OFFICE OF ENVIRONMENTAL HEALTH HAZARD ASSESSMENT

GOOD CATCH CALIFORNIA
Your Fish Advisor

Statewide Health Advisory and Guidelines for Eating Fish from California's Lakes and Reservoirs without Site-Specific Advice

August 2021

Fish, Ecotoxicology, and Water Section
Pesticide and Environmental Toxicology Branch
Office of Environmental Health Hazard Assessment
California Environmental Protection Agency

LIST OF CONTRIBUTORS

Office of Environmental Health Hazard Assessment

Project Leads
Lori Chumney, M.S.
Susan Klasing, Ph.D., Section Chief
Huyen Tran Pham, M.P.H.

Primary Reviewers
Wesley Smith, Ph.D.
Shannon R. Murphy, Ph.D.

Final Reviewers
David Ting, Ph.D., Branch Chief
David Siegel, Ph.D., Assistant to the Deputy Director
Vincent Cogliano, Ph.D., Deputy Director for Scientific Programs

Director
Lauren Zeise, Ph.D.

ACKNOWLEDGMENTS

Developing fish consumption advisories depends on sampling and analysis of fish. The Office of Environmental Health Hazard Assessment acknowledges the contribution of information from the following entities: the State Water Resources Control Board, the California Department of Fish and Wildlife and its analytical resources, the Moss Landing Marine Laboratories and the Water Pollution Control Laboratory. Data were obtained primarily from the California Environmental Data Exchange Network (http://ceden.waterboards.ca.gov/AdvancedQueryTool). Other projects and programs also contributed data to this statewide dataset and may have used other laboratories for sample analysis. The map was created using ArcMap (10.5) from Environmental Systems Resource Institute (ESRI, Redlands, California).

For further information, contact:

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

1001 I Street, P.O. Box 4010
Sacramento, CA 95812-4010
Telephone: (916) 324-7572
Email address: fish@oehha.ca.gov

1515 Clay Street, 16th Floor
Oakland, California 94612
Telephone: (510) 622-3170

LIST OF ACRONYMS AND ABBREVIATIONS

ATL	Advisory Tissue Level
CALFED	California Bay-Delta Program
CDFW	California Department of Fish and Wildlife, formerly California Department of Fish and Game (CDFG)
DDT(s)	dichlorodiphenyltrichloroethane (DDT) and its metabolites dichlorodiphenyldichloroethane (DDD) and dichlorodiphenyldichloroethylene (DDE)
DHA	docosahexaenoic acid
DWR	Department of Water Resources
EBRPD	East Bay Regional Park District
EBMUD	East Bay Municipal Utility District
EPA	eicosapentaenoic acid
FDA	Food and Drug Administration
FMP	Fish Mercury Project
Hg	mercury
LACDPW	Los Angeles County Department of Public Works
LACFCD	Los Angeles County Flood Control District
LACCEO	Los Angeles County Chief Executive Office
MID	Merced Irrigation District
MDL	method detection limit
MLML	Moss Landing Marine Laboratories
mm	millimeters
NFTS	National Fish Tissue Study
OEHHA	Office of Environmental Health Hazard Assessment
PBDEs	polybrominated diphenyl ethers
PCBs	polychlorinated biphenyls
PCWA	Placer County Water Agency
ppb	parts per billion
RL	reporting limit
RWB	Regional Water Board

Se	selenium
SGRRMP	San Gabriel River Regional Monitoring Program
SWAMP	Surface Water Ambient Monitoring Program
SWRCB	State Water Resources Control Board
TID	Turlock Irrigation District
TSF	The Sierra Fund
TMDL	Total Maximum Daily Load
TSMP	Toxic Substances Monitoring Program
UCDavis	University of California-Davis
USBR	United States Bureau of Reclamation
USGS	United States Geological Survey
USDA	United States Department of Agriculture
USDHHS	United States Department of Health and Human Services
US EPA	United States Environmental Protection Agency
YCWA	Yuba County Water Agency

PREFACE

The Office of Environmental Health Hazard Assessment (OEHHA), a department in the California Environmental Protection Agency, is 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:

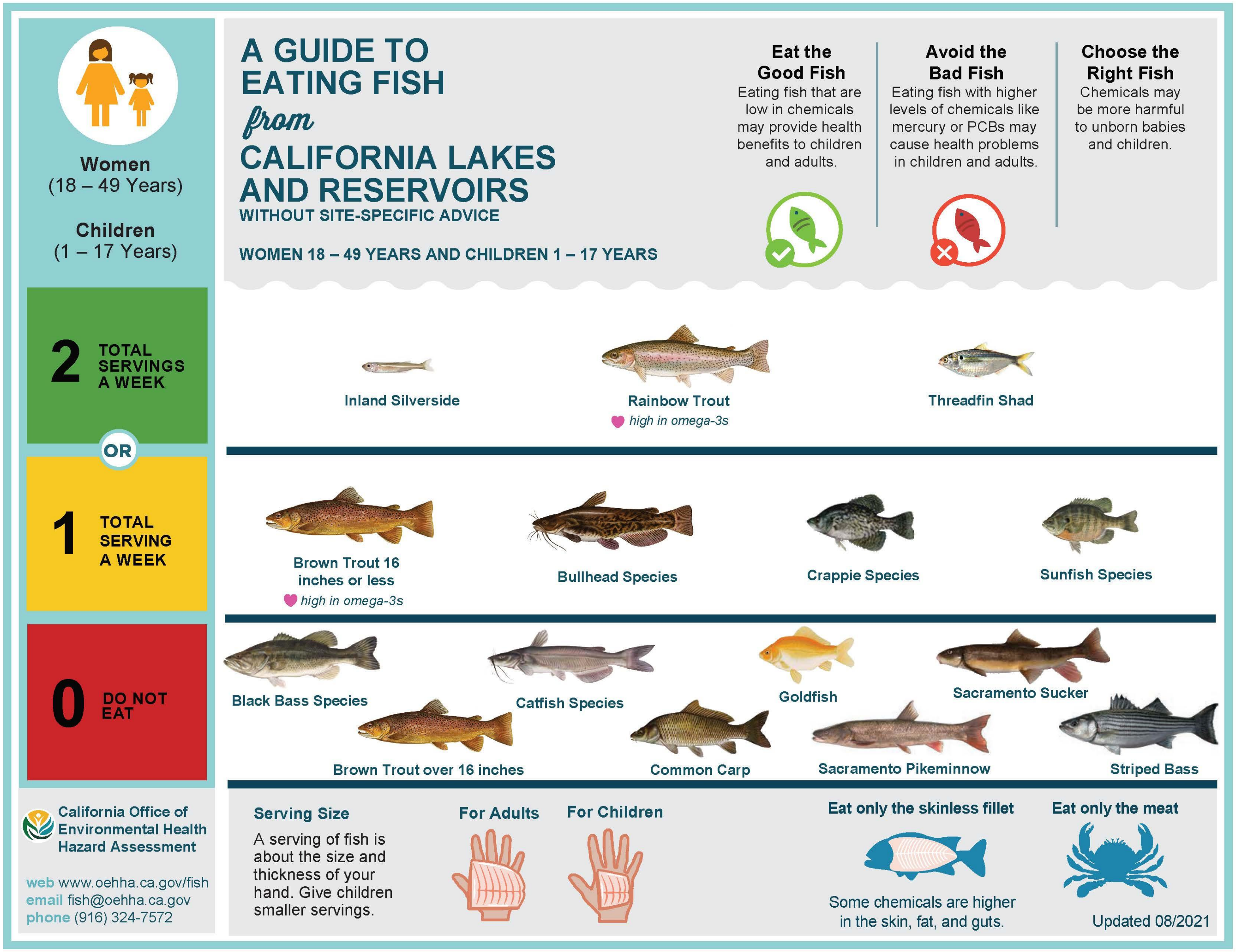
- California Health and Safety Code
    - Section 59009, to protect public health
    - Section 59011, to advise local health authorities
- California Water Code
    - Section 13177.5, to issue health advisories

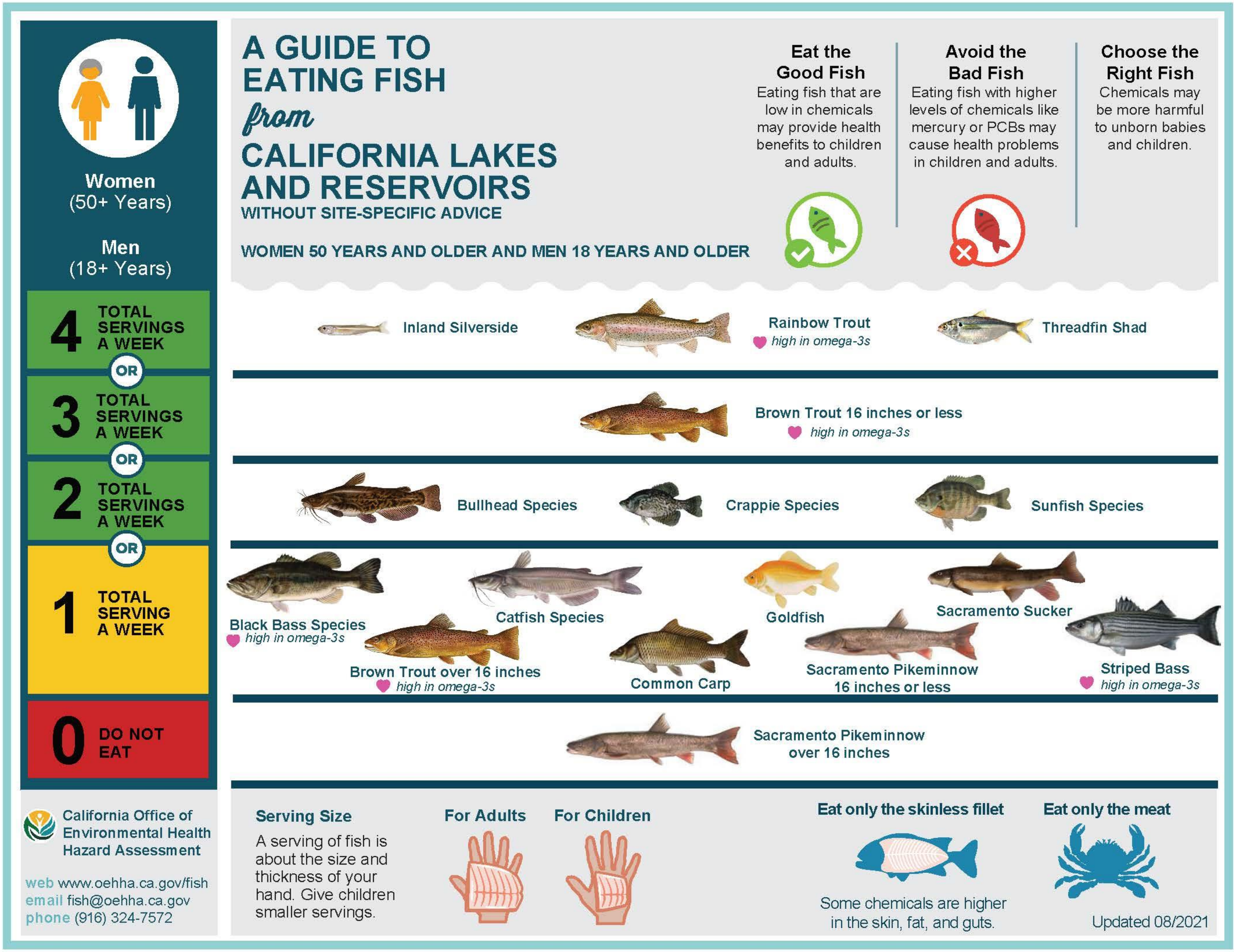
The health advisories are published in the California Department of Fish and Wildlife Sport Fishing Regulations in the section on public health advisories.

This report presents updated guidelines for eating fish from California lakes and reservoirs that do not have site-specific advice. The report provides background information and a technical description of how the guidelines were developed. The resulting advice is summarized in the illustrations after the Table of Contents and List of Figures and Tables.

TABLE OF CONTENTS

LIST OF FIGURES AND TABLES


A GUIDE TO EATING FISH from CALIFORNIA LAKES AND RESERVOIRS
WITHOUT SITE-SPECIFIC ADVICE
WOMEN 18 – 49 YEARS AND CHILDREN 1 – 17 YEARS
Women (18 – 49 Years)
Children (1 – 17 Years)
Eat the Good Fish
Eating fish that are low in chemicals may provide health benefits to children and adults.
Avoid the Bad Fish
Eating fish with higher levels of chemicals like mercury or PCBs may cause health problems in children and adults.
Choose the Right Fish
Chemicals may be more harmful to unborn babies and children.
2 TOTAL SERVINGS A WEEK
Inland Silverside
Rainbow Trout
high in omega-3s
Threadfin Shad
OR
1 TOTAL SERVING A WEEK
Brown Trout 16 inches or less
high in omega-3s
Bullhead Species
Crappie Species
Sunfish Species
0 DO NOT EAT
Black Bass Species
Catfish Species
Goldfish
Sacramento Sucker
Brown Trout over 16 inches
Common Carp
Sacramento Pikeminnow
Striped Bass
California Office of Environmental Health Hazard Assessment
web www.oehha.ca.gov/fish
email fish@oehha.ca.gov
phone (916) 324-7572
Serving Size
A serving of fish is about the size and thickness of your hand. Give children smaller servings.
For Adults
For Children
Eat only the skinless fillet
Some chemicals are higher in the skin, fat, and guts.
Eat only the meat
Updated 08/2021


A GUIDE TO EATING FISH from CALIFORNIA LAKES AND RESERVOIRS
WITHOUT SITE-SPECIFIC ADVICE
WOMEN 50 YEARS AND OLDER AND MEN 18 YEARS AND OLDER
Women (50+ Years)
Men (18+ Years)
Eat the Good Fish
Eating fish that are low in chemicals may provide health benefits to children and adults.
Avoid the Bad Fish
Eating fish with higher levels of chemicals like mercury or PCBs may cause health problems in children and adults.
Choose the Right Fish
Chemicals may be more harmful to unborn babies and children.
4 TOTAL SERVINGS A WEEK
OR
Inland Silverside
Rainbow Trout
high in omega-3s
Threadfin Shad
3 TOTAL SERVINGS A WEEK
OR
Brown Trout 16 inches or less
high in omega-3s
2 TOTAL SERVINGS A WEEK
OR
Bullhead Species
Crappie Species
Sunfish Species
1 TOTAL SERVING A WEEK
Black Bass Species
high in omega-3s
Catfish Species
Goldfish
Sacramento Sucker
Brown Trout over 16 inches
high in omega-3s
Common Carp
Sacramento Pikeminnow 16 inches or less
Striped Bass
high in omega-3s
0 DO NOT EAT
Sacramento Pikeminnow over 16 inches
California Office of Environmental Health Hazard Assessment
web www.oehha.ca.gov/fish
email fish@oehha.ca.gov
phone (916) 324-7572
Serving Size
A serving of fish is about the size and thickness of your hand. Give children smaller servings.
For Adults
For Children
Eat only the skinless fillet
Some chemicals are higher in the skin, fat, and guts.
Eat only the meat
Updated 08/2021

SUMMARY

This report updates and supersedes the Office of Environmental Health Hazard Assessment's (OEHHA) 2013 advisory for consumption of sport fish caught from California lakes and reservoirs *that do not have site-specific advice*[1]. It provides advice for safe consumption of 14 species or species groups. Separate advice is provided for the sensitive population (women 18 – 49 years and children 1 – 17 years) and the general population (women 50 years and older and men 18 years and older).

To develop this advisory, OEHHA compared mercury and PCB levels in fish caught from 343 and 297 lakes, respectively, to levels that are considered safe for human consumption. OEHHA's consumption guidelines balance the risks and benefits of fish consumption, as low-contaminant fish are part of a healthy, well-balanced diet. Fish are a good source of protein and vitamins, and are a primary dietary source of heart-healthy omega-3 fatty acids.

OEHHA recommends the amounts and types of fish that may be eaten as "servings." A serving is about the size and thickness of your hand for fish fillets. Children should be given smaller servings. For small fish species, several individual fish may make up a serving. The advice is as follows.

Women 18–49 years and children 1–17 years

- **Should not eat:** black bass species, Brown Trout over 16 inches, catfish species, Common Carp, Goldfish, Sacramento Pikeminnow, Sacramento Sucker, or Striped Bass

- **May eat:**
  - One serving per week of Brown Trout 16 inches or less, bullhead species, crappie species, or sunfish species, or
  - Two servings per week of Inland Silverside, Rainbow Trout, or Threadfin Shad

Women 50 years and older and men age 18 years and older

- **Should not eat:** Sacramento Pikeminnow over 16 inches in length

- **May eat:**
  - One serving per week of black bass species, Brown Trout over 16 inches, catfish species, Common Carp, Goldfish, Sacramento Pikeminnow 16 inches or less, Sacramento Sucker, or Striped Bass, or
  - Two servings per week of bullhead species, crappie species, or sunfish species, or
  - Three servings per week of Brown Trout 16 inches or less, or

[1] Site-specific consumption advice is available at https://oehha.ca.gov/fish/advisories for over 100 California water bodies, including lakes, rivers, bays, reservoirs, and the coast.

- Four servings per week of Inland Silverside, Rainbow Trout, or Threadfin Shad

INTRODUCTION

This report provides statewide advice for eating recreationally caught fish from California lakes and reservoirs (hereafter referred to as “lakes”) that did not have adequate sampling data to provide site-specific advice or for which advisories have not yet been developed. The Office of Environmental Health Hazard Assessment (OEHHA) released its first statewide advisory of this type in 2013 (OEHHA, 2013). At that time, California sampling programs and fish advisories focused largely on areas of historical mercury or gold mining operations in Northern California where mercury levels were likely to be higher (Alpers et al., 2005). Because of this, the statewide advisory was based only on data collected from lakes where OEHHA had not issued consumption advice (“no advisory lakes”). Sufficient mercury data were available on a statewide basis to issue advice for seven species or species groups: black bass, Brown Trout, bullhead, catfish, Common Carp, Rainbow Trout, and sunfish.

