (www.dfg.ca.gov/regulations/) for salmon, steelhead, striped bass, and white sturgeon, including legal sizes, bag and possession limits, and seasons, which can vary from year to year.

California Office of Environmental Health Hazard Assessment • www.oehha.ca.gov/fish.html • (916) 327-7319 or (510) 622-3170 1-12

INTRODUCTION

The California Department of Fish and Game (DFG) defines anadromous waters as inland waters that are accessible to fish migrating from the ocean (DFG, 2011, p.10, Section 1.04). Anadromous fish are those that live, or spend time, in the ocean but swim up rivers to spawn in fresh water. Due to this pattern of movement, these species can be caught from many different water bodies and locations. Anadromous species in California include American shad, Chinook (king) salmon, steelhead trout, striped bass, and white sturgeon. These species can be caught from the Pacific Ocean off the California coast, San Francisco Bay, the Delta, or rivers that flow into the San Francisco Bay/estuary including the Sacramento, San Joaquin, American, Feather, Cosumnes, and Mokelumne rivers. These species are also found in streams, creeks, or tributaries to major rivers and in ocean-side lagoons. They may be landlocked in lakes or reservoirs because of stocking programs. OEHHA has observed that several of these species, when landlocked in lakes or reservoirs, had higher levels of chemical contaminants compared to those from free-flowing waters. Thus, the advisory and safe eating guidelines described in this report apply to fish from the five species named above caught from any water bodies *except* lakes or reservoirs. Consumption advice for some of these species has been included previously in safe eating guidelines for other water bodies. The Office of Environmental Health Hazard Assessment (OEHHA) is issuing a separate advisory specifically for these fish species to clarify the advice for fish that travel between multiple water bodies. This advisory was based on all available data for each of these species. OEHHA recommends that consumers of these species follow the updated advice described in this report. The previously issued location-specific advisories have also been updated so the advice is consistent with what is presented here.

SPECIES DISTRIBUTIONS

The following sections provide information on the locations where each species can be found. The descriptions were based on Moyle (2002) unless otherwise indicated.

AMERICAN SHAD

American shad (*Alosa sapidissima*) is a large-sized member of the herring family native to the Atlantic coast. A large number of fry were planted in the Sacramento River between 1871 and 1881, and they became abundant. Currently, they can be found from Todos Santos Bay, Mexico to Cook Inlet, Alaska; a population also spread to Russia. The species spawns in major rivers including the Sacramento and rivers to the north to British Columbia. In the Sacramento River, they reach up to Red Bluff and into tributaries including the American, Feather, and Yuba rivers. Smaller runs also exist in the Mokelumne, Cosumnes, Stanislaus, Klamath, Russian, Eel, and Old Rivers, and in the North Delta. The only known landlocked population is in Millerton Reservoir in Madera County, which is excluded from this advisory.

SALMONIDS: CHINOOK (KING) SALMON AND STEELHEAD TROUT

Members of the salmonid family adapt well to diverse and changing environments as long as the water is cool and well oxygenated. Like other anadromous species, they use fresh water habitats for spawning and use the ocean for feeding. Salmonids have the ability to evolve relatively quickly into genetically distinct local forms, races, and spawning runs (for example, spring or winter runs). Most salmonids in California, however, are in danger of extinction (Moyle, 2002).

DFG operates hatchery programs to rear salmon and trout, including steelhead trout, used to restore and preserve fish in inland water bodies. The fish raised in hatcheries are sometimes planted in reservoirs resulting in landlocked populations. Salmon collected from inland reservoirs have typically accumulated higher levels of mercury or other chemicals (e.g., Gassel et al, 2006; Klasing et al., 2008). This advisory applies to ocean or river-run Chinook (king) salmon and steelhead trout. Salmon and steelhead can be caught from numerous rivers and streams in California.

CHINOOK (KING) SALMON

Chinook (king) salmon (*Oncorhynchus tshawytscha*) are widely distributed in the pelagic (offshore) North Pacific Ocean, usually above 40° north latitude, depending on temperature. Along the California coast, however, they can be found south of Monterey Bay. Although they can be caught off southern California, they spawn in the Central Valley and northward. California is considered the southernmost part of their distribution. Spawning runs occur or occurred in larger coastal streams north of San Francisco Bay to the Oregon border including all major streams draining the Sierra Nevada except as limited by dams. Moyle (2002) describes two basic types of life-history strategies, both of which occur in California, with variations. In stream-type Chinook, adults run upstream before reaching full maturity, in spring or summer, and juveniles remain in fresh water for an extended period, usually more than one year. In ocean-type Chinook, adults spawn soon after entering fresh water, in summer and fall, and juveniles spend a shorter time in fresh water, between 3 and 12 months. There are many variations on the timing and duration of spawning runs, by location and over time.

