HEALTH ADVISORY AND GUIDELINES FOR EATING FISH FROM THE LOWER FEATHER RIVER INCLUDING THE DIVERSION POOL BELOW LAKE OROVILLE (Butte, Sutter, and Yuba Counties)

September 2014
(Updated November 2022)

California Environmental Protection Agency
Office of Environmental Health Hazard Assessment

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ACKNOWLEDGEMENT

Sampling and analysis of fish for contaminants are critical in the development of fish consumption advice. The Office of Environmental Health Hazard Assessment (OEHHA) acknowledges the contribution of information from the following entities: San Francisco Estuary Institute, Department of Water Resources, State Water Resources Control Board, as well as the California Department of Fish and Wildlife and its Moss Landing Marine Laboratories and Water Pollution Control Laboratory. We thank the staff at the Central Valley Regional Water Quality Control Board, especially Michelle Wood, for coordinating and providing data to us. Data were also obtained from the California Environmental Data Exchange Network (http://www.ceden.us/AdvancedQueryTool). Walker Wieland and Huyen Tran Pham (OEHHA) created the maps using ArcMap (10.1) from Environmental Systems Resource Institute (ESRI, Redlands, California).

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LIST OF ABBREVIATIONS

ATL	Advisory Tissue Level
CDFW	California Department of Fish and Wildlife
DDTs	dichlorodiphenyltrichloroethane (DDT) and its metabolites dichlorodiphenyldichloroethane (DDD) and dichlorodiphenyl-dichloroethylene (DDE)
DWR	Department of Water Resources
FMP	Fish Mercury Project
MDL	method detection limit
mm	millimeter
OEHHA	Office of Environmental Health Hazard Assessment
PCBs	polychlorinated biphenyls (as congeners)
ppb	parts per billion
RL	Reporting Limit
SFEI-CALFED	San Francisco Estuary Institute-CALFED (A collaboration of California and federal agencies)
SRWP	Sacramento River Watershed Program
SWAMP	Surface Water Ambient Monitoring Program
SWRCB	State Water Resources Control Board
TSMP	Toxic Substances Monitoring Program
US EPA	U.S. Environmental Protection Agency

PREFACE

The Office of Environmental Health Hazard Assessment (OEHHA), a department within the California Environmental Protection Agency, is responsible for evaluating potential public health risks from chemical contamination of sport fish. This task includes issuing health 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; and
  - 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 booklets in the "Public Health Advisory on Fish Consumption" section.

This report on the health advisory and consumption guidelines for eating fish from the Lower Feather River and Diversion Pool is an update of consumption advisories issued in 2006 and 2009. The 2014 update resulted from OEHHA's evaluation of additional data and water bodies (e.g., the Diversion Pool) associated with the Feather River. This report describes how guidelines were developed. This advisory was updated in November 2022 to include the revised advice for anadromous species (OEHHA, 2022). The consumption advice for the Lower Feather River including the Diversion Pool is summarized in the two illustrations after the Table of Contents.