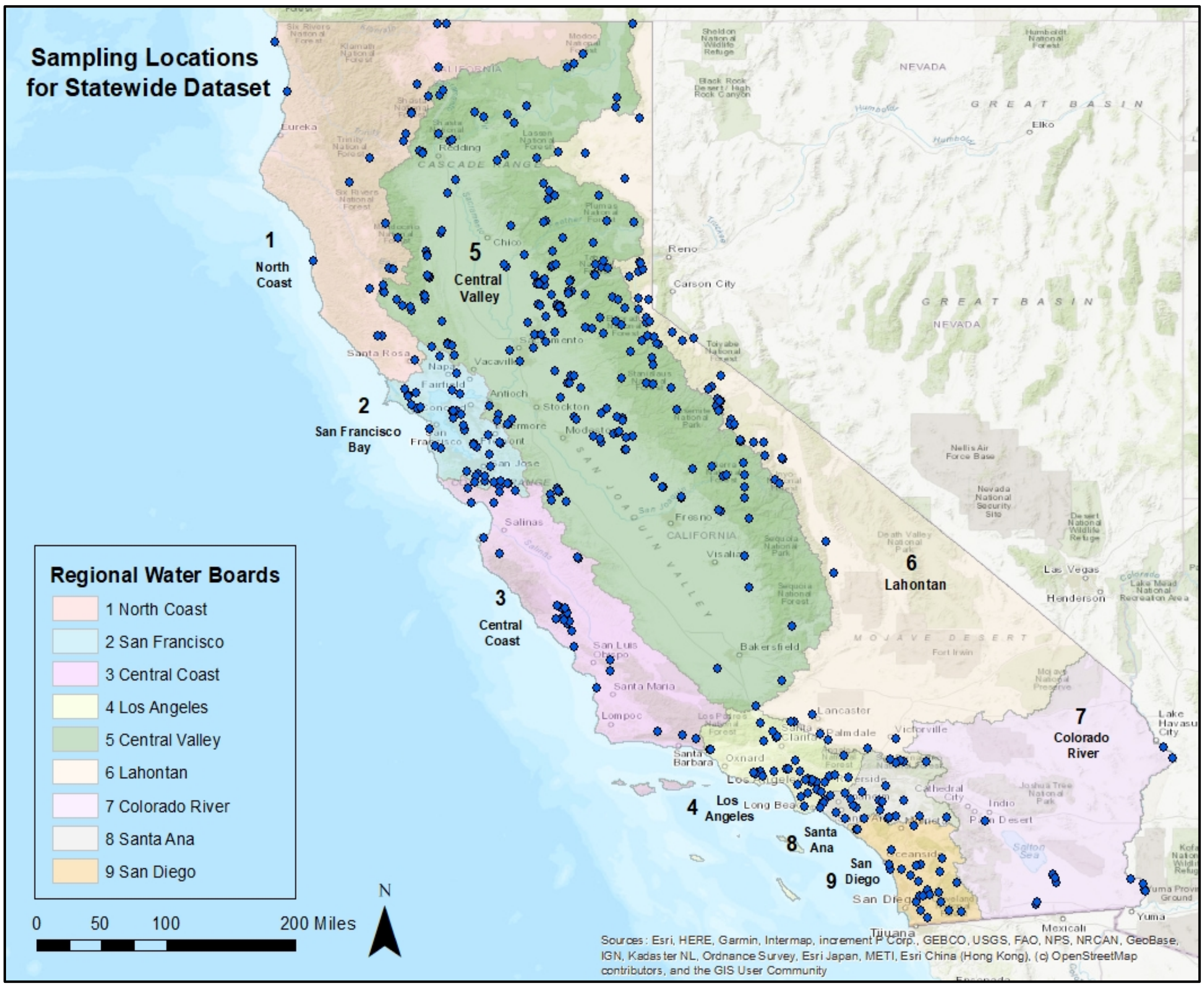
Since the 2013 advisory, significant sampling has been conducted through regional and statewide efforts, including at “no advisory lakes” and numerous lakes with relatively low fish contaminant levels. Because of the increased availability of fish contaminant data, OEHHA has now issued more than three times as many site-specific advisories for lakes than had been issued at the time of the 2013 report. Thus, the number of “no advisory lakes” has decreased and newer data more representative of contaminant conditions from lakes throughout the state are now available. Sample sizes solely from “no advisory lakes” are no longer sufficient to develop statewide advice. For these reasons, OEHHA used all available and suitable data from lakes throughout the state to update the consumption advice for species included in the 2013 advisory and to develop new advice for seven additional species.

The previous statewide advisory for eating fish from California lakes and reservoirs without site-specific advice evaluated only mercury (OEHHA, 2013). This report updates and supersedes the 2013 guidelines and provides consumption advice based on levels of mercury and/or PCBs for 14 species: black bass species, Brown Trout, bullhead species, catfish species, Common Carp, crappie species, Goldfish, Inland Silverside, Rainbow Trout, Sacramento Pikeminnow, Sacramento Sucker, Striped Bass, sunfish species, and Threadfin Shad. Mercury and/or PCBs are risk drivers (the chemical that results in the most restrictive consumption advice) in one or more species in >95% and >30% of California lakes with site-specific advisories, respectively. Other chemicals were not evaluated for this advisory because they impact advice in only few, if any, California lakes.

LOCATION OF LAKES CONTRIBUTING MERCURY AND/OR PCB DATA TO THE STATEWIDE ADVISORY DATASET

Figure 1 shows California lakes where fish were collected and evaluated for mercury and/or PCBs and met OEHHA's data quality criteria for inclusion in the statewide dataset. Also shown are the State Water Resources Control Board's (SWRCB) nine Regional Water Quality Control Boards (Regional Water Boards, or RWBs). Data from 343 lakes were used to evaluate fish mercury levels and data from 297 lakes were used to evaluate fish PCB levels. Maps of sampling locations for mercury and PCB analyses by species can be found in Appendix I.

FIGURE 1. LOCATION OF LAKES CONTRIBUTING MERCURY AND/OR PCB DATA IN THE STATEWIDE ADVISORY DATASET



APPROACH USED

OEHHA used the results from the monitoring studies described in this report to develop the updated statewide advisory for lakes and reservoirs without site-specific advice. OEHHA used the following process in developing consumption advice for sport fish for this advisory:

1) Evaluation of all mercury and PCB data available for each species from all lakes (with and without site-specific advisories) and selection of appropriate data that meet data quality criteria and sampling plan guidelines.
2) Determination of fish species for which adequate data are available to issue fish consumption advice.
3) Calculation of the species mean[2] and 90th percentile value of lake means[3] for each species, as well as other descriptive statistics of the contaminant data, as appropriate, for mercury and PCBs.
4) Comparison of the chemical concentrations with the OEHHA Advisory Tissue Levels (ATLs) for mercury and PCBs.
5) Development of final advice based on a thorough review of the data and best professional judgment relating to the benefits and risks of consuming a particular fish species.

As was the case for the 2013 statewide advisory, OEHHA calculated the lake mean contaminant concentration for all lakes; a lake mean is the arithmetic mean concentration of a chemical from all samples for a fish species collected in a lake. We then selected the 90th percentile value of the lake mean contaminant concentrations from sampled lakes for each species as the basis for consumption advice to update the statewide advisory. Figure 2 provides an example of how the 90th percentile of lake means was calculated using Sacramento Pikeminnow, which were sampled from 10 water bodies for mercury analysis. This is a more health protective approach than using the mean contaminant concentration of a species of all the sampled lakes because there is a lack of data from many of the state's lakes and the range of contaminant concentrations in fish throughout the state is large.

ATLs (discussed further in a subsequent section of this report) are chemical levels (concentrations) in fish tissue that are considered acceptable, based on chemical toxicity, for a range of consumption rates. Development of the ATLs also included consideration of health benefits associated with including fish in the diet (OEHHA, 2008). The ATLs should not be interpreted as static "bright lines," but one component

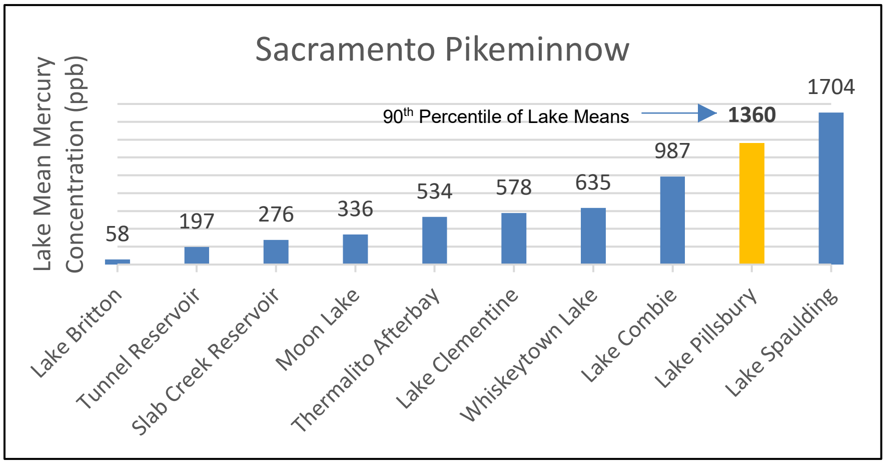
---

[2] The species mean is the arithmetic average of individual values and/or composites (weighted by number of fish) of all samples for each species at a water body.

[3] The 90th percentile value represents an upper bound value of the distribution of the lake mean mercury concentrations from sampled lakes for a fish species. Mean fish mercury concentrations were at or below this value in 90% of the lakes.

of a complex process of data evaluation and interpretation used by OEHHA in the assessment and communication of the benefits and risks of consuming sport fish.

FIGURE 2. EXAMPLE CALCULATION OF 90TH PERCENTILE OF LAKE MEANS



CHEMICALS OF POTENTIAL CONCERN

Certain chemicals are of potential concern for people who eat fish because of their toxicity and their ability to accumulate in fish tissue. The majority of fish consumption advisories in California are issued because of mercury (Hg), followed by polychlorinated biphenyls (PCBs) and, in a few cases, selenium (Se), polybrominated diphenyl ethers (PBDEs), or some legacy pesticides (pesticides that are no longer used but remain in the environment).

Mercury is a natural element found in some rock and soil. Human activities, such as burning coal and the historical use of mercury to mine gold, also add mercury to the environment. If mercury enters waterways, it can be converted to a more toxic form known as methylmercury – that can pass into and build up in fish. High levels of methylmercury can harm the brain, especially in fetuses and children.

PCBs are industrial chemicals previously used in electrical transformers, plastics, and lubricating oils, often as flame retardants or electrical insulators. Their use was banned in the 1970s, but they persist in the environment because they do not break down easily and can accumulate in fish. Depending on the exposure level, PCBs may cause cancer or other health effects, including neurotoxicity, in humans.

Selenium is a naturally occurring metalloid and at low doses is an essential nutrient for many important human health processes, including thyroid regulation and vitamin C metabolism. Higher doses cause selenium toxicity, which can include symptoms ranging from hair loss and gastrointestinal distress to dizziness and tremors.

Chlordanes, dichlorodiphenyltrichloroethane (DDT), dieldrin, and toxaphene are pesticides that were banned from use in 1973 (DDT), the late 1980s (chlordanes and dieldrin) and 1990 (toxaphene), but are still found in some fish in certain California water bodies. Depending on the exposure level, these chemicals may cause cancer or adverse effects on the nervous system.

PBDEs are a class of flame retardants historically used in a variety of consumer products, including furniture, textiles, automotive parts, and electronics. The use of PBDEs in new products was largely phased out by 2013 but, due to their wide usage and persistence in the environment, they are still being detected in fish tissues. PBDEs may affect hormone levels or learning and behavior in children.

Detailed discussion of the toxicity of these chemicals and references are presented in "Development of Fish Contaminant Goals and Advisory Tissue Levels for Common Contaminants in California Sport Fish: Chlordane, DDTs, Dieldrin, Methylmercury, PCBs, Selenium, and Toxaphene" (OEHHA, 2008) and "Development of Fish Contaminant Goals and Advisory Tissue Levels for Common Contaminants in California Sport Fish: Polybrominated Diphenyl Ethers (PBDEs)" (OEHHA, 2011).

As noted above, only mercury and PCB data were used in development of this advisory. This advice was based on mercury and PCB analyses of over 14,000 and 4,000 fish, respectively. Inland Silverside, Threadfin Shad, and White Crappie were the only species for which PCBs were not analyzed. Fish species that do not normally accumulate PCBs or other organic chemicals may not be analyzed for those contaminants in a particular monitoring study. Additionally, some studies do not analyze these chemicals and instead focus only on mercury.

DATA SOURCES

The guidelines for eating fish from lakes and reservoirs that do not have site-specific advisories are based on the chemicals detected in the fish collected for the monitoring studies described below. These studies met OEHHA's data quality criteria, including adequate documentation of sample collection, fish preparation methods (e.g., skinning or filleting), chemical analyses, quality assurance, and sufficiently low detection limits. "Sample," as used in this report, refers to an individual fish or a composite of multiple fish for which contaminant data were reported. "Sampling" or "sampled" refers to the act of collecting fish for chemical analysis. The studies or entities contributing at least five percent of the statewide mercury data (based on number of fish) to this advisory are described below.

Fish Mercury Project (FMP)

The FMP was a three-year (2005 to 2007) sampling program funded by the California Bay-Delta Program (CALFED) (SFEI, 2009). Monitoring of sport fish from Central Valley water bodies was planned and conducted by staff at the California Department of Fish and Wildlife (CDFW), OEHHA, the California Department of Public Health, the University of California-Davis, and the San Francisco Estuary Institute. Fish were collected from popular fishing locations in the Central Valley Regional Water Board

(RWB5) jurisdiction to help characterize the spatial and temporal mercury trends in fishery resources. The samples were analyzed for total mercury, and a small number were additionally analyzed for PCBs.

REGIONAL WATER QUALITY CONTROL BOARDS (RWB1 – 9)

The State Water Resources Control Board (SWRCB) develops water quality objectives and enforces implementation plans that protect the beneficial uses of waters in the State with consideration of the local differences between regions. One of these water quality objectives sets a numeric target for the concentration of methylmercury in fish tissue. The nine Regional Water Quality Control Boards (RWBs) work in collaboration with the SWRCB to assist in that objective. The RWBs coordinate ongoing sampling efforts to monitor contaminant levels, including mercury and PCBs, in sport fish caught from lakes and reservoirs within their regional boundaries.[4]

SURFACE WATER AMBIENT MONITORING PROGRAM: LAKE AND RESERVOIR BIOACCUMULATION MONITORING SURVEYS (SWAMP)[5]

The Surface Water Ambient Monitoring Program (SWAMP), operated by the SWRCB, provides environmental managers and the public with information to evaluate waters within the state. This is accomplished through the design and execution of water quality monitoring programs in California's surface waters (SWRCB, 2010). SWAMP studies that contributed at least five percent of the total data to the statewide dataset are listed below.

CONTAMINANTS IN FISH FROM CALIFORNIA LAKES AND RESERVOIRS, 2007 – 2008 (SWAMP1)

This survey of inland water bodies was the State's largest survey of chemical contaminants in sport fish. The survey sampled popular fishing sites at 272 lakes and reservoirs from 2007 to 2008 (SWRCB, 2010). The SWRCB used the data from this survey to characterize statewide water quality conditions.

---

[4] Further information on the SRWCB and the RWBs can be found online at: https://www.waterboards.ca.gov/water_issues/programs/mercury/ and https://www.waterboards.ca.gov/about_us/contact_us/rwqcbs_directory.html.
[5] Further information on SWAMPs Lakes and Reservoirs Bioaccumulation Monitoring Surveys can be found online at: https://www.waterboards.ca.gov/water_issues/programs/swamp/lakes_study.html.

Survey of Lakes and Reservoirs with Low Concentrations of Contaminants in Sport Fish, 2014 (SWAMP2)

The purpose of this study was to identify and characterize lakes with low concentrations of mercury and other contaminants in fish tissue in order to improve understanding of the conditions and factors that contribute to these lower concentrations.[6]

Long-Term Monitoring of Bass Lakes and Reservoirs in California, 2015 – ongoing (SWAMP3)

This monitoring study is a multi-year effort initiated in 2015 to document long-term trends related to mercury contamination in sport fish from California lakes and reservoirs dominated by bass species (Davis et al., 2019 a,b; Davis et al., *manuscript in preparation* [a]).

Monitoring of Contaminants in Fish from California Lakes and Reservoirs, 2016 (SWAMP4)

The purpose of this study was to supplement long-term monitoring data that documented bioaccumulation impacts on the beneficial uses of California waters. The study focused on water bodies that provide beneficial uses through fishing and had either not been previously sampled or were previously sampled, but needed data gaps filled to determine impairment or develop consumption advisories (Davis et al., *manuscript in preparation* [b]).

Toxic Substances Monitoring Program

The TSMP operated from 1976 to 2003 as a state water quality-monitoring program managed by SWRCB (SWRCB, 2007 and 2013). Its objective was to provide statewide information on the occurrence of toxic substances by monitoring water bodies with known or suspected water quality impairment. Staff from CDFW, then known as the California Department of Fish and Game, collected fish that were analyzed for mercury.

Other Studies

Smaller studies that contributed less than five percent of the total number of fish used in the statewide dataset are not described in this section. These smaller studies cumulatively account for less than 20 percent of the overall data used to develop this statewide advice. Those studies, along with the ones described above, are listed in Appendix II.

---

[6] The sampling plan for this study can be found on the SWAMP website, online at: https://www.waterboards.ca.gov/water_issues/programs/swamp/docs/lakes_study/lakes_sampling_plan_may14.pdf.

FISH SAMPLES INCLUDED IN THE STATEWIDE DATASET

The majority of the fish sampling data used in this advisory were retrieved from the California Environmental Data Exchange Network (CEDEN), the state's repository for environmental data. Approximately seven percent of the total data included in the statewide dataset were not available in CEDEN. These data were used previously in site-specific advisories and were retrieved directly from the entity that collected the samples; refer to Appendix II for further information on data sources. Samples were excluded when the fish were not legal size to take or did not meet OEHHA's criteria for minimum "edible" size based on species size at maturity, and professional judgment (as described in OEHHA, 2005).

For the 2013 statewide advisory, OEHHA established several criteria to determine whether data for a species were adequate to be included in the advisory. For species with a statewide range, it was determined that samples should be from the biogeographic jurisdictions of more than five Regional Water Boards and that there should be mercury data from more than 100 samples or 50 lakes. For species with a limited range, it was determined that samples should be from Regional Water Board jurisdictions in the species' range. These criteria were met for the seven species or species groups included in the 2013 advisory (black bass, Brown Trout, bullhead, catfish, sunfish, Rainbow Trout, and Common Carp).

For this advisory, OEHHA evaluated all available data that met both data quality criteria as well as the minimum number of fish, water bodies, and regions, and determined that crappie species, Threadfin Shad, and Inland Silverside could be included. Striped Bass were just short of the criteria for number of samples (98 versus >100) but met the criteria for number of regions and were thus included. Despite a limited number of samples, Goldfish, Sacramento Pikeminnow and Sacramento Sucker were also included in the updated advisory because of their overall high contaminant concentrations, hybridization with another species included in the advisory, and/or the existence of supporting data. More discussion can be found in the section Consumption Advice for Fish from Statewide Lakes and Reservoirs without Site-Specific Advice.