STEELHEAD TROUT

Steelhead trout (*Oncorhynchus mykiss*) are the anadromous form of native coastal rainbow trout on the west coast, ranging from Baja to Alaska. DFG defines steelhead trout as any rainbow trout over 16 inches in total length found in anadromous waters (DFG, 2011, p.25, Section 5.88). The diversity of forms of trout combined with widespread planting of hatchery-raised trout with mixed origins and hybridization, has contributed to confusion in identification and naming of “species” and local forms. Moyle (2002) names several types of steelhead, by location, as follows: Klamath Mountains Province, Northern California, Central Valley, Central Coast, South/Central Coast, and Southern steelhead. Although he indicates that each form also has a nonmigratory population, the advisory described in this report does not apply to

nonmigratory (landlocked) steelhead. For this advisory, OEHHA included data labeled as rainbow, steelhead, or rainbow steelhead trout, provided the samples were over 16 inches and from anadromous waters.

Striped Bass

Striped bass (*Morone saxatilis*) were first introduced to California in 1879; they were planted in the San Francisco Estuary and subsequently proliferated. The species is native to streams and bays of the Atlantic coast and is tolerant of a wide range of salinity. The main breeding population remains in the San Francisco Estuary, although striped bass have been found in salt water near the Mexican border to southern British Columbia. Some live mostly in either marine or fresh water, but others travel regularly between the two environments. They are abundant in the ocean and estuaries when water temperatures are warmer due to El Niño, and they reach upstream as far as barrier dams on the Sacramento, American, and Yuba rivers. Although some striped bass have survived plantings in reservoirs, such as Millerton Reservoir, the species thrives by using large cool-water pools for spawning and large water bodies, such as San Francisco Bay or the ocean, to feed on small fishes. The estuary is also important for larval and juvenile bass, which feed on invertebrates. While Atlantic populations make long-range migrations in the ocean, California striped bass spend much of their lives in San Francisco and San Pablo bays. Smaller reproducing populations have also been transplanted to the Colorado River.

Striped bass caught from lakes or reservoirs are not included in this advisory.

White Sturgeon

White sturgeon (*Acipenser transmontanus*) can be found from Ensenada, Mexico to the Gulf of Alaska; however, spawning occurs only in rivers from the Sacramento-San Joaquin and northward. The species has been overfished and impacted by pollution, competition, and habitat loss. Currently, self-reproducing populations exist only in the Sacramento River and, to the north, in the Columbia and Fraser rivers. The San Francisco Estuary population spawns mainly in the Sacramento or Feather rivers, or in the San Joaquin River if water flow and quality are adequate. Following construction of dams, some white sturgeon have become landlocked, as in Shasta Reservoir. The species is also cultivated and is sometimes planted in other reservoirs.

This advisory applies only to white sturgeon free to swim between marine and fresh waters.

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. The potential beneficial effects are believed 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, increased anti-inflammatory response, 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. The Dietary Guidelines for Americans (USDA and HHS, 2010) reported that the average intake of seafood in the U.S. is about 3½ ounces per week. These Guidelines recommended increased intake to consume 8 to 12 ounces per week (cooked, edible portion) to obtain at least 250 milligrams per day of DHA and EPA. A discussion on the risks and benefits of fish consumption is provided by Klasing and Brodberg (2008). In order to take the benefits from fish consumption into account and best promote the overall health of the 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).

DATA SOURCES

This section summarizes data sources for American shad, Chinook (king) salmon, steelhead trout, striped bass, and white sturgeon evaluated in this report.

REGIONAL MONITORING PROGRAM FOR SAN FRANCISCO BAY (RMP)

Sampling and analysis of chemical contaminants in a variety of fish species from San Francisco Bay began in 1994 with a pilot study by the San Francisco Bay Regional Water Quality Control Board, as part of the Bay Protection and Toxics Cleanup Program[1] (SFBRWQCB, 1995). DFG collected fish from multiple locations in the bay. Striped bass, white sturgeon, and Chinook (king) salmon were among the species collected in this study. 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 chlordanes.

[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.

Beginning in 1997, monitoring of chemicals in fish from San Francisco Bay continued every three years under 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. 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, bivalve, and sport fish monitoring, among other studies. One of the objectives for the RMP fish contamination monitoring is to produce information for OEHHA to conduct human health risk assessments and update fish consumption advisories.