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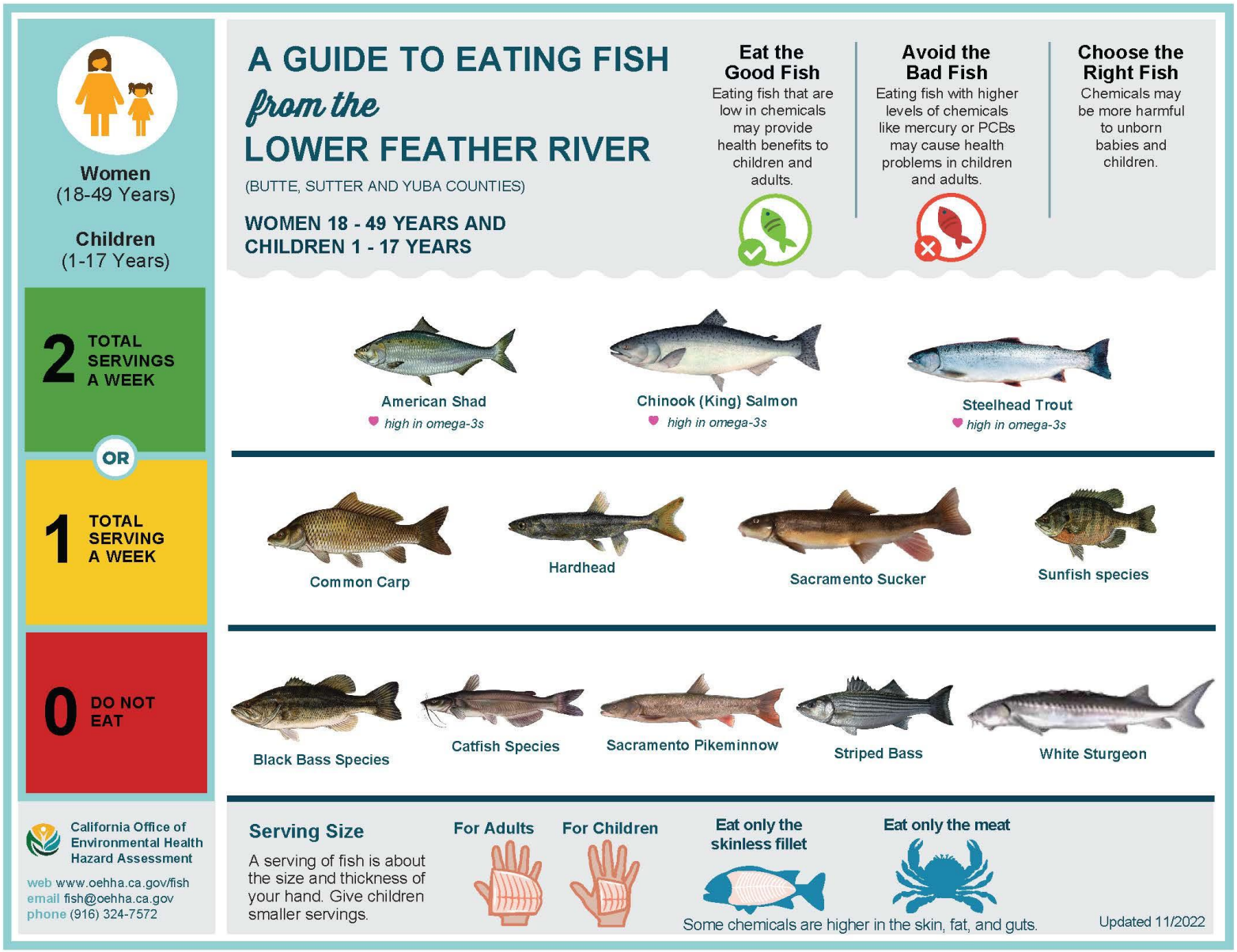
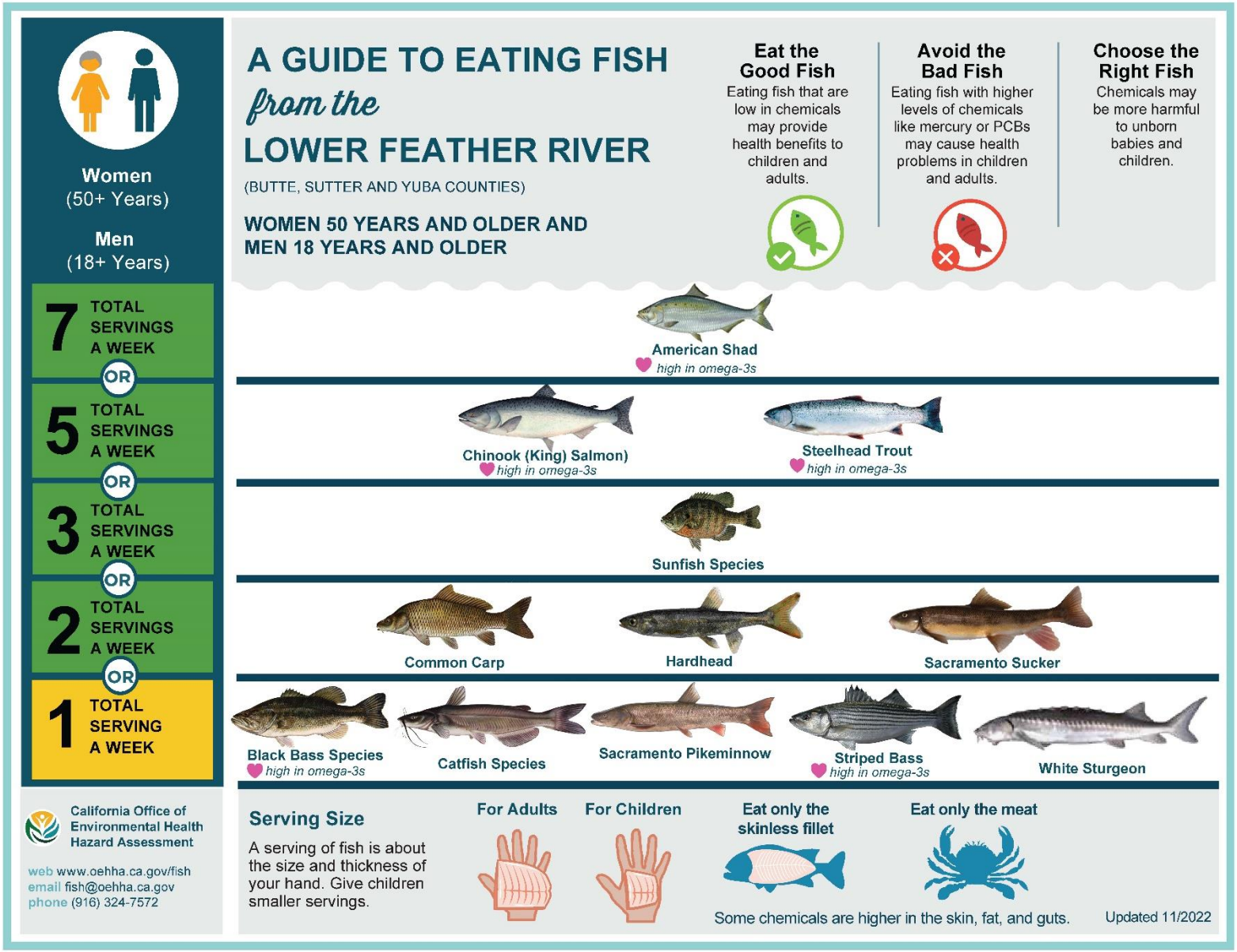