Samples of one or more species from several water bodies were excluded from the analysis because they have very high contaminant levels that are not representative of levels typically found in fish from California lakes and reservoirs. This included mercury data for all species collected from Almaden Lake, Almaden Reservoir, Calero Reservoir, and Guadalupe Reservoir, located in the vicinity of the historic New Almaden Mercury Mine. Additionally, PCB data for all species from Silverwood Lake were excluded, as were PCB data for Brown Bullhead from Pyramid Lake, and Sacramento Pikeminnow from Thermalito Afterbay. Inclusion of these data would unduly influence the statewide mean and 90th percentile concentrations for mercury or PCBs. A summary of all fish species evaluated for this advisory is shown in Table 1, including the common and scientific name of the species, project or program name, year sampled, and contaminants analyzed.

TABLE 1. FISH SAMPLES EVALUATED FOR THE STATEWIDE ADVISORY

Common Name	Scientific Name	Program/Project Name[a]	Year Collected	Contaminants Analyzed[b]
Black Bullhead	*Ameiurus melas*	SWAMP/RWB4	2013	Hg, PCBs
		SWAMP/RWB8	2005	Hg, PCBs
		TSMP	1991 – 1993, 2001	Hg
		USGS	2002	Hg
Black Crappie	*Pomoxis nigromaculatus*	CDFG	1976, 1984	Hg
		DWR	2003	Hg
		FMP	2006 – 2007	Hg
		OEHHA	1997	Hg
		SGRRMP	2018	Hg, PCBs
		SWAMP1	2007	Hg, PCBs
		SWAMP2	2014	Hg
		SWAMP3	2017	Hg, PCBs
		SWAMP4	2016	Hg
		SWAMP/RWB4	2010	Hg, PCBs
		SWAMP/RWB6	2013	Hg, PCBs
		SWAMP/RWB6	2017	Hg
		SWAMP/RWB7	2004	Hg, PCBs
		SWAMP/RWB7	2014	Hg
		SWAMP/RWB9	2015	Hg, PCBs
		TMDL/RWB7	2016	PCBs
		TSMP	1983, 1985 – 1987, 2000 – 2001	Hg
		USGS	1999	Hg
Bluegill	*Lepomis macrochirus*	CALFED	1999	Hg
		CDFG	1976	Hg
		DWR	2003	Hg
		FMP	2005 – 2007	Hg
		LACDPW	2009	MeHg, PCBs
		SGRRMP	2009, 2011, 2015 – 2017	Hg, PCBs
		SWAMP1	2007	Hg, PCBs
		SWAMP2	2014	Hg, PCBs
		SWAMP3	2017	Hg, PCBs
		SWAMP4	2016	Hg, PCBs
		SWAMP/RWB2	2004 – 2005	Hg, PCBs
		SWAMP/RWB2	2011, 2013	Hg
		SWAMP/RWB3	2011	Hg, PCBs
		SWAMP/RWB3	2012	Hg
		SWAMP/RWB4	2010	Hg, PCBs
		SWAMP/RWB4	2019	Hg
		SWAMP/RWB6	2011, 2017	Hg
		SWAMP/RWB6	2013	Hg, PCBs
		SWAMP/RWB7	2014	Hg
		SWAMP/RWB9	2015	PCBs
		TSF	2015 – 2016	Hg
		TSMP	1981, 1983 – 1984, 1987 – 1988, 1991, 1993, 1999, 2001	Hg
		UCDavis	1995 – 1997	Hg
		USBR	2004	Hg
		USGS	1999, 2002 – 2004, 2006	Hg

Common Name	Scientific Name	Program/Project Name[a]	Year Collected	Contaminants Analyzed[b]
Brown Bullhead	*Ameiurus nebulosus*	CDFG	1976, 1984	Hg
		FMP	2006 – 2007	Hg
		SWAMP1	2007 – 2008	Hg, PCBs
		SWAMP2	2014	Hg, PCBs
		SWAMP3	2017	Hg, PCBs
		SWAMP4	2016	Hg, PCBs
		SWAMP/RWB3	2011	Hg, PCBs
		SWAMP/RWB4	2010, 2012	Hg
		SWAMP/RWB6	2011	Hg
		SWAMP/RWB7	2014	Hg, PCBs
		SWAMP/RWB9	2015	Hg, PCBs
		TSMP	1983 – 1984, 1989	Hg
		USGS	1996 – 1997, 2002	Hg
Brown Trout	*Salmo trutta*	FMP	2006	Hg
		MID	2009	Hg
		NFTS	2002	Hg, PCBs
		PCWA	2007 – 2008	Hg
		SWAMP1	2007 – 2008	Hg, PCBs
		SWAMP2	2014	Hg, PCBs
		SWAMP3	2019	Hg
		SWAMP4	2016	Hg, PCBs
		SWAMP5	2012 – 2013	Hg
		SWAMP/RWB6	2005	Hg, PCBs
		SWAMP/RWB6	2017	Hg
		TSMP	1988 – 1992, 1994, 1998, 2002	Hg
		USGS	1999	Hg
Bullhead spp.	*Ameiurus*	TSMP	1985 – 1988, 2002	Hg
Channel Catfish	*Ictalurus punctatus*	CDFG	1982 – 1984	Hg
		DWR	2002 – 2003	Hg, PCBs
		FMP	2005 – 2007	Hg
		FMP	2007	PCBs
		LACDPW	2009	MeHg, PCBs
		OEHHA	1997	Hg
		OEHHA/USEPA	1997	Hg
		SGRRMP	2011	Hg, PCBs
		SWAMP1	2007 – 2008	Hg, PCBs
		SWAMP2	2014	Hg, PCBs
		SWAMP3	2017	Hg, PCBs
		SWAMP4	2016	Hg, PCBs
		SWAMP/RWB2	2004 – 2005	Hg, PCBs
		SWAMP/RWB2	2010 – 2011	Hg, PCBs
		SWAMP/RWB3	2012	Hg
		SWAMP/RWB4	2004 – 2005, 2010, 2012 – 2013	Hg, PCBs
		SWAMP/RWB4	2019	Hg
		SWAMP/RWB6	2011	Hg
		SWAMP/RWB7	2004, 2014	Hg, PCBs
		SWAMP/RWB8	2005	Hg, PCBs
		TID/MID	2009	Hg
		TSMP	1983 – 1990, 1995, 2000 – 2002	Hg
		UCDavis	1992, 2000	Hg
		USBR	2004	Hg
		USGS	1999, 2003 – 2004	Hg

Common Name	Scientific Name	Program/Project Name[a]	Year Collected	Contaminants Analyzed[b]
Common Carp	*Cyprinus carpio*	CALFED	2000	Hg
		CDFG	1976	Hg
		DWR	2002 – 2003	Hg, PCBs
		FMP	2005 – 2007	Hg
		LACDPW	2009	MeHg, PCBs
		LACDPW	2017	PCBs
		LACFCD	2013	PCBs
		OEHHA	1997, 1999	Hg
		OEHHA/USEPA	1997	Hg
		SGRRMP	2006, 2009, 2011, 2015 – 2018	Hg, PCBs
		SGRRMP	2007	Hg
		SWAMP1	2007 – 2008	Hg, PCBs
		SWAMP2	2014	Hg, PCBs
		SWAMP3	2015, 2017	Hg, PCBs
		SWAMP3	2019	Hg
		SWAMP4	2016	Hg, PCBs
		SWAMP/RWB2	2005, 2011, 2013	Hg, PCBs
		SWAMP/RWB3	2011	Hg, PCBs
		SWAMP/RWB4	2004 – 2005, 2010, 2013	Hg, PCBs
		SWAMP/RWB4	2019	Hg
		SWAMP/RWB6	2011, 2013	Hg
		SWAMP/RWB6	2013	PCBs
		SWAMP/RWB7	2004, 2014	Hg, PCBs
		SWAMP/RWB8	2004 – 2005	Hg, PCBs
		TMDL/RWB7	2016	PCBs
		TSMP	1982 – 1990, 1994 – 1995, 1997 – 1998, 2000 – 2002	Hg
		UCDavis	1992, 1996	Hg
Crappie spp.	*Pomoxis*	CALFED	1999 – 2000	Hg
		OEHHA/USEPA	1997	Hg
		SWAMP2	2014	Hg
		SWAMP3	2017	Hg
		SWAMP/RWB8	2005	Hg, PCBs
Eagle Lake Trout	*Oncorhynchus mykiss aquilarum*	SWAMP1	2007	Hg, PCBs
		SWAMP5	2012	Hg
		TSMP	1988 – 1989, 2001	Hg
Goldfish	*Carassius auratus*	FMP	2005 – 2006	Hg
		SWAMP1	2008	Hg, PCBs
		SWAMP/RWB2	2004 – 2005, 2011	Hg, PCBs
		SWAMP/RWB3	2011	Hg, PCBs
		SWAMP/RWB4	2013	Hg
		TSMP	1983 – 1985, 1989, 1991, 2002	Hg
Green Sunfish	*Lepomis cyanellus*	DWR	2003	Hg
		SWAMP2	2014	Hg, PCBs
		SWAMP3	2017	Hg
		SWAMP4	2016	Hg
		SWAMP/RWB2	2010	Hg, PCBs
		SWAMP/RWB2	2013	Hg
		SWAMP/RWB6	2013	Hg
		TSMP	1981 – 1982, 1996, 1998	Hg
		USGS	1996, 1999, 2002, 2004	Hg

Common Name	Scientific Name	Program/Project Name[a]	Year Collected	Contaminants Analyzed[b]
Inland Silverside[c]	*Menidia beryllina*	EBRPD	2017	Hg
		SWAMP2	2014	Hg
		SWAMP3	2015, 2017	Hg
		SWAMP4	2016	Hg
		SWAMP5	2012, 2013	Hg
		TMDL	1980, 2006	Hg
		UCDavis	1999	Hg
Lahontan Cutthroat Trout	*Oncorhynchus clarkii henshawi*	NFTS	2003	Hg, PCBs
		SWAMP4	2016	Hg, PCBs
		TSMP	2001	Hg
Largemouth Bass	*Micropterus salmoides*	CALFED	1999 – 2000	Hg
		CDFG	1976 – 1977, 1982 – 1983, 1987	Hg
		DWR	1996	Hg
		DWR	2002 – 2003	Hg, PCBs
		DWR	2004 – 2006	PCBs
		EBRPD	2016	Hg
		FMP	2005 – 2007	Hg
		FMP	2007	PCBs
		LACDPW	2009	MeHg, PCBs
		LACDPW	2017	Hg
		LACFCD	2013	Hg, PCBs
		NFTS	2000 – 2003	Hg, PCBs
		OEHHA	1997	Hg
		OEHHA/USEPA	1997	Hg
		SGRRMP	2006 – 2009, 2015 – 2018	Hg, PCBs
		SWAMP1	2007 – 2008	Hg, PCBs
		SWAMP2	2014	Hg, PCBs
		SWAMP3	2015 – 2017, 2019	Hg
		SWAMP3	2017	PCBs
		SWAMP4	2016	Hg, PCBs
		SWAMP5	2012 – 2013	Hg
		SWAMP/RWB1	2015	Hg, PCBs
		SWAMP/RWB2	2005, 2011, 2013	Hg
		SWAMP/RWB3	2011	Hg, PCBs
		SWAMP/RWB3	2012	Hg
		SWAMP/RWB4	2004, 2010, 2012 – 2013	Hg, PCBs
		SWAMP/RWB4	2019	Hg
		SWAMP/RWB6	2011	Hg
		SWAMP/RWB6	2013	Hg, PCBs
		SWAMP/RWB7	2004	Hg, PCBs
		SWAMP/RWB7	2014	Hg
		SWAMP/RWB8	2004 – 2005	Hg, PCBs
		SWAMP/RWB9	2014	Hg
		TIC/MID	2008 – 2009	Hg
		TMDL	2004, 2007	Hg
		TMDL/RWB7	2015 – 2016	PCBs
		TSF	2015 – 2016	Hg
		TSMP	1982 – 2003	Hg
		UCDavis	1992, 1995 – 1996	Hg
		USBR	2004	Hg
		USGS	1997, 1999 – 2000, 2002, 2004	Hg

Common Name	Scientific Name	Program/Project Name[a]	Year Collected	Contaminants Analyzed[b]
Pumpkinseed	*Lepomis gibbosus*	FMP	2005 – 2006	Hg
		SGRRMP	2015	Hg, PCBs
		SWAMP1	2007	Hg, PCBs
		SWAMP2	2014	Hg, PCBs
		SWAMP3	2017	Hg
		SWAMP/RWB2	2004	Hg
		SWAMP/RWB4	2010	Hg
		SWAMP/RWB8	2005	Hg, PCBs
		TMDL	2006	Hg
		TMDL/RWB6	2016	Hg
Rainbow Trout	*Oncorhynchus mykiss*	CDFG	1982 – 1983	Hg
		EBMUD/TSMP	2000	Hg
		FMP	2006	Hg
		FMP	2007	Hg, PCBs
		LACDPW	2009	MeHg, PCBs
		MID	2009	Hg
		NFTS	2001 – 2003	Hg, PCBs
		OEHHA	1997	Hg
		PCWA	2007, 2009	Hg
		SWAMP1	2007 – 2008	Hg, PCBs
		SWAMP2	2014	Hg, PCBs
		SWAMP3	2019	Hg
		SWAMP4	2016	Hg, PCBs
		SWAMP5	2012 – 2013	Hg
		SWAMP/RWB2	2004 – 2005, 2011	Hg, PCBs
		SWAMP/RWB2	2013	Hg
		SWAMP/RWB4	2010	Hg, PCBs
		SWAMP/RWB4	2012 – 2013	PCBs
		SWAMP/RWB6	2005, 2011, 2013, 2017	Hg
		SWAMP/RWB8	2004	Hg, PCBs
		TSF	2015 – 2016, 2018	Hg
		TSMP	1982, 1989 – 1990, 1992, 1994 – 1995, 1998, 2000 – 2002	Hg
		USGS	1996 – 1997, 1999, 2002, 2004, 2006	Hg
		YCWA	2011	Hg
Redear Sunfish	*Lepomis microlophus*	CALFED	1999	Hg
		DWR	2003	Hg
		FMP	2005 – 2007	Hg
		SGRRMP	2008, 2015, 2017, 2018	Hg, PCBs
		SWAMP1	2007	Hg, PCBs
		SWAMP2	2014	Hg
		SWAMP3	2017	Hg
		SWAMP4	2016	Hg, PCBs
		SWAMP/RWB1	2015	Hg, PCBs
		SWAMP/RWB2	2005	Hg, PCBs
		SWAMP/RWB3	2012	Hg
		SWAMP/RWB4	2010, 2012 – 2013	Hg
		SWAMP/RWB6	2017	Hg
		SWAMP/RWB7	2014	Hg
		TSMP	1987, 1992 – 1993, 2001	Hg
		USGS	2002	Hg

Common Name	Scientific Name	Program/Project Name[a]	Year Collected	Contaminants Analyzed[b]
Sacramento Pikeminnow	*Ptychocheilus grandis*	DWR	2002	Hg, PCBs
		FMP	2006	Hg
		SWAMP1	2007	Hg, PCBs
		SWAMP3	2019	Hg
		SWAMP4	2016	Hg
		TSF	2015	Hg
		TSMP	1989, 1993, 1999 – 2000	Hg
Sacramento Sucker	*Catostomus occidentalis*	DWR	2002	PCBs
		FMP	2006	Hg
		FMP	2007	Hg, PCBs
		MID	2009	Hg
		SWAMP1	2007 – 2008	Hg, PCBs
		SWAMP3	2017	Hg, PCBs
		SWAMP4	2016	Hg, PCBs
		TSMP	1985, 1987, 1989, 1991, 2001	Hg
		UCDavis	1996	Hg
Smallmouth Bass	*Micropterus dolomieu*	CDFG	1982	Hg
		EBRPD	2016	Hg
		FMP	2006	Hg
		NFTS	2003	Hg, PCBs
		SWAMP1	2007	Hg
		SWAMP1	2008	Hg, PCBs
		SWAMP3	2015, 2017, 2019	Hg
		SWAMP4	2016	Hg
		SWAMP5	2012 – 2013	Hg
		SWAMP/RWB3	2012	Hg
		SWAMP/RWB6	2017	Hg
		TSF	2015 – 2016, 2018	Hg
		TSMP	1989, 1991, 2002	Hg
		USGS	1996 – 1997, 1999, 2004	Hg
		YCWA	2011	Hg
Spotted Bass	*Micropterus punctulatus*	DWR	1996, 2002	Hg, PCBs
		DWR	1997, 2003	Hg
		FMP	2005 – 2007	Hg
		NFTS	2001	Hg, PCBs
		SWAMP1	2007	Hg
		SWAMP3	2015, 2019	Hg
		SWAMP4	2016	Hg
		TSF	2015	Hg
		USBR	2004	Hg
		USGS	1999, 2002 – 2004	Hg
Striped Bass	*Morone saxatilis*	EBRPD	2016 – 2017	Hg
		FMP	2007	Hg
		SWAMP1	2007	Hg, PCBs
		SWAMP2	2014	Hg
		SWAMP3	2017, 2019	Hg
		SWAMP4	2016	Hg
		SWAMP/RWB3	2012	Hg
		SWAMP/RWB4	2012	PCBs
		SWAMP/RWB6	2011	Hg
		SWAMP/RWB7	2014	Hg
		TSMP	1980, 1984, 1989, 2001	Hg

Common Name	Scientific Name	Program/Project Name[a]	Year Collected	Contaminants Analyzed[b]
Threadfin Shad[c]	*Dorosoma petenense*	CDFG	1982	Hg
		EBRPD	2017	Hg
		SWAMP2	2014	Hg
		SWAMP3	2015, 2017, 2019	Hg
		SWAMP4	2016	Hg
		SWAMP5	2012 – 2013	Hg
		SWAMP/RWB4	2019	Hg
		TMDL	2006, 2017	Hg
		UCDavis	1999	Hg
White Catfish	*Ameiurus catus*	CALFED	1999	Hg
		CDFG	1976, 1983, 1984	Hg
		DWR	2002	Hg, PCBs
		FMP	2007	Hg
		SGRRMP	2009, 2015	Hg, PCBs
		SWAMP2	2014	Hg, PCBs
		SWAMP3	2017	Hg
		SWAMP/RWB2	2005	Hg
		SWAMP/RWB3	2012	Hg
		SWAMP/RWB4	2013	Hg, PCBs
		SWAMP/RWB6	2013	Hg, PCBs
		TSF	2016	Hg
		TSMP	1980, 1983, 1988 – 1989, 2002	Hg
		USBR	2004	Hg
		USGS	1996, 2002, 2004	Hg
White Crappie	*Pomoxis annularis*	CDFG	1984	Hg
		SWAMP2	2014	Hg
		TSMP	1984 – 1985	Hg

[a]Over 75 percent of samples were analyzed skinless. Some studies analyzed samples with skin on and others did not report the sample preparation method.
[b]PCB data generated prior to 2000 were excluded from the analysis because data that are more recent are considered more reliable due to improved analytical methods.
[c]Inland Silverside and Threadfin Shad samples were analyzed as whole organisms.