The species and chemicals analyzed varied between years. Striped bass and white sturgeon were collected and analyzed for mercury, PCBs, and pesticides (DDTs, chlordanes, and dieldrin) in years 1997, 2000, and 2003; sturgeon samples were also analyzed for selenium. In 2006, striped bass were collected and analyzed for mercury. Chinook (king) salmon were added to the target species list in 2006 as a special study of other species of interest and were analyzed for mercury and PCBs. In 2009, striped bass and white sturgeon were analyzed for pesticides, PCBs, flame retardant polybrominated diphenyl ethers (PBDEs), and selenium.

Mercury was analyzed in either individual or composite (multiple fish of similar size within a species) samples. Selenium was analyzed in individual white sturgeon. PCBs and pesticides were usually analyzed in composite samples, occasionally in individual fish, and PBDEs were analyzed in composite samples.

FISH MERCURY PROJECT (FMP)

The Fish Mercury Project (FMP) was a three-year, multi-million dollar effort funded by CALFED (www.calwater.ca.gov). Monitoring of mercury in fish from Central Valley water bodies 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 the San Francisco Estuary Institute (SFEI). Tasks included sport fish monitoring, public outreach activities, and development of consumption advice and educational materials for the Sacramento River, San Joaquin River, and Delta.

OEHHA previously evaluated American shad, Chinook (king) salmon, striped bass, and white sturgeon sampled in the FMP and developed advisories including these species for the Delta, Sacramento River, and San Joaquin River[2]. OEHHA re-evaluated Chinook (king) salmon, striped bass, and white sturgeon for the 2011 San Francisco Bay advisory, including new data from 2009. In addition to those species previously evaluated, the advisory presented in this report also includes steelhead trout collected in 2006 under the FMP. OEHHA has not previously evaluated steelhead trout.

[2] Salmon and shad were included in the Sacramento River and North Delta advisory only. Striped bass and white sturgeon were included in all three advisories: 1) the 2008 Sacramento River and North Delta advisory, 2) the 2010 Central and South Delta advisory, and 3) the 2010 San Joaquin River advisory.

SACRAMENTO RIVER WATERSHED PROGRAM (SRWP)

The Sacramento River Watershed Program was founded in 1996 and certified as a California not-for-profit corporation in 2002 (www.sacriver.org). Its mission is to sustain, restore, and enhance current and potential watershed resources. The SRWP operates through collaborative partnerships and conducts coordinated research and monitoring activities to assess water quality and other indicators of watershed health. SRWP conducted fish tissue sampling from 1998-2003 and analyzed mercury and, in some years, organochlorine compounds in the Sacramento River watershed including the Sacramento, San Joaquin, Feather, and American rivers. This evaluation includes striped bass collected by the SRWP.

TOXIC SUBSTANCE MONITORING PROGRAM (TSMP)

The California State Water Resources Control Board (SWRCB) initiated the Toxic Substances Monitoring Program (TSMP) in 1976. The TSMP was organized to provide a statewide approach to the detection and evaluation of toxic substances in fresh, estuarine, and marine waters through the analysis of fish and other aquatic life. This program was subsumed under the SWRCB's currently operating Surface Water Ambient Monitoring Program (SWAMP). For the advisory described in this report, OEHHA evaluated one composite sample of American shad collected under the TSMP in 2003 and analyzed for mercury.

COASTAL FISH CONTAMINATION PROGRAM (CFCP)

The California legislature established the Coastal Fish Contamination Program (CFCP) in 1998 to develop comprehensive monitoring and assessment of chemical contamination in sport fish and shellfish from California coastal waters. DFG conducted sampling along various portions of the coast over a five-year period. The CFCP was also subsequently incorporated into the state's SWAMP. For the advisory presented in this report, OEHHA evaluated Chinook (king) salmon samples collected in 2000 from the San Francisco coast, Marin coast, and Farallon Islands under the CFCP and analyzed for mercury.

CHEMICAL ANALYSIS

This section describes the analytical methods used to measure and report chemical concentrations in the fish species sampled.

All the species included in this report and advisory were analyzed either as individual or composite samples of skinless fillets. The organochlorine compounds PCBs, DDTs, and chlordanes were analyzed by gas chromatography/tandem mass spectrometry with selective ion monitoring (GC/MS/MS-SIM). The organochlorine dieldrin was detected by gas chromatography equipped with an electron capture detector (GC-ECD)

according to EPA method 8081M. PBDEs were determined in 2009 samples using gas chromatography with tandem mass spectrometry (GC/MS/MS).

Total 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 striped bass 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.