CHEMICAL CONCENTRATIONS

All samples were analyzed for mercury and/or PCBs. Most fish samples were prepared as skinless fillets; however, some studies analyzed samples with skin on, and other studies did not report the fillet preparation method. Inland Silverside and Threadfin Shad samples were analyzed as whole organisms. Samples were analyzed as individual fish or composites.

For this advisory, OEHHA used the weighted (by the number of individual fish) 90th percentile of lake means of the chemical concentrations (in wet weight) for each fish species to estimate human exposure.

MERCURY

Most samples were analyzed for total mercury, as either individual fish or composite samples, using a direct mercury analyzer (DMA) at the CDFW Moss Landing Marine Laboratories (MLML). The DMA method utilizes thermal decomposition and atomic absorption. OEHHA assumed all mercury detected was methylmercury, which is the most common form found in fish and is also the more toxic form (Bloom, 1992). Some samples were analyzed for mercury using Cold Vapor Atomic Fluorescence Spectrometry or a Flow Injection Mercury System, and some studies used other laboratories for analyses. A small number of samples were analyzed for methylmercury rather than total mercury. Table 2 shows the number of samples, total number of fish, number of lakes, number of Regional Water Boards, and the 90th percentile of lake mean mercury concentrations in each species. The mean mercury concentration for each species, as well as the average and range of total length, is shown in Appendix III. The DMA method detection limit (MDL)[7] and the reporting limit (RL)[8] for total mercury were most commonly reported between 3 – 12 and 9 – 36 parts per billion (ppb), respectively, depending on the study. Some studies, such as TSMP, did not report the MDL and RL for mercury.

PCBS

Some samples were analyzed for PCBs, either as composites or individuals. Most PCBs were analyzed by gas chromatography at the CDFW Water Pollution Control Laboratory. A few samples were analyzed at other laboratories. Each of the concentrations presented was the sum of the detected parent compound, congeners[9], or metabolites, where applicable. Since the MDLs or RLs were relatively low (≤ 5 ppb), individual congeners or metabolites with concentrations reported as non-detects were assumed to be zero. This is a standard method of handling non-detect values for PCBs and other chemicals with multiple congeners or metabolites in a given sample when detection levels are adequate (US EPA, 2000a). Table 3 shows the number of samples, total number of fish, number of lakes, number of Regional Water Boards, and the 90th percentile of lake mean PCB concentrations in each species. The mean PCB concentration for each species, as well as the average and range of total length, is shown in Appendix III.

[7] The MDL is the lowest quantity of a chemical that can be distinguished (as greater than zero) in a sample.
[8] The RL is the lowest quantity of a chemical that can be accurately quantified in a sample.
[9] Congeners are related compounds with similar chemical forms. Of the 209 PCB congeners, 48–54 are generally reported.

TABLE 2. 90TH PERCENTILE OF LAKE MEAN MERCURY CONCENTRATIONS IN THE STATEWIDE DATASET BY SPECIES

Species	Number of Samples[a]	Total Number of Fish	Number of Lakes	Number of Regional Water Boards	90th Percentile[b] Lake Mean Mercury Concentration (ppb)
Black Bass Species	4692	5539	204	9	845
Largemouth Bass	4151	4921	196	9	839
Smallmouth Bass	359	376	28	6	906
Spotted Bass	182	242	15	2	779
Brown Trout[c]	149	280	38	3	402
Brown Trout ≤ 16 inches	82	122	23	3	168
Brown Trout > 16 inches	44	50	12	2	811
Bullhead Species	133	367	40	8	249
Black Bullhead	9	40	7	5	230
Brown Bullhead	118	298	33	8	250
Bullhead Species (Unidentified)	6	29	5	4	126
Catfish Species	633	1139	81	9	488
Channel Catfish	519	970	72	9	506
White Catfish	114	169	23	6	580
Common Carp, Goldfish	575	1947	123	9	400
Common Carp	525	1823	118	9	399
Goldfish	50	124	13	4	358
Crappie Species	159	397	37	9	367
Black Crappie	130	308	31	8	353
Crappie Species (Unidentified)	12	53	7	5	430
White Crappie	17	36	3	2	385
Inland Silverside	160	387	32	8	105
Rainbow Trout	667	1476	136	8	133
Eagle Lake Trout	17	48	1	1	n/a
Lahontan Cutthroat Trout	27	36	4	2	68
Rainbow Trout	623	1392	132	8	135
Sacramento Pikeminnow[c]	63	89	10	2	1360
Sacramento Pikeminnow ≤ 16 inches	26	26	7	1	465
Sacramento Pikeminnow > 16 inches	30	36	8	2	1213
Sacramento Sucker	80	235	28	4	549
Striped Bass	98	108	13	9	1035

Species	Number of Samples[a]	Total Number of Fish	Number of Lakes	Number of Regional Water Boards	90th Percentile[b] Lake Mean Mercury Concentration (ppb)
Sunfish Species	692	1922	125	9	276
Bluegill	480	1262	100	9	291
Green Sunfish	42	156	18	7	271
Pumpkinseed	52	103	11	5	262
Redear Sunfish	118	401	36	9	197
Threadfin Shad	149	546	41	8	149

[a]More than 75 percent of samples included in mercury analyses were analyzed skinless. Some studies analyzed samples with skin on and some studies did not report the sample preparation method.
[b]The 90th percentile value is from the distribution of means for the different lakes in the dataset.
[c]The number of samples and fish in each Brown Trout and Sacramento Pikeminnow size classes do not equal the total number for each species due to exclusion of composites that spanned both size classes.
n/a = not applicable due to species collected from a single water body.

Table 3. 90th Percentile of Lake Mean PCB Concentrations in the Statewide Database by Species

Species	Number of Samples[a]	Total Number of Fish	Number of Lakes	Number of Regional Water Boards	90th Percentile[b] Lake Mean PCB Concentration (ppb)
Black Bass Species	189	1034	98	9	12
Largemouth Bass	176	952	95	9	13
Smallmouth Bass	3	20	3	2	1
Spotted Bass	10	62	1	1	n/a
Brown Trout[c]	15	81	15	2	19
Brown Trout ≤ 16 inches	8	47	8	2	14
Brown Trout > 16 inches	2	11	2	2	45
Bullhead Species	27	151	19	8	8
Black Bullhead	3	13	2	2	11
Brown Bullhead	24	138	18	8	4
Catfish Species	99	416	43	7	50
Channel Catfish	92	388	41	7	52
White Catfish	7	28	6	3	37
Common Carp, Goldfish	227	1273	104	9	64
Common Carp	217	1226	102	9	67
Goldfish	10	47	5	2	111

Species	Number of Samples[a]	Total Number of Fish	Number of Lakes	Number of Regional Water Boards	90th Percentile[b] Lake Mean PCB Concentration (ppb)
Crappie Species	15	70	8	7	1
Black Crappie	12	61	7	6	1
Crappie Species (Unidentified)	3	9	1	1	n/a
Rainbow Trout	108	621	91	7	4
Eagle Lake Trout	1	20	1	1	n/a
Lahontan Cutthroat Trout	2	10	2	2	5
Rainbow Trout	105	591	88	7	3
Sacramento Pikeminnow	1	4	1	1	n/a
Sacramento Sucker	18	104	18	4	14
Striped Bass	2	20	2	2	22
Sunfish Species	52	338	31	9	3
Bluegill	35	220	23	8	4
Green Sunfish	2	25	2	2	4
Pumpkinseed	4	28	4	3	2
Redear Sunfish	11	65	6	4	4

[a]More than 80 percent of the samples included in PCB analyses were analyzed skinless. Some studies analyzed samples with skin on and some studies did not report the sample preparation method.
[b]The 90th percentile value is from the distribution of means for the different lakes in the dataset.
[c]The number of samples and fish in each Brown Trout size class do not equal the total number of Brown Trout due to exclusion of composites that spanned both size classes.
n/a = not applicable due to species collected from a single water body.

DEVELOPMENT OF GUIDELINES

The OEHHA fish advisory process considers the health benefits of fish consumption as well as the risk from exposure to the chemical contaminants found in fish. Benefits are included in the advisory process because there is considerable evidence and scientific consensus that fish should be part of a healthy, well-balanced diet. Fish contain many nutrients that are important for general health and, in particular, help promote optimal growth and development of babies and young children, and may reduce the incidence of heart disease in adults (FDA/US EPA, 2017; American Heart Association, 2016; OEHHA, 2008; Institute of Medicine, 2007; Kris-Etherton et al., 2002). Fish are a significant source of the beneficial omega-3 fatty acids, docosahexaenoic acid (DHA) and eicosapentaenoic acid (EPA) (USDA/USDHHS, 2020; Weaver et al., 2008).

The US Department of Agriculture (USDA) recommends “including at least 8 ounces of cooked seafood[10] per week. Young children need less, depending on their age and calorie needs” (MyPlate.gov). According to the 2020–2025 Dietary Guidelines, “women who are pregnant or lactating should consume at least 8 and up to 12 ounces of a variety of seafood per week from choices that are lower in methylmercury” (USDA/USDHHS, 2020). Additionally, “based on FDA and EPA’s advice, depending on body weight, some women should choose seafood lowest in methylmercury or eat less seafood than the amounts in the Healthy U.S.-Style Dietary Pattern” (USDA/USDHHS, 2020). For more detailed information, see USDA/USDHHS (2020) and other USDA MyPlate.gov materials. The particular fish that people eat is an important factor in determining the net beneficial effects of fish consumption. For example, studies have shown that children of mothers who ate low-mercury fish during pregnancy scored better on cognitive tests compared to children of mothers who did not eat fish or ate high-mercury fish (Oken et al., 2005 and 2008). Accordingly, because of the high mercury content of certain fish species, the US Food and Drug Administration (FDA) and the US Environmental Protection Agency recommend that women who are pregnant (or might become pregnant) or breastfeeding, and young children avoid consuming shark, swordfish, tilefish (Gulf of Mexico), bigeye tuna, marlin, orange roughy, and king mackerel (FDA/US EPA, 2017).

To address the potential health concerns associated with exposure to contaminants in sport fish, OEHHA has established ATLs for chemicals that are known to accumulate in the edible tissues of fish. ATLs consider both the toxicity of the chemical and potential benefits of eating fish. OEHHA uses the ATLs to determine the maximum number of servings per week that consumers can eat, for each species and at each location, to limit their exposure to these contaminants. Consumers can use OEHHA’s guidance when choosing which fish and how much to eat as part of an overall healthy diet.

There are two sets of ATLs for methylmercury in fish because of the age-related toxicity of this chemical (OEHHA, 2008). The fetus and children are more sensitive to the toxic effects of methylmercury. Thus, the ATLs for the sensitive population, including women who might become pregnant (typically 18 to 49 years of age) and children 1-17 years, are lower than those for women 50 years and older and men 18 years and older. The lower ATL values for the sensitive population provide additional protection to allow for normal growth and development of the brain and nervous system of unborn babies and children. Detailed discussion about the toxicity of common fish contaminants and health benefits of fish consumption, as well as derivation of the ATLs, are provided in “Development of Fish Contaminant Goals and Advisory Tissue Levels for Common Contaminants in California Sport Fish: Chlordane, DDTs, Dieldrin, Methylmercury, PCBs, Selenium, and Toxaphene” (OEHHA, 2008) and “Development of Fish Contaminant Goals and Advisory Tissue Levels for Common Contaminants in California

[10] Seafood as used here refers to fish and shellfish from freshwater and marine environments.

Sport Fish: Polybrominated Diphenyl Ethers (PBDEs)" (OEHHA, 2011). A list of the ATLs used in this report is presented in Appendix IV.

For each fish species in this advisory, OEHHA compared the 90th percentile of lake mean mercury and PCB concentrations detected in the fillet to the corresponding ATLs to establish the maximum number of servings per week that could be consumed (see Appendix IV). For fish fillets, a serving size is considered to be 8 ounces, prior to cooking, or about the size and thickness of a hand. Children should be given smaller servings. For smaller fish species, several individual fish may be required to yield a serving.

The consumption advice for a fish species is initially based on the chemical with the lowest allowable number of servings per week. Because some chemicals, such as mercury and PCBs, are known to have similar adverse effects, additivity of toxicity is assumed in such cases and may be assessed using a multiple chemical exposure methodology (US EPA, 1989 and 2000b). If two or more chemicals with similar adverse effects are present in fish tissue, multiple chemical exposure methodology is employed. This may result in advising the sensitive population to consume fewer meals per week than would be the case for the presence of one chemical alone, in a similar concentration. The potential effect of multiple chemical exposures (mercury and PCBs) was assessed in Brown Trout 16 inches or less and Common Carp/Goldfish, and was found to affect advice for the latter. Advice for other species in this advisory was based solely on mercury or PCB concentrations without the need to apply the multiple-chemical method.

OEHHA recommends that individuals strive to meet the US Dietary Guidelines' seafood consumption recommendations, while also adhering to federal and OEHHA recommendations to limit the consumption of fish with higher contaminant levels. The advice discussed in the following section represents the maximum recommended number of servings per week for different fish species. People should eat no more than the recommended number of servings for each fish species or species group. OEHHA's consumption advice for a particular fish species can be extended to other closely related fish species[11] known to accumulate similar levels of contaminants.

Consumption advice should not be combined. That is, if a person chooses to eat a serving of fish from the "one-serving-a-week'' category, then they should not eat any other fish from any source (including commercial) until the next week. If a person chooses to eat a serving of fish from the "two servings per week" category, they can combine fish species from that category, or eat one serving of fish from that category and one from a category that recommends more than two servings per week (if available), for a total of two servings in that week. Then they should not eat any other fish from any source (including commercial) until the following week.

[11] Fish species within the same genus are most closely related, and family is the next level of relationship.

CONSUMPTION ADVICE FOR FISH FROM STATEWIDE LAKES AND RESERVOIRS WITHOUT SITE-SPECIFIC ADVICE

The following advice is based on mercury and/or PCB concentrations and applies to all lakes and reservoirs that do not have a site-specific advisory. The advice covers both the sensitive population and the general population. The sensitive population is defined as women 18 to 49 years and children 1 to 17 years, and the general population is defined as women 50 years and older and men 18 years and older.

PCB concentrations are reported below, however, it should be noted that PCB data for several species were not sufficient for evaluation and are included here for informational purposes only. PCB concentrations were high enough to impact advice (or match advice based on mercury levels) only for catfish species, Common Carp and Goldfish.

Black Bass Species (Largemouth Bass, Smallmouth Bass, Spotted Bass)

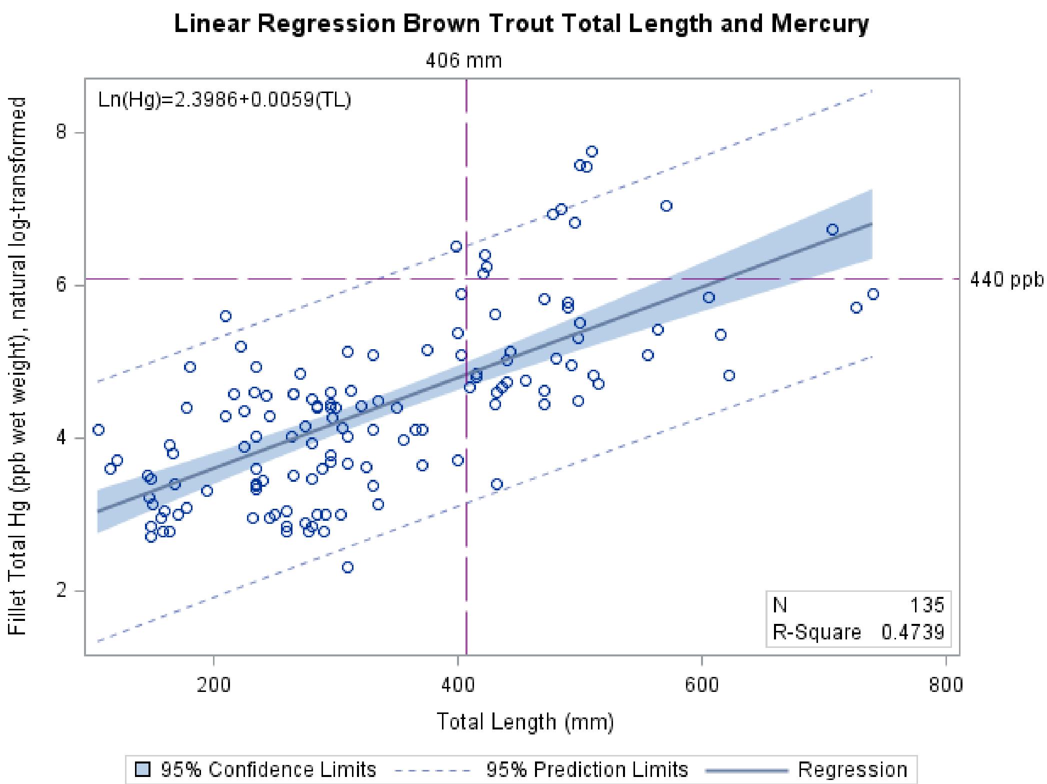
The 90th percentiles of lake mean mercury and PCB concentrations in black bass species were 845 ppb and 12 ppb, respectively. The 90th percentiles of lake mean mercury and PCB concentrations for individual black bass species were as follows: Largemouth Bass, Hg: 839 ppb, PCB: 13 ppb; Smallmouth Bass, Hg: 906 ppb, PCBs: 1 ppb; and Spotted Bass, Hg: 779 ppb, PCBs not determined because samples were collected from only one water body. OEHHA recommends no consumption of black bass species for the sensitive population, and a maximum of one serving per week for the general population, based on mercury.