Total DDTs were calculated as the sum of the isomers: *p,p'*-DDT, *o,p'*-DDT, *p,p'*-DDE, *o,p'*-DDE, *p,p'*-DDD, and *o,p'*-DDD. MDLs for DDTs 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. MDLs for chlordanes ranged from 0.175 to 1.53 ppb, and RLs were 0.9 to 2 ppb. MDLs for dieldrin were 0.2 to 0.66 ppb, and RLs were 0.46 to 2 ppb.

Total PBDEs were calculated as the sum of 27 congeners analyzed using a newly validated method for PBDEs in 2009. MDLs for PBDEs ranged from 0.95 to 2.65 ppb, and the RLs were 0.484 to 10 ppb.

OEHHA's evaluation of organochlorine contaminants data (PCBs and pesticides) included analytical results from 2000 to 2009. Data from prior years were excluded because analytical methods, including detection limits, have greatly improved over time and older data are considered less reliable. For PBDEs, OEHHA evaluated the 2009 data, which offered the best quality.

As indicated above, for PCBs, pesticides, and PBDEs, total concentration for each compound was the sum of detected concentrations of parent compounds, congeners, or metabolites, as applicable. 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 classes with multiple congeners (U.S. EPA, 2008).

Fish samples were combusted and analyzed for total 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, the form of health concern. A conservative assumption was made that all measured mercury was methylmercury. For ease of communication, the term "mercury" is often used to refer to concentrations of the metal measured in fish and 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.

Tissue 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.

DATA EVALUATION

This section describes the process OEHHA used to evaluate the data.

ADVISORY TISSUE LEVELS

OEHHA developed advisory tissue levels (ATLs) for PCBs, DDTs, mercury, PBDEs, and other contaminants found in fish as a first step in interpreting contaminant levels in fish and shellfish (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 1). 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).

Serving sizes are based on a standard eight-ounce (227 grams) portion of uncooked fish, which is approximately six ounces after cooking. The standard portion size is for adults who weigh roughly 70 kilograms (approximately equivalent to 160 pounds). OEHHA recommends that serving sizes be adjusted according to body weight.

The developing nervous system in fetuses and children is the most sensitive target from exposure to methylmercury and might be affected by exposure to PCBs in utero. Therefore, sensitive populations are defined as women ages 18–45 years (to protect the fetus) and children 1–17 years. The RfD used for women over 45 years and men (3×10^{-4} mg/kg-day) is three times higher than the RfD for the sensitive population (1×10^{-4} mg/kg-day). As a result, ATLs for mercury for women over 45 years and men are approximately three times higher than for the sensitive population.

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 chemical contaminants for which ATLs have been developed.

SAMPLES

Images of the fish species included in the advisory with their scientific names are shown in Appendix I. Fish were generally collected 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, used when there are no legal size requirements. Table 2 shows the minimum size requirements (and maximum, as applicable) by species. The fish collected did not always meet size requirements. OEHHA evaluated data for samples that were within two percent of the required legal size. The RMP reported mean total lengths for many but not all samples. When it was not possible for OEHHA to verify that the fish in these samples met legal or edible size requirements, the samples were excluded from evaluation. Much of the data OEHHA received for earlier sampling years, particularly 1994, were missing the needed length data and thus are not included in the evaluation. Data from the TSMP and CFCP included mean total lengths or fork lengths, which were converted to total lengths based on conversion factors OEHHA developed considering the relative degree of fork in the tail. FMP samples were all analyzed as individuals, and lengths were reported for all samples.

As stated previously, fish were collected from various locations including the San Francisco coast, Marin coast, Farallon Islands, San Francisco Bay, the Delta, and the Sacramento, San Joaquin, American, Feather, Cosumnes, and Mokelumne rivers (Figure 1). Table 3 lists sampling locations and years sampled by species.

CALCULATING CHEMICAL CONCENTRATIONS

Because the fish species described in this report can be caught in many different places including rivers, estuaries, and coastal waters in California, OEHHA determined the mean (average) concentrations for each chemical in each species from all sampling locations combined. Mean concentrations were calculated as the weighted average of all samples in all years for which data were available. A summary of mean concentrations of chemicals analyzed by species is presented in Table 4. The numbers of fish analyzed and evaluated by analyte and by species are also presented in Table 4. 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). Table 5 shows mean total lengths and the ranges of fish lengths for each species, as available.

OEHHA compared the mean chemical concentrations for each species to ATLs. Concentrations of DDTs, chlordanes, dieldrin, PBDEs, and selenium were below levels of concern (see Klasing and Brodberg, 2008; 2011) in all samples. Therefore, this report and advisory is based only on mercury and PCBs.

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 for the sensitive population 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 included in the evaluation. The results are also shown in Table 3 (sampling locations and years sampled), Table 4 (analytical results for all chemicals and the number of samples analyzed), and Table 5 (length measurements).

American Shad

One composite sample of five shad was collected under the TSMP in 2003 and analyzed for mercury. Fifty American shad were collected from various locations in the Delta, the Feather River, and the Sacramento River in 2006 under the FMP and analyzed as individuals for mercury. The mean mercury concentration for American shad was 61 ppb.

Chinook (King) Salmon

In 2000, the Coastal Fish Contamination Program collected eight Chinook salmon from the Marin coast and Farallon Islands. They were analyzed as two composite samples for mercury, DDTs, and PCBs as Aroclors. The sum of DDTs was below a level of concern and the Aroclors were below the reporting limits.

In 2002, one composite sample of three Chinook (king) salmon was collected from the Sacramento River under the TSMP.

The RMP collected two composite samples and three composite samples of three salmon each in 2003 and 2006, respectively, from San Francisco Bay. The samples were analyzed for mercury and PCBs.

FMP samples collected in 2005 and 2006 included nine salmon from the Sacramento River and Merced River. Additionally, five salmon each were collected as they returned to each of five hatcheries: Coleman, Feather River, Merced River, Mokelumne River, and Nimbus. The samples were analyzed individually for mercury.

The overall mean concentration for all Chinook (king) salmon samples was 82 ppb mercury, and the mean concentration of PCBs (as congeners) from the RMP samples was 5 ppb.

STEELHEAD TROUT

The data for steelhead trout include one collected in 2005 from the Sacramento River by the SRWP. Under the FMP, steelhead trout were collected in 2006 as they returned to hatcheries: six from the Feather River, six from the Mokelumne River, and 12 from the Nimbus Hatchery. All steelhead samples were analyzed individually for mercury. The mean mercury concentration was 81 ppb.

STRIPED BASS

The following samples of striped bass collected from San Francisco Bay under the RMP were used in this evaluation.

In 1997, five composite samples of striped bass were collected and analyzed for mercury. In addition, 18 individual striped bass from San Francisco Bay were analyzed for mercury.

In 2000, 32 striped bass were analyzed as individuals for mercury. Ten composite samples were made from these samples for analysis of PCBs, DDTs, chlordanes, and dieldrin.

In 2003, 24 individual striped bass were collected and analyzed for mercury. The samples were also used to make eight composite samples for analysis of PCBs, DDTs, chlordanes, and dieldrin.

In 2006, 16 striped bass were collected and analyzed individually for mercury. In 2009, 18 striped bass were collected and analyzed for mercury. The 2009 striped bass were also made into six composite samples for analysis of PCBs, DDTs, chlordanes, dieldrin, PBDEs, and selenium.

The TSMP collected two striped bass from Hill Slough (which flows into Suisun Bay) in 1997 that were analyzed for mercury.

The FMP collected 70 individual striped bass from throughout the Delta including Fremont Weir, Liberty Island, Old River at Clifton Court Forebay, the Sacramento River and the Cosumnes River in 2006. The samples were analyzed as individuals for mercury. Of these samples, eight striped bass were also analyzed as individuals for PCBs, DDTs, chlordanes, and dieldrin.

In 2007, the FMP collected 43 striped bass from the Sacramento River and Delta that were analyzed individually for mercury. Of these, nine striped bass were also analyzed as individuals for PCBs, DDTs, chlordanes, and dieldrin.

Mean concentrations for all striped bass samples were 443 ppb mercury, 40 ppb PCBs, 25 ppb DDTs, 2 ppb chlordanes, 2 ppb dieldrin, 5 ppb PBDEs, and 462 ppb selenium.

WHITE STURGEON

The RMP collected white sturgeon from San Francisco Bay. Two sturgeon collected in 1997 were composited and analyzed for mercury. In 2000, mercury was analyzed in 12 individual sturgeon samples, and four composite samples were made and analyzed for PCBs, DDTs, chlordanes, and dieldrin. In 2003, seven sturgeon were analyzed as individuals for mercury and two composite samples were formed and analyzed for PCBs, DDTs, chlordanes, and dieldrin. In sturgeon samples from 2006, four composite samples were analyzed for mercury, PCBs, DDTs, and chlordanes, and three of these composite samples were analyzed for dieldrin. In 2009, four composite samples of sturgeon were analyzed for PCBs, DDTs, chlordanes, dieldrin, and PBDEs.

Selenium was analyzed in individual white sturgeon samples: 13 from 1997, 12 from 2000, 7 from 2003, 12 from 2006, and 12 from 2009.

The FMP collected 12 white sturgeon in 2006 and 2007 (including eight collected as part of the McAvoy Derby) from the Sacramento River, Suisun Bay, Cache Slough, and Honker Bay. Sturgeon were analyzed as individuals for mercury.