Brown Trout

The 90th percentiles of lake mean mercury and PCB concentrations in all Brown Trout were 402 ppb and 19 ppb, respectively. Mercury concentrations are known to increase as fish age (grow), and, for this reason, OEHHA advises consumers to eat smaller (legal-sized) fish of a species. Brown Trout, in particular, are known to change diet from invertebrates to fish as they age, which results in greater mercury accumulation. Brown Trout exceeding 16 inches feed almost exclusively on fish (Moyle, 2002). For this reason, advice for Brown Trout was adjusted for size in the 2013 advisory. After evaluating the data, separate advice was provided for Brown Trout greater than 16 inches and for those equal to or less than 16 inches. A similar assessment was conducted for this advisory, and regression analysis was performed using individual Brown Trout samples to examine the relationship between mercury concentration and fish length. Mercury concentrations were natural log transformed to normalize the distribution. Brown Trout that were not included in the statewide dataset because they did not meet the minimum edible size to take were included in this analysis to best define the relationship between the two variables. Analysis showed that 47% of the increase in mercury concentration could be accounted for by an increase in fish length (R^2=0.4739), as shown in Figure 3. This relationship was statistically significant ($p<0.0001$).

Brown Trout samples were grouped by total length, as defined above, with the removal of composite samples that did not provide minimum or maximum total lengths of the fish in the composite, or included fish from each size group. Further examination showed that when fish were at or under 16 inches (406 mm) in length (n=122), mercury levels were lower than the 440 ppb threshold in all but one sample (see Figure 3). The 90th percentile of lake mean mercury concentrations in these Brown Trout was 168 ppb compared to 811 ppb in Brown Trout larger than 16 inches. Thus, for Brown Trout over 16 inches, OEHHA recommends no consumption for the sensitive population and a maximum of one serving a week for the general population, based on mercury. For Brown Trout 16 inches or less, OEHHA recommends a maximum of one serving per week for the sensitive population and a maximum of three servings per week for the general population, based on mercury.

FIGURE 3. FISH LENGTH AND MERCURY CONCENTRATIONS OF INDIVIDUAL BROWN TROUT SAMPLES, INCLUDING UNDERSIZED FISH



BULLHEAD SPECIES (BLACK BULLHEAD, BROWN BULLHEAD)

The 90th percentiles of lake mean mercury and PCB concentrations in bullhead species were 249 ppb and 8 ppb, respectively. The 90th percentile of lake mean mercury concentrations for individual bullhead species were as follows: Black Bullhead, Hg: 230 ppb, PCBs: 11 ppb; Brown Bullhead, Hg: 250 ppb, PCBs: 4 ppb; and unidentified bullhead species, Hg: 126 ppb, PCBs not analyzed. OEHHA recommends a maximum of one serving a week of bullhead species for the sensitive population, and a maximum of two servings a week for the general population, based on mercury.

Catfish Species (Channel Catfish, White Catfish)

The 90th percentiles of lake mean mercury and PCB concentrations in catfish species were 488 ppb and 50 ppb, respectively. The 90th percentile of lake mean mercury and PCB concentrations for individual catfish species were as follows: Channel Catfish, Hg: 506 ppb, PCBs: 52 ppb and White Catfish, Hg: 580 ppb, PCBs: 37 ppb. OEHHA recommends no consumption for the sensitive population, based on mercury, and a maximum of one serving per week for the general population, based on mercury or PCBs.

Common Carp, Goldfish

Common Carp and Goldfish were grouped because they are very closely related and frequently hybridize when they are co-located, making them difficult to distinguish (Halas et al., 2018). Further, the data show that mercury and PCB concentrations for Common Carp and Goldfish are relatively similar, and the same advice would be provided for the two species if they were to be considered separately.

The 90th percentiles of lake mean mercury and PCB concentrations in Common Carp and Goldfish were 400 ppb and 64 ppb, respectively. The 90th percentile of lake mean mercury and PCB concentrations for individual species were as follows: Common Carp, Hg: 399 ppb, PCBs: 67 ppb and Goldfish, Hg: 358 ppb, PCBs: 111 ppb. OEHHA recommends no consumption of Common Carp or Goldfish for the sensitive population, based on a combined exposure to mercury and PCBs, and a maximum of one serving a week for the general population, based on PCBs.

Crappie Species (Black Crappie, White Crappie)

The 90th percentiles of lake mean mercury and PCB concentrations in crappie species were 367 ppb and 1 ppb, respectively. The 90th percentile of lake mean mercury and PCB concentrations for individual crappie species were as follows: Black Crappie, Hg: 353 ppb, PCBs: 1 ppb; White Crappie, Hg: 385 ppb, PCBs not analyzed; and unidentified crappie species, Hg: 430 ppb, PCBs not determined because samples were collected from only one water body. OEHHA recommends a maximum of one serving per week for the sensitive population and a maximum of two servings per week for the general population, based on mercury.

Inland Silverside

The 90th percentile of lake mean mercury concentrations in Inland Silverside was 105 ppb. OEHHA recommends a maximum of two servings per week for the sensitive population. At this concentration, OEHHA would typically recommend a maximum of six servings per week for the general population. For risk communication purposes on the advisory poster (page 8), OEHHA elected to group this species with the four servings per week species for the general population. PCBs were not analyzed in this species.

Rainbow Trout Species (Lahontan Cutthroat Trout, Rainbow Trout, Eagle Lake Trout)

Eagle Lake Trout and Lahontan Cutthroat Trout were grouped with Rainbow Trout for several reasons. Eagle Lake Trout are a subspecies of Rainbow Trout that are found exclusively in Eagle Lake, and therefore have a very similar appearance to Rainbow Trout. Lahontan Cutthroat Trout are closely related to Rainbow Trout, and the two species are known to hybridize in water bodies where they are co-located (Peacock and Kirchoff, 2003).[12] Although the sample sizes for Eagle Lake Trout and Lahontan Cutthroat Trout were too small to draw conclusions, it is expected that chemical concentrations would be similar between these species.

The 90th percentiles of lake mean mercury and PCB concentrations in Rainbow Trout species were 133 ppb and 4 ppb, respectively. The 90th percentile of lake mean mercury and PCB concentrations for individual Rainbow Trout and Rainbow Trout-related species were as follows: Lahontan Cutthroat Trout, Hg: 68, PCBs: 5 ppb and Rainbow Trout, Hg: 135 ppb, PCBs: 3 ppb. Because Eagle Lake Trout were only collected from one water body, a 90th percentile of lake mean mercury concentration could not be calculated. Based on the concentration of mercury in Rainbow Trout species, OEHHA recommends a maximum of two servings per week for the sensitive population and maximum of four servings per week for the general population.

Sacramento Pikeminnow

Only 63 Sacramento Pikeminnow samples comprised of 89 fish from 10 water bodies were available from California lakes and reservoirs, almost all of which were collected from Region 5. The historical range of Sacramento Pikeminnow is located primarily in Region 5[13] and, thus, the limited range of available data was not considered a reason to exclude this species from the advisory. Because Sacramento Pikeminnow had the highest 90th percentile of lake mean mercury concentration of any species in the dataset (1,360 ppb), OEHHA considered it important to provide advice for this species, even with the relatively small sample size. OEHHA reviewed the much larger database for Sacramento Pikeminnow from California rivers (231 samples comprised of 579 fish) and found that the mean mercury concentration of Sacramento Pikeminnow from rivers was even higher than that from lakes and reservoirs (948 ppb versus 820 ppb). OEHHA determined that these additional data would support providing advice for this species.

---

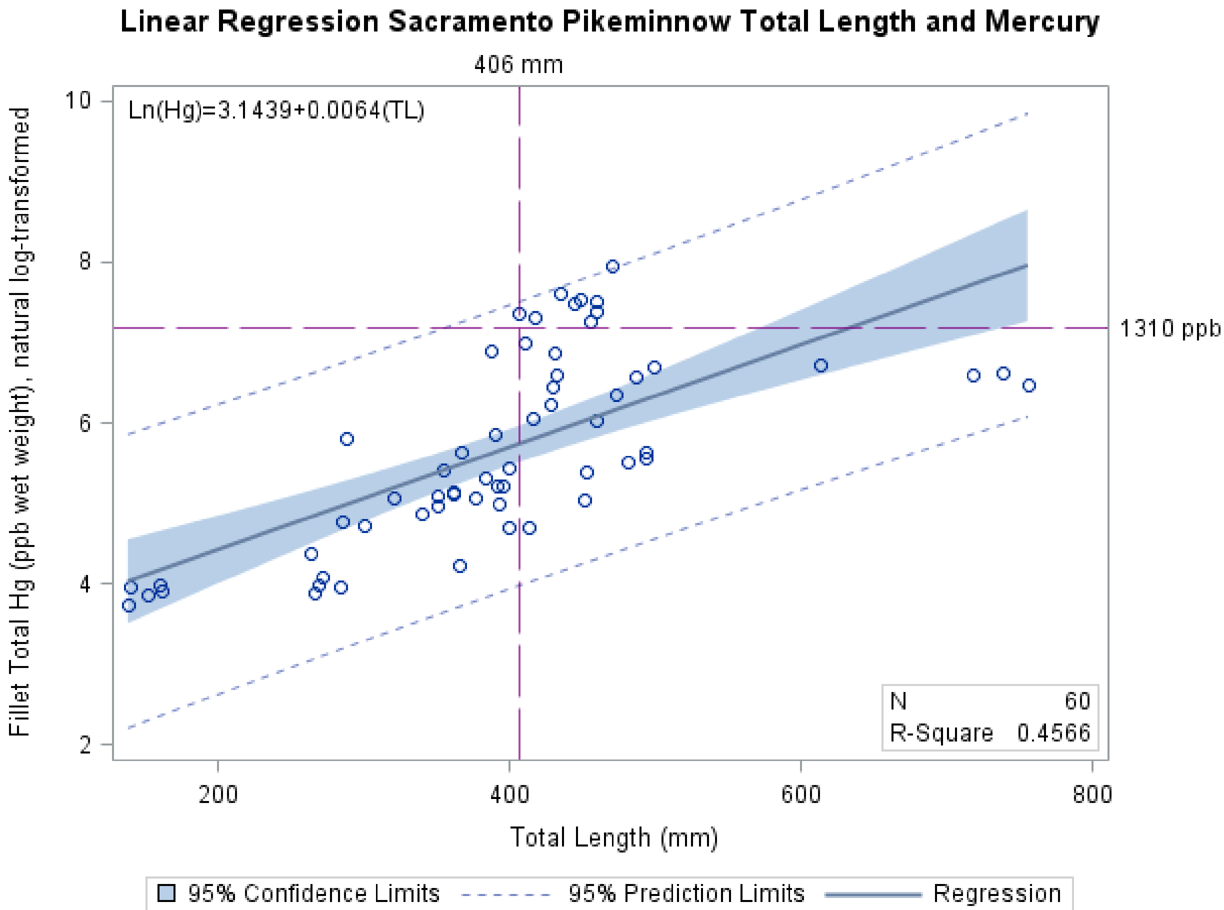
[12] Further information on Eagle Lake Rainbow Trout and Lahontan Cutthroat Trout can be found online at: https://caltrout.org/pdf/Eagle Lake Rainbow Trout.pdf and https://caltrout.org/sos/species-accounts/trout/lahontan-cutthroat-trout-2, respectively.

[13] Information on the historical range of Sacramento Pikeminnow can be found online at: https://nas.er.usgs.gov/queries/factsheet.aspx?speciesid=627.

OEHHA conducted a similar assessment for Sacramento Pikeminnow as was done for Brown Trout to determine if size-adjusted advice could be provided to allow some consumption for the general population. Regression analysis was performed using individual Sacramento Pikeminnow samples collected from lakes and reservoirs, including fish that were excluded from the statewide dataset because they were below the edible size to take, to examine the relationship between mercury concentrations and fish length. Mercury concentrations were natural log transformed to normalize the distribution. The analysis showed that 46% of the increase in mercury concentration could be accounted for by an increase in fish length (R^2=0.4566), as shown in Figure 4. This relationship was statistically significant ($p<0.0001$). Further examination of the data showed that, when fish were at or under 16 inches in length, mercury levels were lower than the 1,310 ppb threshold for all samples. The 90th percentile of lake mean mercury concentrations in fish at or under 16 inches in length was 465 ppb compared to 1,213 ppb in Sacramento Pikeminnow larger than 16 inches. The 90th percentile in Sacramento Pikeminnow over 16 inches (1,213 ppb) was lower than the 90th percentile of all Sacramento Pikeminnow samples combined (1,360 ppb); this was the result of excluding several composite samples from the size analysis due to a lack of information regarding minimum and maximum lengths for fish in the composites. Most of the excluded composite samples had mean total lengths over 16 inches and mercury concentrations in excess of 1310 ppb.

OEHHA does not recommend consumption of Sacramento Pikeminnow over 16 inches for any population group, based on mercury. For Sacramento Pikeminnow 16 inches or less, OEHHA recommends no consumption for the sensitive population and a maximum of one serving per week for the general population, based on mercury.

FIGURE 4. FISH LENGTH AND MERCURY CONCENTRATIONS OF INDIVIDUAL SACRAMENTO PIKEMINNOW SAMPLES, INCLUDING UNDERSIZED FISH



SACRAMENTO SUCKER

Sacramento Sucker had a relatively small sample size (80 samples of 235 fish) from 28 water bodies. The majority of the samples were from Region 5, which is consistent with the historical range of the species.[14] OEHHA considered it important to provide advice for this species because 27% of the samples exceeded the do not consume threshold for mercury for the sensitive population (>440 ppb). The 90th percentiles of lake mean mercury and PCB concentrations were 549 ppb and 14 ppb, respectively. OEHHA recommends no consumption of Sacramento Sucker for the sensitive population and a maximum of one serving per week for the general population, based on mercury.

---

[14] Information on the historical range of Sacramento Sucker can be found online at: https://nas.er.usgs.gov/queries/factsheet.aspx?SpeciesID=349.

STRIPED BASS

Striped Bass were available from only 13 lakes and reservoirs. Nearly 40% of these were collected from relatively low-mercury areas of the state (southeastern California). Nonetheless, mean mercury levels were comparable to Striped Bass collected from anadromous waters, for which an advisory has been in place since 2012. An analysis of lakes and reservoirs where Largemouth Bass and Striped Bass were both sampled showed that, in 10 of 12 water bodies, mercury concentrations in Striped Bass were higher than in Largemouth Bass (data not shown). For these reasons, OEHHA determined that Striped Bass should be included in the updated statewide advisory. The 90th percentiles of lake mean mercury and PCB concentrations were 1,035 ppb and 22 ppb, respectively. OEHHA recommends no consumption of Striped Bass for the sensitive population and a maximum of one serving per week for the general population, based on mercury.

SUNFISH SPECIES (BLUEGILL, GREEN SUNFISH, PUMPKINSEED, REDEAR SUNFISH)

The 90th percentiles of lake mean mercury and PCB concentrations in sunfish species were 276 ppb and 3 ppb, respectively. The 90th percentile of lake mean mercury and PCB concentrations for individual sunfish species were as follows: Bluegill, Hg: 291 ppb, PCBs: 4 ppb; Green Sunfish, Hg: 271 ppb, PCBs: 4 ppb; Pumpkinseed, Hg: 262 ppb, PCBs: 2 ppb; and Redear Sunfish, Hg: 197 ppb and PCBs: 4 ppb. OEHHA recommends a maximum of one serving per week for the sensitive population and a maximum of two servings per week for the general population, based on mercury.

THREADFIN SHAD

The 90th percentile of lake mean mercury concentrations in Threadfin Shad was 149 ppb. OEHHA recommends a maximum of two servings per week for the sensitive population and a maximum of four servings per week for the general population, based on mercury. PCBs were not analyzed in this species.

RECOMMENDED MAXIMUM NUMBER OF SERVINGS

The recommended maximum numbers of servings per week for fish from lakes without site-specific advice are shown in Table 4.

TABLE 4. RECOMMENDED MAXIMUM NUMBER OF SERVINGS PER WEEK FOR FISH FROM CALIFORNIA LAKES AND RESERVOIRS WITHOUT SITE-SPECIFIC ADVICE

Fish Species	Women 18–49 years and Children 1–17 years	Women 50 years and older and Men 18 years and older
Black Bass Species	0	1
Brown Trout >16 inches	0	1
Brown Trout ≤16 inches	1	3
Bullhead Species	1	2
Catfish Species	0	1
Common Carp	0	1
Crappie Species	1	2
Goldfish	0	1
Inland Silverside	2	4
Rainbow Trout	2	4
Sacramento Pikeminnow >16 inches	0	0
Sacramento Pikeminnow ≤16 inches	0	1
Sacramento Sucker	0	1
Sunfish Species	1	2
Striped Bass	0	1
Threadfin Shad	2	4

REFERENCES

Alpers, C.N., M.P. Hunerlach, J.T. May, and R.L. Hothem. 2005. Mercury contamination from historical gold mining in California. U.S. Geological Survey, U.S. Department of the Interior. Fact Sheet 2005–3014 Version 1.1. Online at: http://pubs.usgs.gov/fs/2005/3014/fs2005_3014_v1.1.pdf.

American Heart Association. 2016. Fish and Omega-3 Fatty Acids. Online at: http://www.heart.org/HEARTORG/HealthyLiving/HealthyEating/HealthyDietGoals/Fish-and-Omega-3-Fatty-Acids_UCM_303248_Article.jsp#.Wl57BnlG2Uk.

Bloom, N.S. 1992. On the chemical form of mercury in edible fish and marine invertebrate tissue. Can. J. Fish. Aquat. Sci. 49(5):1010–1017.

Davis, J.A., J.R.M. Ross, S.N. Bezalel, A. Bonnema, G. Ichikawa, B. Jakl, and W.A. Heim. 2019a. Long-Term Monitoring of Bass Lakes and Reservoirs in California: 2015 Data Report. A Report of the Surface Water Ambient Monitoring Program (SWAMP). California State Water Resources Control Board, Sacramento, CA.

Davis, J.A., J.R.M. Ross, S.N. Bezalel, A. Bonnema, G. Ichikawa, B. Jakl, and W.A. Heim. 2019b. Long-Term Monitoring of Bass Lakes and Reservoirs in California: 2017 Data Report. A Report of the Surface Water Ambient Monitoring Program (SWAMP). California State Water Resources Control Board, Sacramento, CA.

Davis, J.A., A. Bonnema, B. Jakl, G. Ichikawa, and W.A. Heim. *Manuscript in preparation* [a]. Long-Term Monitoring of Bass Lakes and Reservoirs in California: 2019 Data Report. A Report of the Surface Water Ambient Monitoring Program (SWAMP). California State Water Resources Control Board, Sacramento, CA.

Davis, J.A., J.R.M. Ross, S.N. Bezalel, A. Bonnema, G. Ichikawa, B. Jakl, and W.A. Heim. *Manuscript in preparation* [b]. Monitoring of Contaminants in Fish from California Lakes and Reservoirs: 2016 Data Report. A Report of the Surface Water Ambient Monitoring Program (SWAMP). California State Water Resources Control Board, Sacramento, CA.

FDA/US EPA. 2017. Eating Fish: What pregnant women and parents should know. Advice by FDA and US EPA/January, 2017. Online at: https://www.fda.gov/food/consumers/advice-about-eating-fish.

Halas D., N. Lovejoy, and N.E. Mandrak. 2018. Undetected Diversity of Goldfish (Carassius spp.) in North America. Aquatic Invasions. 13(2): 211–219. Online at: http://www.aquaticinvasions.net/2018/AI_2018_Halas_etal.pdf.

Institute of Medicine. 2007. Seafood choices, balancing benefits and risks. Committee on Nutrient Relationships in Seafood: Selections to Balance Benefits and Risks.

Institute of Medicine, Food and Nutrition Board. The National Academies Press, Washington, D.C.

Kris-Etherton, P.M., W.S. Harris, and L.J. Appel. 2002. Fish consumption, fish oil, omega-3 fatty acids, and cardiovascular disease. Circ. 106:2747–2757.

Moyle, P.B. 2002. Inland Fishes of California. University of California Press.

OEHHA. 2005. General Protocol for Sport Fish Sampling and Analysis. Office of Environmental Health Hazard Assessment, California Environmental Protection Agency, Sacramento, California. Online at: http://oehha.ca.gov/media/downloads/fish/document/fishsamplingprotocol2005.pdf.

OEHHA. 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, Sacramento, California. Online at: http://oehha.ca.gov/media/downloads/fish/report/atlmhgandothers2008c.pdf.

OEHHA. 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, Sacramento, California. Online at: http://oehha.ca.gov/media/downloads/fish/report/pbdes052311.pdf.

OEHHA. 2013. Statewide Health Advisory and Guidelines for Eating Fish from California's Lakes and Reservoirs Without Site-specific Advice. Office of Environmental Health Hazard Assessment, California Environmental Protection Agency, Sacramento, California.

Oken, E., R.O. Wright, K.P. Kleinman, D. Bellinger, C.J. Amarasiriwardena, H. Hu, J.W. Rich-Edwards, and M.W. Gillman. 2005. Maternal fish consumption, hair mercury, and infant cognition in a U.S. cohort. Environ. Health Perspect. 113(10):1376–1380.

Oken, E., J.S. Radesky, R.O. Wright, D. Bellinger, C.J. Amarasiriwardena, K.P. Kleinman, H. Hu, J.W. Rich-Edwards, and M.W. Gillman. 2008. Maternal fish intake during pregnancy, blood mercury levels, and infant cognition at age 3 years in a U.S. cohort. Am. J. Epidemiol. 167(10):1171–1181.

Peacock, M.M, and V. Kirchoff. 2003. Assessing the Conservation Value of Hybridized Cutthroat Trout Populations in the Quinn River Drainage, Nevada. Trans. Am. Fish. Soc. 113(2):309–325.

SFEI. 2009. Fish Mercury Project. A collaborative effort of the San Francisco Estuary Institute, the University of California, Davis, the California Department of Fish and

Game, the Moss Landing Marine Laboratory, the California Department of Health Services, and the California Protection Agency's Office of Environmental Health Hazard Assessment. Online at: http://www.sfei.org/cmr/fishmercury/index.php#sthash.puWVjPvC.dpbs.

SWRCB. 2007. Bioaccumulation of Pollutants in California Waters: A Review of Historic Data and Assessment of Impacts on Fishing and Aquatic Life. State Water Resources Control Board, California Environmental Protection Agency, Sacramento, California. Online at: http://www.waterboards.ca.gov/water_issues/programs/swamp/docs/bop/cw117_swrcb_report.pdf.

SWRCB. 2010. Contaminants in Fish from California Lakes and Reservoirs, 2007–2008: Summary Report on a Two-Year Screening Survey. State Water Resources Control Board, California Environmental Protection Agency, Sacramento, California. Online at: http://www.waterboards.ca.gov/water_issues/programs/swamp/docs/lakes_study/lake_survey_yr2_no_app.pdf.

SWRCB. 2013. State Mussel Watch (SMW) Program/Toxic Substances Monitoring (TSM) Program. State Water Resources Control Board, California Environmental Protection Agency, Sacramento, California. Online at: http://www.waterboards.ca.gov/water_issues/programs/swamp/mussel_watch.shtml.

USDA/USDHHS. 2020. 2020–2025 Dietary Guidelines for Americans. 9th Edition. U.S. Department of Health and Human Services and U.S. Department of Agriculture. Online at: https://www.dietaryguidelines.gov/sites/default/files/2020-12/Dietary_Guidelines_for_Americans_2020-2025.pdf.

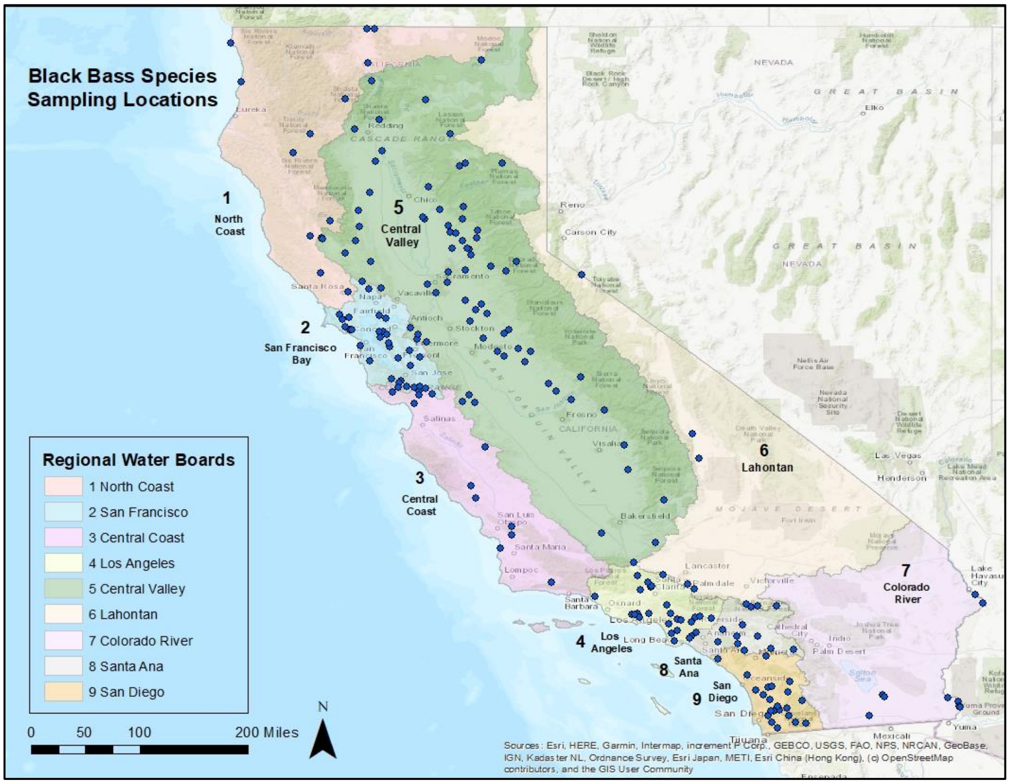
US EPA. 1989. Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part A) Interim Final. EPA/5401-89/002, December 1989. Office of Emergency and Remedial Response, U.S. Environmental Protection Agency, Washington, D.C. Online at: https://rais.ornl.gov/documents/HHEMA.pdf.

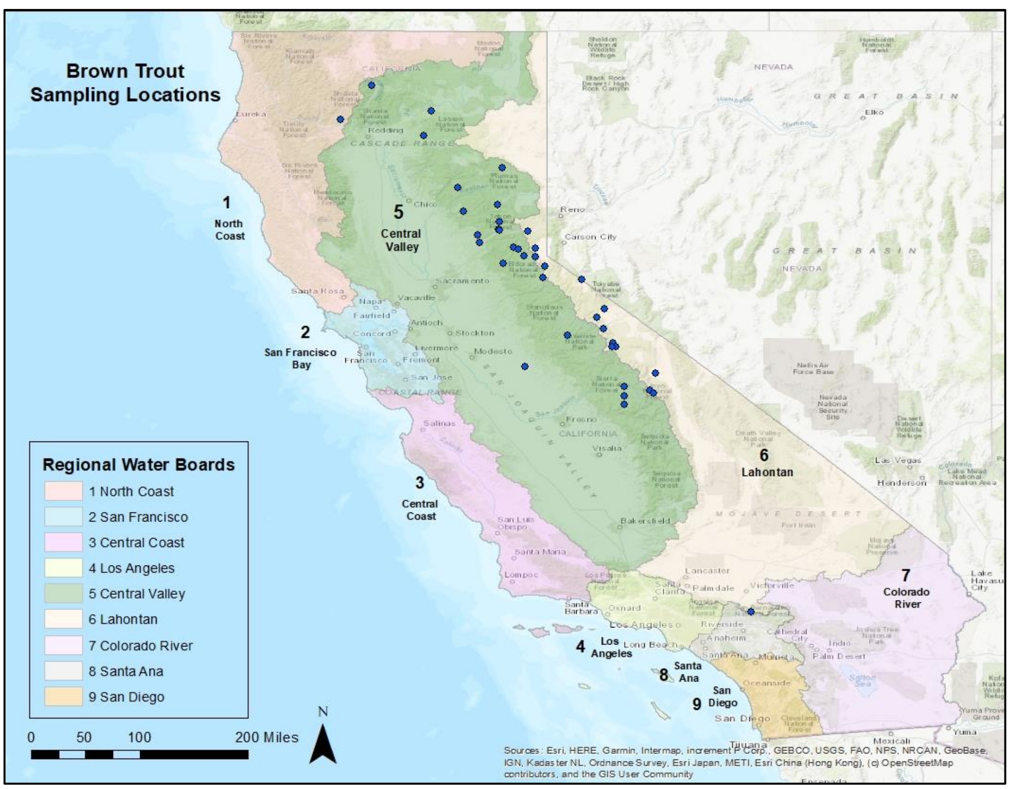
US EPA. 2000a. Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories: Volume 1. Fish Sampling and Analysis, 3rd Edition. EPA 823-B00-007. Office of Water, U.S. Environmental Protection Agency, Washington, D.C.

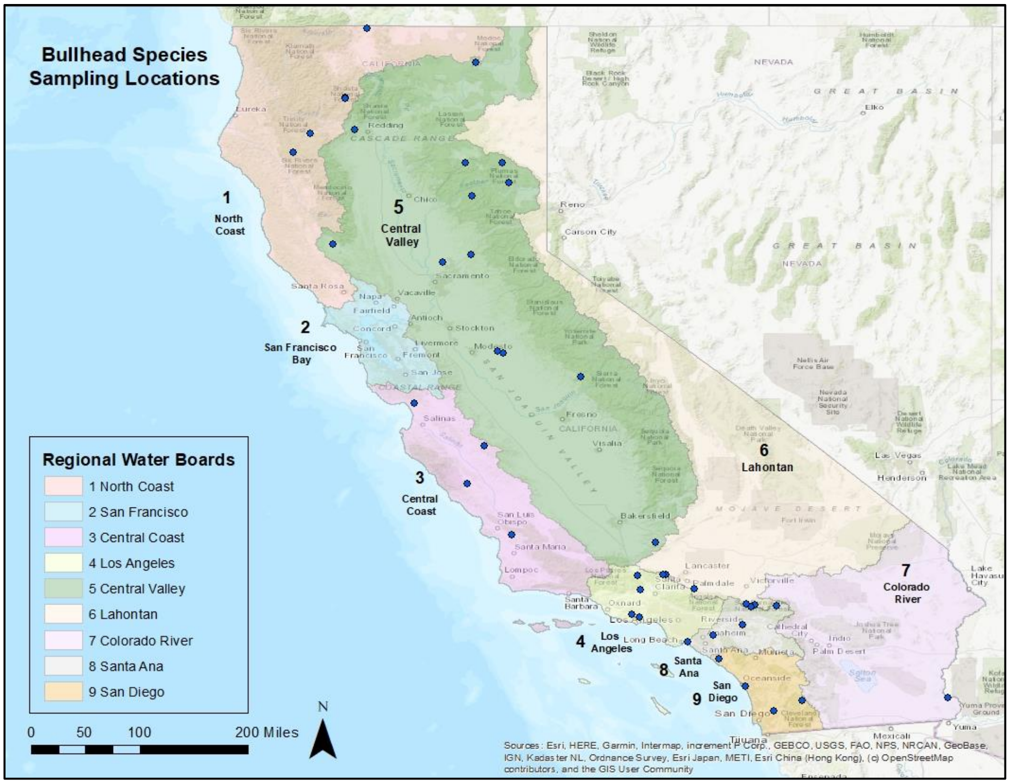
US EPA. 2000b. Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories: Volume 2. Risk Assessment and Fish Consumption Limits, 3rd Edition. EPA 823-B-00-007. Office of Water, U.S. Environmental Protection Agency, Washington, D.C.

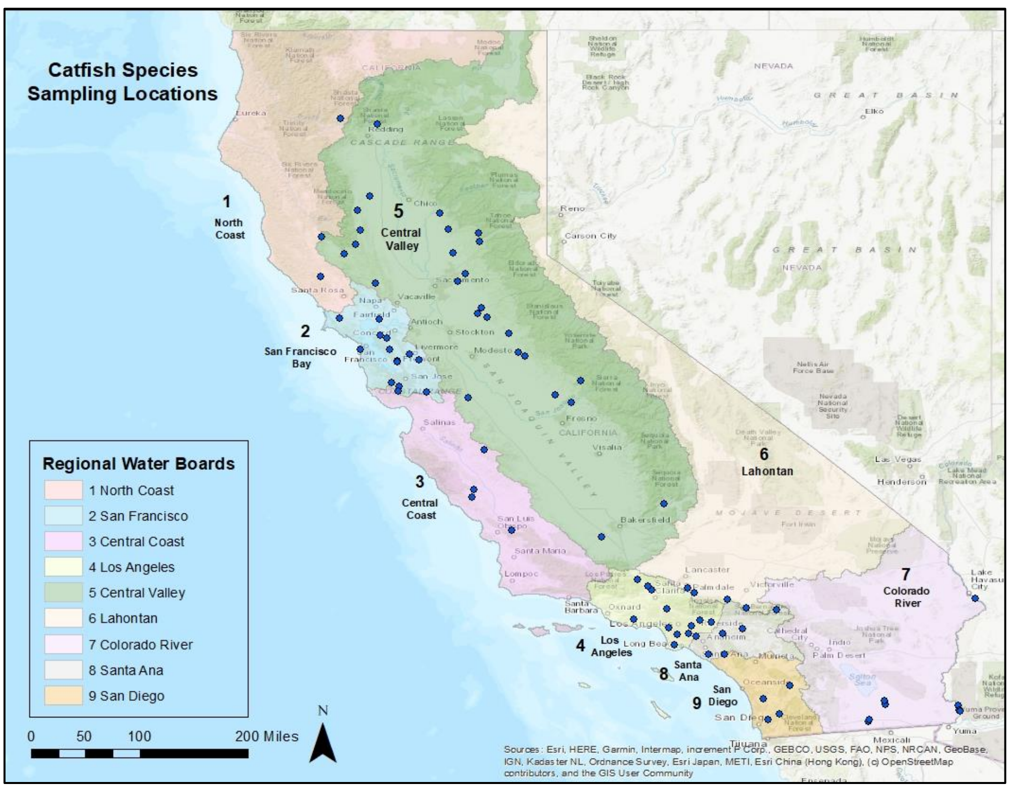
Weaver, K.L., P. Ivester, J.A. Chilton, M.D. Wilson, P. Pandey, and F.H. Chilton. 2008. The content of favorable and unfavorable polyunsaturated fatty acids found in commonly eaten fish. J. American Dietetic Assoc. 108:1178–1185.