The overall mean concentrations for white sturgeon samples were 315 ppb mercury, 76 ppb PCBs, 30 ppb DDTs, 6 ppb chlordanes, 1 ppb dieldrin, 3 ppb PBDEs, and 1,413 ppb selenium[3].

GUIDELINES FOR EATING ANADROMOUS FISH CAUGHT IN CALIFORNIA RIVERS, ESTUARIES, AND COASTAL WATERS

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. Because of the beneficial effects from regular fish consumption, believed 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

[3] 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).

avoid regular consumption of fish that cannot safely be eaten at a minimum of one six-ounce serving (after cooking) a week.

Recommendations for Women 18–45 Years, Including Pregnant and Breastfeeding Women, and Children 1–17 Years:

- Eat a total of **three servings per week** of American shad OR
- Eat a total of **two servings per week** of Chinook (king) salmon or steelhead trout
- Do **not eat** striped bass or white sturgeon

Recommendations for Women Over 45 Years and Men:

- Eat a total of **seven servings per week** of American shad, Chinook (king) salmon, or steelhead trout OR
- Eat a total of **two servings per week** of striped bass OR
- Eat a total of **one serving per week** of white sturgeon

Recommendations for All Consumers:

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.

These guidelines do not apply to American shad, Chinook (king) salmon, steelhead, striped bass, or white sturgeon caught in lakes or reservoirs.

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 per 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 2–3 servings per week, for example, they can combine fish species from that group for a total of two to three servings in that week. Then they should not eat any other fish until the next week.

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.

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TABLE 1. 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
Chlordanes	≤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.

When concentrations are lower than in the table, OEHHA has calculated ATLs for consumption of more than three servings per week.

*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 2. MINIMUM (AND MAXIMUM) SIZE REQUIREMENTS BY SPECIES

Common Name	Minimum Legal or Edible Size (mm)	Maximum Legal Size (mm)
American shad	275	
Chinook (king) salmon	**610**	
Steelhead trout	**406**	
Striped bass	**457**	
White sturgeon	**1168**	**1676**[4]

Note: sizes in **bold** are legal requirements per DFG 2011

[4] Historically, the maximum legal size range was greater, for example, in 2000 it was 46–72 inches (1168–1829 mm).

TABLE 3. SAMPLING LOCATIONS BY YEAR SAMPLED AND SPECIES

Year	Species Common Name	Station Name
1997	Striped Bass	Berkeley
1997	Striped Bass	Davis Point
1997	Striped Bass	Hill Slough u/s McCoy Ditch
1997	Striped Bass	San Pablo Bay
1997	Striped Bass	South Bay
1997	Striped Bass	Suisun Bay
1997	White Sturgeon	San Pablo Bay
1997	White Sturgeon	South Bay
1999	Striped Bass	Cosumnes River
1999	Striped Bass	Feather River/ Nicolaus
1999	Striped Bass	Mokelumne River d/s Cosumnes River
1999	Striped Bass	Paradise Cut
1999	Striped Bass	San Joaquin River/Howard Road
1999	Striped Bass	San Joaquin River/ Hwy 4
1999	Striped Bass	San Joaquin River/ Lake Ramona
1999	Striped Bass	San Joaquin River/Vernalis
1999	Striped Bass	Stockton Deep Water Channel
2000	Chinook Salmon	Marin coast/Farallon Islands
2000	Chinook Salmon	San Francisco coast
2000	Striped Bass	Berkeley
2000	Striped Bass	Feather River b/w Yuba and Bear Rivers
2000	Striped Bass	Feather River/Nicolaus
2000	Striped Bass	Sacramento River at RM 44
2000	Striped Bass	Sacramento River/Colusa
2000	Striped Bass	San Joaquin River/ Hwy 140
2000	Striped Bass	San Joaquin River/Naval Station
2000	Striped Bass	San Joaquin River/Potato Slough
2000	Striped Bass	San Pablo Bay
2000	Striped Bass	South Bay
2000	White Sturgeon	San Pablo Bay
2000	White Sturgeon	South Bay
2002	Chinook Salmon	Sacramento River at RM 44
2002	Striped Bass	American River @ Discovery Park
2003	American Shad	Sacramento River near Verona
2003	Chinook Salmon	Berkeley/San Pablo Bay
2003	Chinook Salmon	San Pablo Bay