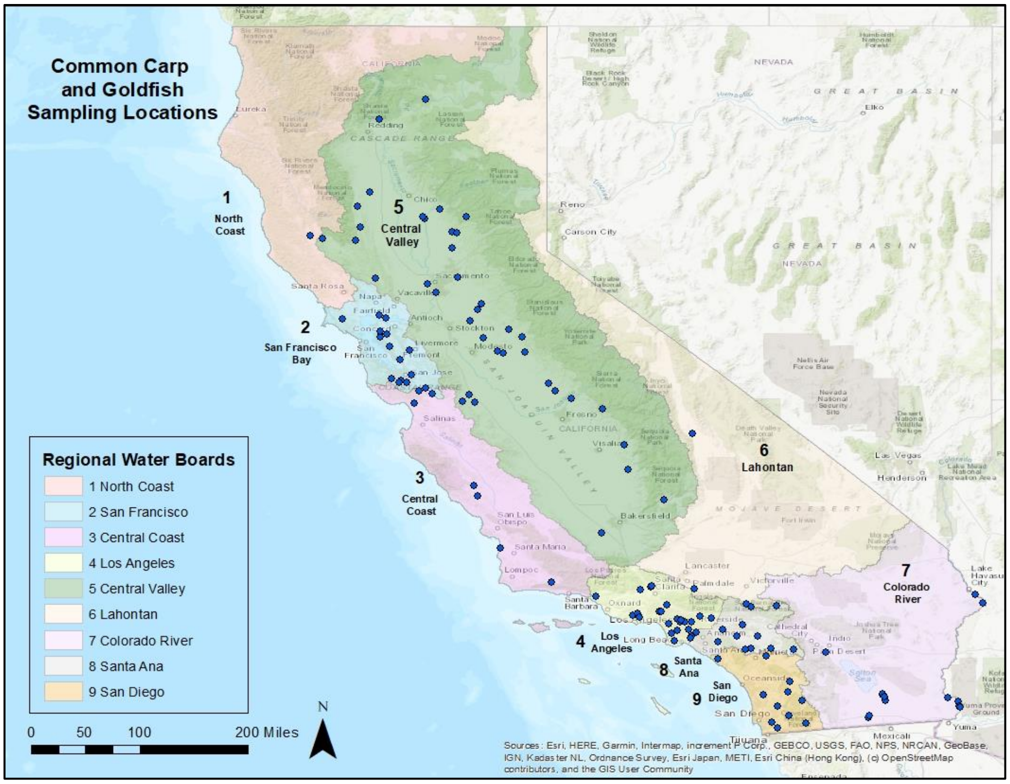
APPENDIX I. SAMPLING LOCATIONS FOR MERCURY AND PCB ANALYSES BY SPECIES

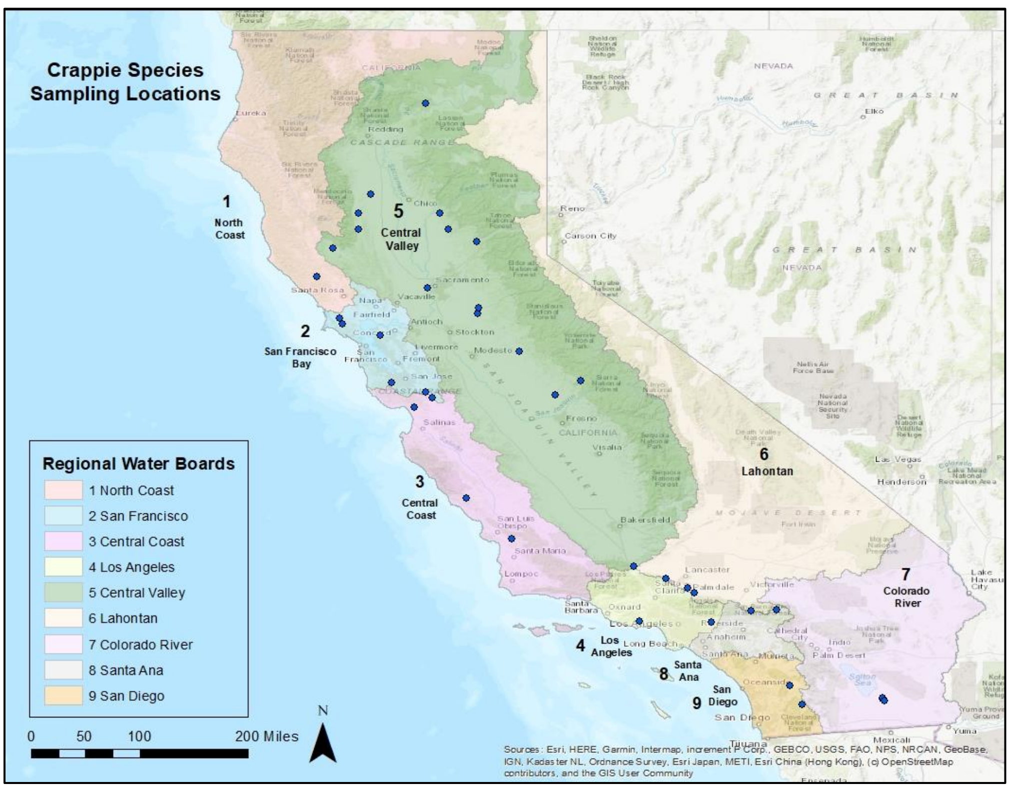


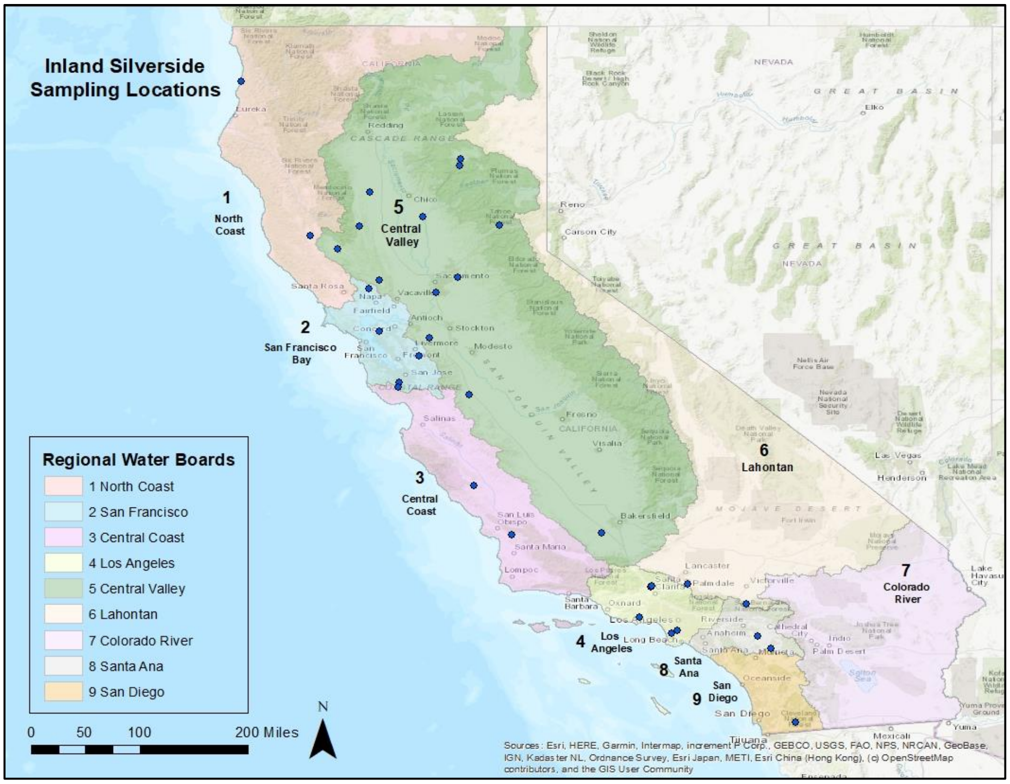


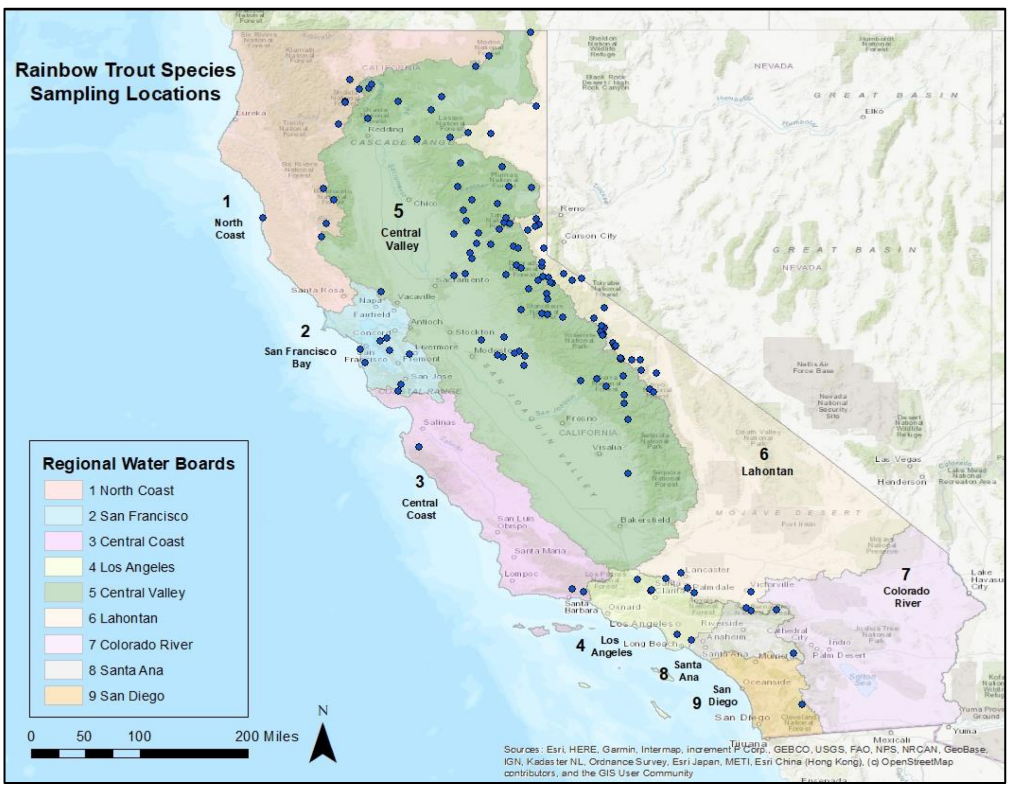

Bullhead Species
Sampling Locations
Regional Water Boards
1 North Coast
2 San Francisco
3 Central Coast
4 Los Angeles
5 Central Valley
6 Lahontan
7 Colorado River
8 Santa Ana
9 San Diego
0 50 100 200 Miles
N
1 North Coast
2 San Francisco Bay
3 Central Coast
4 Los Angeles
5 Central Valley
6 Lahontan
7 Colorado River
8 Santa Ana
9 San Diego
Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community

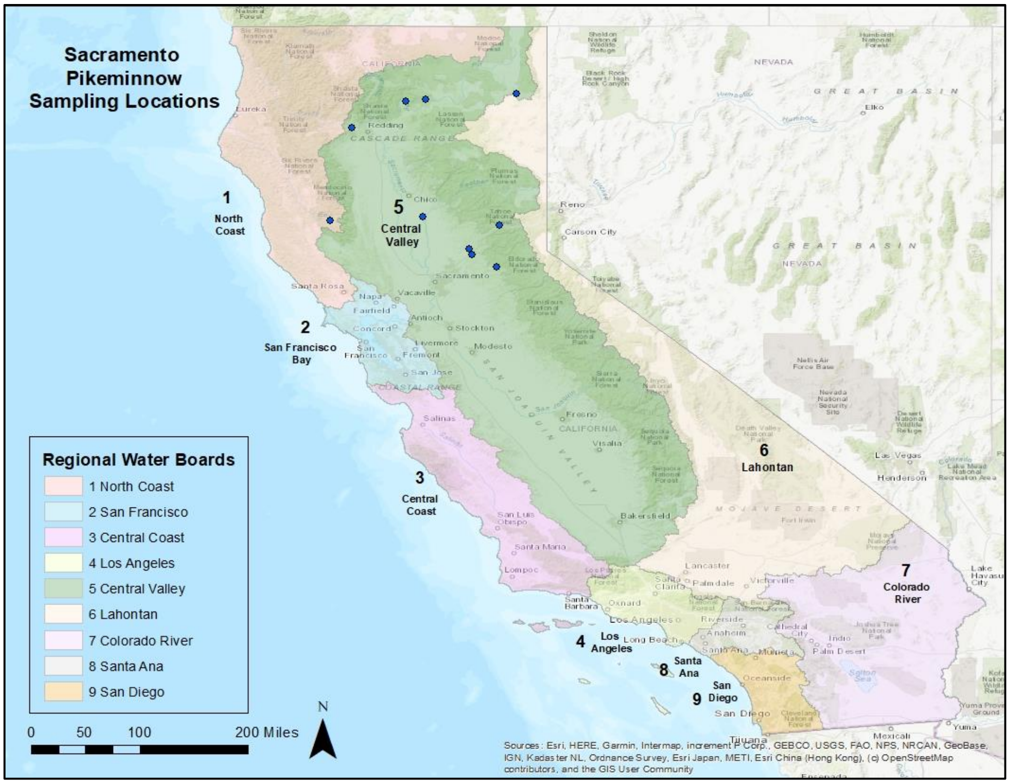

Catfish Species
Sampling Locations
Regional Water Boards
1 North Coast
2 San Francisco
3 Central Coast
4 Los Angeles
5 Central Valley
6 Lahontan
7 Colorado River
8 Santa Ana
9 San Diego
0 50 100 200 Miles
N
1 North Coast
2 San Francisco Bay
3 Central Coast
4 Los Angeles
5 Central Valley
6 Lahontan
7 Colorado River
8 Santa Ana
9 San Diego
Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community

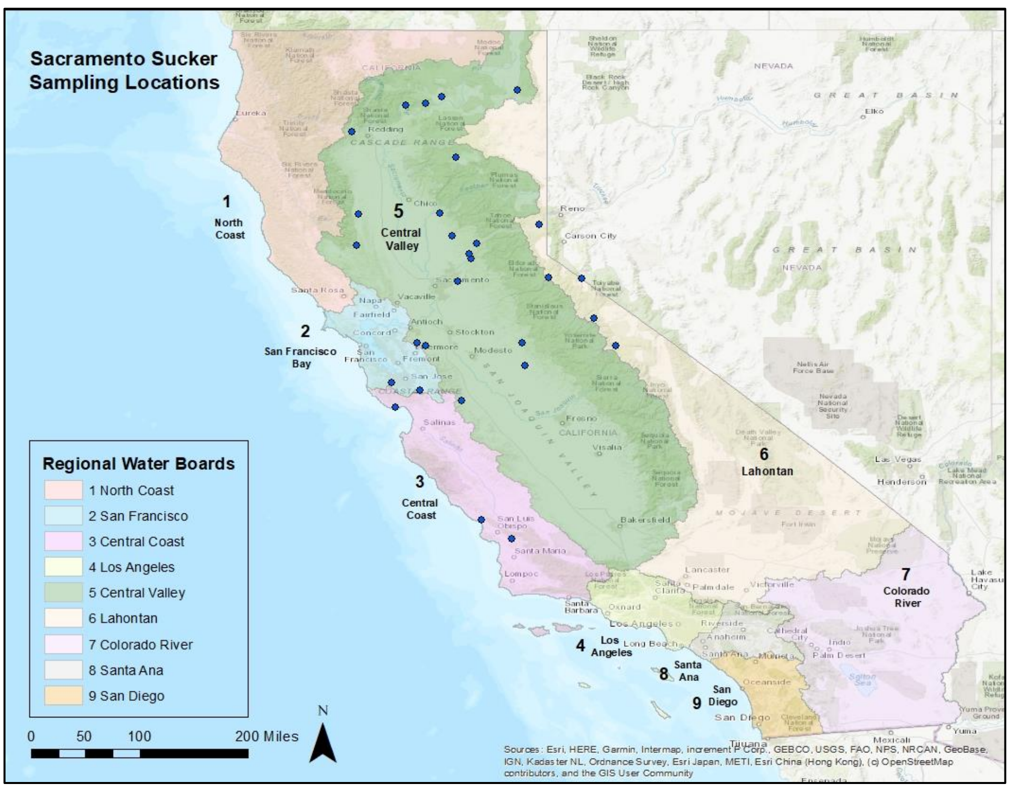

Common Carp and Goldfish Sampling Locations
1 North Coast
2 San Francisco Bay
3 Central Coast
4 Los Angeles
5 Central Valley
6 Lahontan
7 Colorado River
8 Santa Ana
9 San Diego
Regional Water Boards
1 North Coast
2 San Francisco
3 Central Coast
4 Los Angeles
5 Central Valley
6 Lahontan
7 Colorado River
8 Santa Ana
9 San Diego
0 50 100 200 Miles
N
Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community

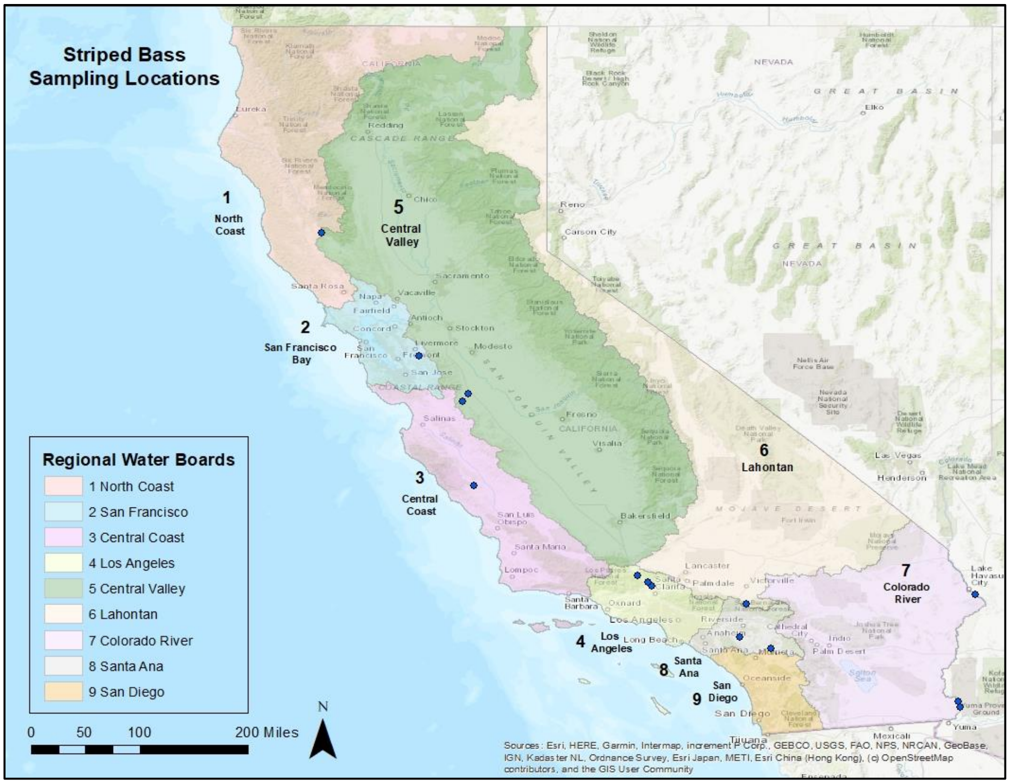

Crappie Species Sampling Locations
1 North Coast
2 San Francisco Bay
3 Central Coast
4 Los Angeles
5 Central Valley
6 Lahontan
7 Colorado River
8 Santa Ana
9 San Diego
Regional Water Boards
1 North Coast
2 San Francisco
3 Central Coast
4 Los Angeles
5 Central Valley
6 Lahontan
7 Colorado River
8 Santa Ana
9 San Diego
0 50 100 200 Miles
N
Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community

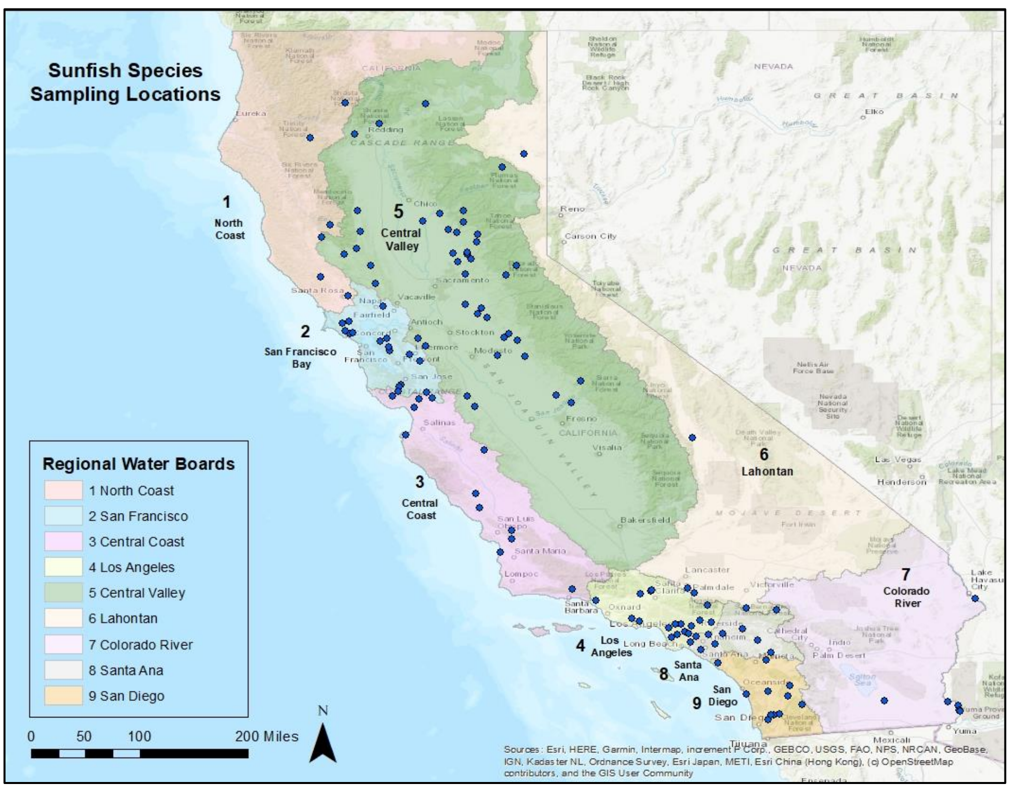

Inland Silverside Sampling Locations
1 North Coast
2 San Francisco Bay
3 Central Coast
4 Los Angeles
5 Central Valley
6 Lahontan
7 Colorado River
8 Santa Ana
9 San Diego
Regional Water Boards
1 North Coast
2 San Francisco
3 Central Coast
4 Los Angeles
5 Central Valley
6 Lahontan
7 Colorado River
8 Santa Ana
9 San Diego
0 50 100 200 Miles
N
Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community