Year	Species Common Name	Station Name
2003	Striped Bass	Berkeley
2003	Striped Bass	San Francisco Waterfront
2003	Striped Bass	San Pablo Bay
2003	Striped Bass	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 Hatchery
2005	Chinook Salmon	Merced River at Hatfield State Park
2005	Chinook Salmon	Mokelumne River Hatchery
2005	Chinook Salmon	Nimbus Hatchery
2005	Chinook Salmon	Sacramento River at River Mile 44
2005	Steelhead Trout	Sacramento River at Grimes
2005	Striped Bass	Prospect Slough (mid-Prospect)
2005	Striped Bass	Sacramento River at RM44
2005	Striped Bass	San Joaquin River @ Vernalis
2006	American Shad	American River at Hazel Ave and Nimbus Dam
2006	American Shad	Feather River at Oroville Outlet
2006	American Shad	Fremont Weir
2006	American Shad	Sacramento River at Colusa
2006	American Shad	Sacramento River at Knights Landing
2006	Chinook Salmon	Sacramento River at Tisdale Boat Ramp AKA River Bend Marina
2006	Chinook Salmon	San Pablo Bay
2006	Steelhead Trout	Feather River Hatchery
2006	Steelhead Trout	Mokelumne River Hatchery
2006	Steelhead Trout	Nimbus Hatchery
2006	Striped Bass	Cache Slough at Miner Slough
2006	Striped Bass	Cache Slough
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
2006	Striped Bass	Sacramento River/Rio Vista Fish Derby
2006	Striped Bass	Sacramento River at Knights Landing
2006	Striped Bass	Sacramento River at Tisdale Boat Ramp AKA River Bend Marina
2006	Striped Bass	Sacramento River Near Hamilton (Scotty's Boat Landing)

Year	Species Common Name	Station Name
2006	Striped Bass	San Pablo Bay
2006	Striped Bass	South Bay
2006	Striped Bass	Toe Drain
2006	White Sturgeon	Sacramento River at Channel Marker 33
2006	White Sturgeon	San Pablo Bay
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	Prospect Slough (mid-Prospect)
2007	Striped Bass	Sacramento River @ Rio Vista
2007	Striped Bass	Sacramento River at Knights Landing
2007	Striped Bass	Toe Drain
2007	White Sturgeon	Honker Bay (McAvoy Fish Derby)
2007	White Sturgeon	Sacramento River at Channel Marker 33
2007	White Sturgeon	Sacramento River at Ryer Island (McAvoy Fish Derby)
2007	White Sturgeon	Suisun Slough (McAvoy Fish Derby)
2007	White Sturgeon	Upper Cache Slough (McAvoy Fish Derby)
2009	Striped Bass	Central Bay
2009	Striped Bass	San Pablo Bay
2009	White Sturgeon	San Pablo Bay
2009	White Sturgeon	South Bay

TABLE 4. CHEMICAL CONCENTRATIONS BY SPECIES AND NUMBER OF FISH ANALYZED PER ANALYTE

Chemical concentrations shown in **bold** represent mean[5] values in parts per billion wet weight, followed by the range and standard deviation (in parentheses, unweighted)

Analyte *Number*	American shad	Chinook (king) salmon	Steelhead trout	Striped bass	White sturgeon
Mercury	**61** 29–337 (52)	**82** 62–138 (27)	**81** 38–165 (29)	**443** 132–3,500 (295)	**315** 149–914 (168)
Number analyzed for mercury	*55*	*60*	*25*	*278*	*43*
PCBs	-	**5** 1–8 (3)	-	**40** 2–156 (32)	**75** 5–383 (115)
Number analyzed for PCBs	*0*	*15*	*0*	*85*	*43*
DDTs	-	-	-	**25** 4–104 (22)	**30** 4–103 (32)
Number analyzed for DDTs	*0*	*0*	*0*	*87*	*43*
Chlordanes	-	-	-	**2** 0–7 (2)	**6** 0–23 (7)
Number analyzed for chlordanes	*0*	*0*	*0*	*87*	*43*
Dieldrin	-	-	-	**2** 0–10 (2)	**1** 0–3 (1)
Number analyzed for dieldrin	*0*	*0*	*0*	*81*	*40*
PBDEs	-	-	-	**5** 1–9 (3)	**3** 2–5 (2)
Number analyzed for PBDEs	*0*	*0*	*0*	*18*	*12*