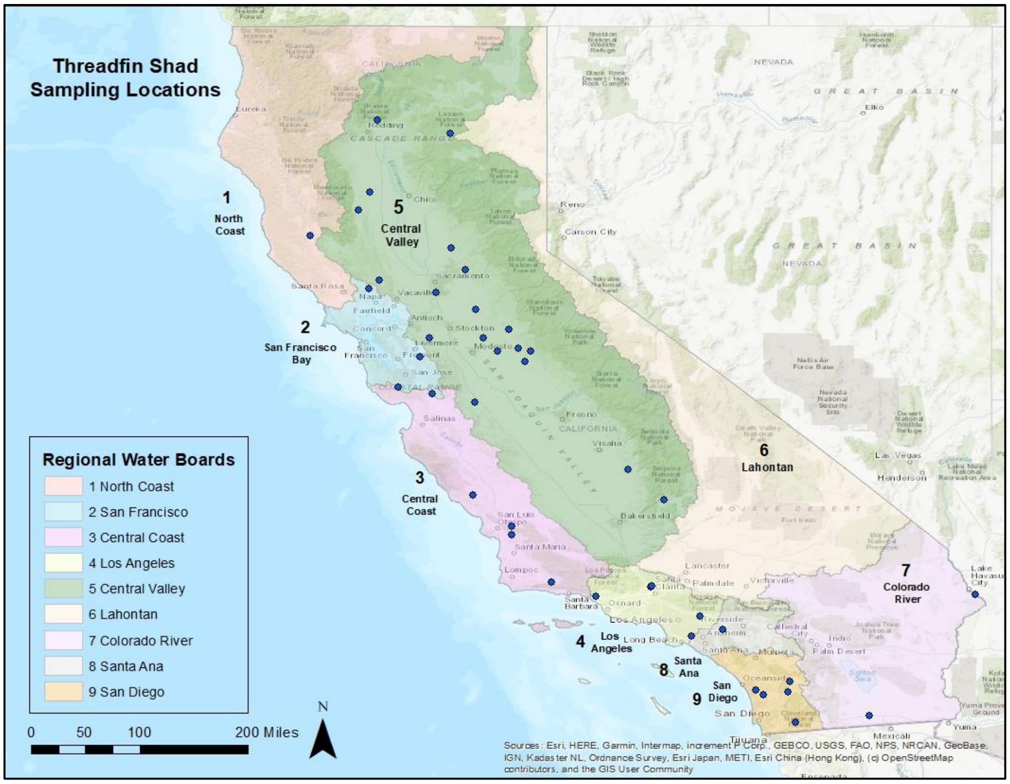

Rainbow Trout Species Sampling Locations
1 North Coast
2 San Francisco Bay
3 Central Coast
4 Los Angeles
5 Central Valley
6 Lahontan
7 Colorado River
8 Santa Ana
9 San Diego
Regional Water Boards
1 North Coast
2 San Francisco
3 Central Coast
4 Los Angeles
5 Central Valley
6 Lahontan
7 Colorado River
8 Santa Ana
9 San Diego
0 50 100 200 Miles
N
Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community


Sacramento Pikeminnow Sampling Locations
Regional Water Boards
1 North Coast
2 San Francisco
3 Central Coast
4 Los Angeles
5 Central Valley
6 Lahontan
7 Colorado River
8 Santa Ana
9 San Diego
0 50 100 200 Miles
N
Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community


Sacramento Sucker Sampling Locations
Regional Water Boards
1 North Coast
2 San Francisco
3 Central Coast
4 Los Angeles
5 Central Valley
6 Lahontan
7 Colorado River
8 Santa Ana
9 San Diego
0 50 100 200 Miles
N
Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community


Striped Bass
Sampling Locations
Regional Water Boards
1 North Coast
2 San Francisco
3 Central Coast
4 Los Angeles
5 Central Valley
6 Lahontan
7 Colorado River
8 Santa Ana
9 San Diego
0 50 100 200 Miles
N
1 North Coast
2 San Francisco Bay
3 Central Coast
4 Los Angeles
5 Central Valley
6 Lahontan
7 Colorado River
8 Santa Ana
9 San Diego
Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community


Sunfish Species
Sampling Locations
Regional Water Boards
1 North Coast
2 San Francisco
3 Central Coast
4 Los Angeles
5 Central Valley
6 Lahontan
7 Colorado River
8 Santa Ana
9 San Diego
0 50 100 200 Miles
N
1 North Coast
2 San Francisco Bay
3 Central Coast
4 Los Angeles
5 Central Valley
6 Lahontan
7 Colorado River
8 Santa Ana
9 San Diego
Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community


Threadfin Shad Sampling Locations
Regional Water Boards
1 North Coast
2 San Francisco
3 Central Coast
4 Los Angeles
5 Central Valley
6 Lahontan
7 Colorado River
8 Santa Ana
9 San Diego
1 North Coast
2 San Francisco Bay
3 Central Coast
4 Los Angeles
5 Central Valley
6 Lahontan
7 Colorado River
8 Santa Ana
9 San Diego
0 50 100 200 Miles
N
Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community

APPENDIX II. DATA SOURCES

Program or Project Name	Data Source[a]	Fish Advisory Using Non-CEDEN Data[b]
CALFED	CEDEN	Not Applicable
California Department of Fish and Game (CDFG)	CEDEN	Not Applicable
Department of Water Resources (DWR)	DWR	Lake Oroville, Thermalito Forebay and Afterbay
East Bay Regional Park District (EBRPD)	EBRPD	Lake del Valle
East Bay Municipal Utility District/Toxic Substances Monitoring Program (EBMUD/TSMP)	EBMUD/TSMP	San Pablo Reservoir
Fish Mercury Project (FMP)	CEDEN	Not Applicable
Los Angeles County Department of Public Works (LACDPW)	LACDPW	Puddingstone Reservoir
Los Angeles County Flood Control District (LACFCD)	LACFCD	Puddingstone Reservoir
Los Angeles County Chief Executive Office (LACCEO)	LACCEO	Magic Johnson Lakes
Merced Irrigation District (MID)	MID	Lake McClure, Lake McSwain
National Fish Tissue Study (NFTS)	CEDEN	Not Applicable
OEHHA/United States Environmental Protection Agency (OEHHA/USEPA)	OEHHA	Black Butte Reservoir, San Pablo Reservoir
Placer County Water Agency (PCWA)	PWCA	French Meadows Reservoir, Hell Hole Reservoir
San Gabriel River Regional Monitoring Program (SGRRMP)	CEDEN, SGRRMP	Puddingstone Reservoir, Santa Fe Dam Lake
Statewide Lake and Reservoir Screening Study (SWAMP1)	CEDEN	Not Applicable
Low Concentrations of Contaminants Survey (SWAMP2)	CEDEN	Not Applicable
Long-Term Monitoring Survey (SWAMP3)	CEDEN	Not Applicable
Monitoring of Contaminants in Fish from California Lakes and Reservoirs (SWAMP4)	CEDEN	Not Applicable
Wildlife Bioaccumulation Monitoring Survey (SWAMP5)	CEDEN	Not Applicable
SWAMP/Regional Water Boards (SWAMP/RWB)	CEDEN	Not Applicable
The Sierra Fund (TSF)	CEDEN	Not Applicable
Total Maximum Daily Load/Region 6 (TMDL/RWB6)	CEDEN	Not Applicable
Total Maximum Daily Load/Region 7 (TMDL/RWB7)	CEDEN	Not Applicable
Total Maximum Daily Load (TMDL)	CEDEN, TMDL	Lexington Reservoir
Toxic Substances Monitoring Program (TSMP)	CEDEN	Not Applicable
Turlock/Modesto Irrigation District (TID/MID)	TID/MID	Don Pedro Lake
University of California-Davis (UCDavis)	CEDEN	Not Applicable
United States Bureau of Reclamation (USBR)	USBR	New Melones Reservoir
United States Geological Survey (USGS)	CEDEN, USGS	Camp Far West Reservoir, Folsom Lake
Yuba County Water Agency (YCWA)	YCWA	New Bullards Bar Reservoir

[a]Data sourced from the California Environmental Data Exchange Network (CEDEN) can be found online at: https://ceden.waterboards.ca.gov/AdvancedQueryTool.
[b]OEHHA's fish consumption advisories are online at: https://oehha.ca.gov/fish/advisories. Fish advisory reports provide either the raw or summarized data used to develop advice for a particular water body.

APPENDIX III. MEAN MERCURY AND PCB CONCENTRATIONS IN FISH USED IN THE STATEWIDE DATASET

Species	Number of Samples[a]	Total Number of Fish	Total Length (mm)		Mercury Concentration[a] (ppb)	
			Mean[b]	Range[c]	Mean[b]	Range[c]
Black Bass Species	4692	5539	380	305 – 854	462	0 – 4080
Largemouth Bass	4151	4921	383	305 – 854	454	0 – 4080
Smallmouth Bass	359	376	357	305 – 557	503	49 – 2060
Spotted Bass	182	242	359	305 – 522	561	132 – 1550
Brown Trout	149	280	353	203 – 740	202	10 – 2310
Brown Trout ≤ 16 inches	82	122	293	203 – 402	82	10 – 662
Brown Trout > 16 inches	44	50	492	410 – 740	474	30 – 2310
Bullhead Species	133	367	297	177 – 535	117	0 – 771
Black Bullhead	9	40	262	177 – 510	141	30 – 310
Brown Bullhead	118	298	306	200 – 535	116	6 – 771
Bullhead Species (Unidentified)	6	29	255	216 – 338	91	0 – 150
Catfish Species	633	1139	476	200 – 1396	283	0 – 1900
Channel Catfish	519	970	498	200 – 1396	273	0 – 1900
White Catfish	114	169	351	202 – 835	341	9 – 1020
Common Carp and Goldfish	575	1947	539	282 – 1467	164	0 – 1200
Common Carp	525	1823	551	288 – 1467	163	0 – 1200
Goldfish	50	124	363	282 – 457	175	0 – 514
Crappie Species	159	397	231	150 – 386	222	0 – 1300
Black Crappie	130	308	232	151 – 386	219	0 – 810
Crappie Species (Unidentified)	12	53	238	150 – 365	231	36 – 591
White Crappie	17	36	217	151 – 318	237	50 – 1300
Inland Silverside	160	387	63	34 – 120	60	10 – 542
Rainbow Trout	667	1476	331	200 – 598	61	0 – 910
Eagle Lake Trout	17	48	472	392 – 547	49	20 – 104
Lahontan Cutthroat Trout	27	36	315	240 – 511	55	10 – 356
Rainbow Trout	623	1392	327	200 – 598	62	0 – 910
Sacramento Pikeminnow	63	89	446	264 – 836	820	48 – 2850
Sacramento Pikeminnow ≤ 16 inches	26	26	343	264 – 400	189	48 – 987
Sacramento Pikeminnow > 16 inches	30	36	541	407 – 836	864	110 – 2850

Species	Number of Samples[a]	Total Number of Fish	Total Length (mm)		Mercury Concentration[a] (ppb)	
			Mean[b]	Range[c]	Mean[b]	Range[c]
Sacramento Sucker	80	235	405	211 – 604	274	32 – 1230
Striped Bass	98	108	565	458 – 794	422	29 – 1490
Sunfish Species	692	1922	160	100 – 382	124	0 – 1300
Bluegill	480	1262	150	100 – 315	131	0 – 1300
Green Sunfish	42	156	146	101 – 209	142	10 – 500
Pumpkinseed	52	103	146	100 – 220	134	22 – 348
Redear Sunfish	118	401	202	131 – 382	94	0 – 595
Threadfin Shad	149	546	75	28 – 136	58	1 – 249

[a]More than 75 percent of the samples included in mercury analyses were analyzed skinless. Some studies analyzed samples with skin on and some studies did not report the sample preparation method.
[b]Means are an arithmetic average of individual values and/or a weighted average of composites.
[c]Range of individuals and/or range of the composites.

Species	Number of Samples[a]	Total Number of Fish	Total Length (mm)		PCBs Concentration[a] (ppb)	
			Mean[b]	Range[c]	Mean[b]	Range[c]
Black Bass Species	189	1034	370	305 – 582	8	0 – 86
Largemouth Bass	176	952	372	305 – 582	8	0 – 86
Smallmouth Bass	3	20	356	319 – 405	0	0 – 1
Spotted Bass	10	62	346	313 – 380	12	3 – 35
Brown Trout	15	81	343	203 – 605	6	0 – 55
Brown Trout ≤ 16 inches	8	47	290	203 – 392	5	0 – 28
Brown Trout > 16 inches	2	11	467	412 – 605	17	3 – 55
Bullhead Species	27	151	306	202 – 535	2	0 – 18
Black Bullhead	3	13	330	226 – 510	8	5 – 12
Brown Bullhead	24	138	303	202 – 535	2	0 – 18
Catfish Species	99	416	500	200 – 836	24	0 – 316
Channel Catfish	92	388	504	200 – 836	24	0 – 316
White Catfish	7	28	438	285 – 686	21	0 – 57
Common Carp and Goldfish	227	1273	563	288 – 1011	31	0 – 473
Common Carp	217	1226	570	288 – 1011	31	0 – 473
Goldfish	10	47	393	309 – 457	35	1 – 173

Species	Number of Samples[a]	Total Number of Fish	Total Length (mm)		PCBs Concentration[a] (ppb)	
			Mean[b]	Range[c]	Mean[b]	Range[c]
Crappie Species	15	70	217	152 – 355	1	0 – 4
Black Crappie	12	61	219	152 – 355	0	0 – 3
Crappie Species (Unidentified)	3	9	203	179 – 239	3	2 – 4
Rainbow Trout	108	621	326	214 – 587	2	0 – 17
Eagle Lake Trout	1	20	504	448 – 547	2	2 – 2
Lahontan Cutthroat Trout	2	10	297	250 – 334	4	2 – 6
Rainbow Trout	105	591	320	214 – 587	2	0 – 17
Sacramento Pikeminnow	1	4	401	354 – 432	1	1 – 1
Sacramento Sucker	18	104	408	223 – 564	7	0 – 66
Striped Bass	2	20	530	481 – 582	13	9 – 25
Sunfish Species	52	338	164	102 – 277	3	0 – 32
Bluegill	35	220	162	107 – 277	3	0 – 32
Green Sunfish	2	25	136	102 – 186	3	0 – 5
Pumpkinseed	4	28	137	111 – 189	0	0 – 2
Redear Sunfish	11	65	190	146 – 242	1	0 – 5

[a]More than 80 percent of the samples used for PCB analysis in the statewide dataset were analyzed skinless. Some studies analyzed samples with skin on and some studies did not report the sample preparation method.
[b]Means are an arithmetic average of individual values and/or a weighted average of composites.
[c]Range of individuals and/or range of the composites.

APPENDIX IV. ADVISORY TISSUE LEVELS

Advisory Tissue Levels (ATLs; OEHHA, 2008 and 2011) guide the development of advice for people eating sport fish. ATLs are levels of contaminants found in fish that correspond to the maximum numbers of recommended fish servings. OEHHA uses ATLs to provide advice to prevent consumers from being exposed to:

- More than the reference dose[15] on an average daily basis for chemicals not known to cause cancer, such as methylmercury, or
- For cancer-causing chemicals, a risk level greater than one additional cancer case in a population of 10,000 people consuming fish at the given consumption rate over a lifetime. This cancer endpoint is the maximum acceptable risk level recommended by the US EPA (2000b) for fish advisories.

For each chemical, ATLs were determined for both cancer and non-cancer risk, if appropriate, for one to seven eight-ounce servings per week. The most health-protective ATLs for each chemical, selected from either cancer or non-cancer based risk, are shown in the table below for zero to seven servings per week. When the guidelines for eating fish from a water body are followed, exposure to chemicals in fish from the water body would be at or below the average daily reference dose or the cancer risk probability of one in 10,000.

ADVISORY TISSUE LEVELS FOR SELECTED ANALYTES

Contaminant	Consumption Frequency Categories (8-ounce servings/week)[a] and ATLs (in ppb)							
	7	6	5	4	3	2	1	0
Chlordanes	≤ 80	>80–90	>90–110	>110–140	>140–190	>190–280	>280–560	>560
DDTs	≤ 220	>220–260	>260–310	>310–390	>390–520	>520–1,000	>1,000–2,100	>2,100
Dieldrin	≤ 7	>7–8	>8–9	>9–11	>11–15	>15–23	>23–46	>46
MeHg (Women 18–49 and children 1–17)	≤ 31	>31–36	>36–44	>44–55	>55–70	>70–150	>150–440	>440
MeHg (Women > 49 and men)	≤ 94	>94–109	>109–130	>130–160	>160–220	>220–440	>440–1,310	>1,310
PBDEs	≤ 45	>45–52	>52–63	>63–78	>78–100	>100–210	>210–630	>630
PCBs	≤ 9	>9–10	>10–13	>13–16	>16–21	>21–42	>42–120	>120
Selenium	≤ 1000	>1,000–1200	>1,200–1,400	>1,400–1,800	>1,800–2,500	>2,500–4,900	>4,900–15,000	>15,000
Toxaphene	≤ 87	>87–100	>100–120	>120–150	>150–200	>200–300	>300–610	>610

[a] Serving sizes (prior to cooking, wet weight) are based on an average 160-pound person. Individuals weighing less than 160 pounds should eat proportionately smaller amounts.

---

[15] The reference dose is an estimate of the maximum daily exposure to a chemical likely to be without significant risk of harmful health effects over a lifetime.