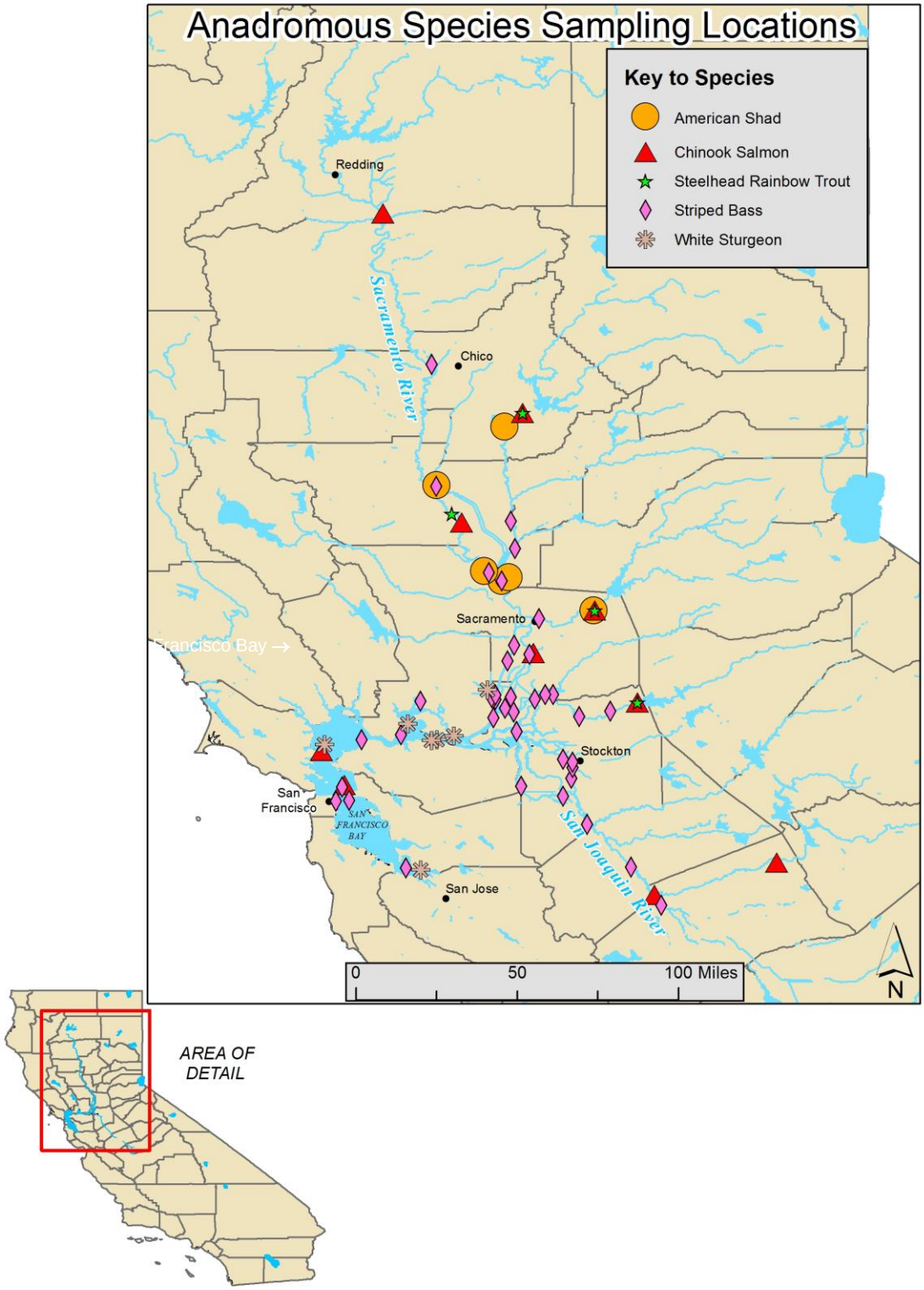
[5] When samples for a species included individuals and composites, the mean values were weighted by the number of fish per sample.

Analyte *Number*	American shad	Chinook (king) salmon	Steelhead trout	Striped bass	White sturgeon
Selenium	-	-	-	**462** 420–500 (34)	**1,413** 390–4,110 (776)
Number analyzed for selenium	*0*	*0*	*0*	*18*	*56*

TABLE 5. SIZE MEASUREMENTS OF FISH SAMPLES

Species Common Name	Mean Total Length (mm)	Minimum Length (mm)	Maximum Length (mm)
American shad	429	286	571
Chinook (King) Salmon	816	559	980
Steelhead trout	620	420	930
Striped Bass	591	448	1149
White Sturgeon	1367	1170	1820

FIGURE 1. MAP OF SAMPLING LOCATIONS



APPENDIX I. FISH SPECIES IMAGES

(not to scale)

American shad *Alosa sapidissima*

Duane Raver, USFWS

Chinook salmon *Oncorhynchus tshawytscha*

Steelhead trout *Oncorhynchus mykiss*

Striped bass *Morone saxatilis*

White sturgeon *Acipenser transmontanus*