A GUIDE TO EATING FISH
from the
LOWER FEATHER RIVER
(BUTTE, SUTTER AND YUBA COUNTIES)
WOMEN 18 - 49 YEARS AND
CHILDREN 1 - 17 YEARS
Eat the Good Fish
Eating fish that are low in chemicals may provide health benefits to children and adults.
Avoid the Bad Fish
Eating fish with higher levels of chemicals 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.
Women
(18-49 Years)
Children
(1-17 Years)
2 TOTAL SERVINGS A WEEK
OR
1 TOTAL SERVING A WEEK
0 DO NOT EAT
American Shad
high in omega-3s
Chinook (King) Salmon
high in omega-3s
Steelhead Trout
high in omega-3s
Common Carp
Hardhead
Sacramento Sucker
Sunfish species
Black Bass Species
Catfish Species
Sacramento Pikeminnow
Striped Bass
White Sturgeon
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
Eat only the meat
Some chemicals are higher in the skin, fat, and guts.
Updated 11/2022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(50+ Years)
Men
(18+ Years)
7 TOTAL SERVINGS A WEEK
OR
5 TOTAL SERVINGS A WEEK
OR
3 TOTAL SERVINGS A WEEK
OR
2 TOTAL SERVINGS A WEEK
OR
1 TOTAL SERVING A WEEK
American Shad
high in omega-3s
Chinook (King) Salmon
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INTRODUCTION

This advisory report updates previously issued consumption advice for the Lower Feather River in Butte, Sutter, and Yuba counties, California. It covers more species, including anadromous species, and is based on a larger database than those used in earlier advice. Anadromous fish live, or spend time, in the ocean but swim up rivers to spawn in fresh water, including the Feather River. OEHHA developed the consumption advice for anadromous species in 2012, updated the advice in 2022 (OEHHA, 2022), and applied the advice to rivers, estuaries, and coastal waters where these species migrate. OEHHA has also developed fish consumption guidelines for other water bodies in the Oroville area that are part of the Feather River watershed or the Oroville Dam complex. These advisories are: Lake Oroville (OEHHA, 2013a), Thermalito Forebay and Thermalito Afterbay (OEHHA, 2014a), and the Upper Feather River (OEHHA, 2014b).

This consumption guideline for eating fish from the Lower Feather River covers fish taken from the Diversion Pool (Figure 1). The Diversion Pool is formed by two dams that collect and divert water from Lake Oroville: (1) The Thermalito Diversion Dam releases water to Thermalito Forebay and then Thermalito Afterbay for eventual release to the Lower Feather River. (2) The Diversion Dam directs water to the Lower Feather River. Thus, the Diversion Pool feeds water into the Feather River channel below Oroville Dam. The Feather River empties into the Sacramento River at Verona.

A 12-mile portion of the Lower Feather River flows through the Oroville Wildlife Area. While this guidance covers this portion of the river, it does not cover several ponds in the Oroville Wildlife Area that are adjacent to the river. When there is a high water release from Lake Oroville to the Feather River, water spills out to these ponds and allows for fish redistribution in the entire area. However, OEHHA evaluated fish tissue data from these ponds (see Appendix I) and found that the results were highly variable, different from chemical levels in fish from the river, and that the number of samples of fish from the ponds was limited. Consequently, OEHHA did not include data from the ponds for this evaluation. Advice for these ponds would require additional sampling. The statewide advice for lakes and reservoir (Appendix I; OEHHA, 2013b) could be used as an interim consumption guide until more monitoring data are available.

In the river itself, both non-anadromous and anadromous fish species are available. The non-anadromous fish species include black bass, carp, channel catfish, hardhead, pikeminnow, sucker, small sunfish (panfish), and white catfish. The anadromous fish species are: American shad, Chinook (King) salmon, steelhead trout, striped bass, and white sturgeon. While only sucker was sampled from the Diversion Pool, other species such as black bass, carp, and catfish found in both Lake Oroville and Lower Feather River are expected to be found there since the pool is a link between these two water bodies.

FIGURE 1. LOCATION OF THE LOWER FEATHER RIVER AND NEARBY WATERBODIES.

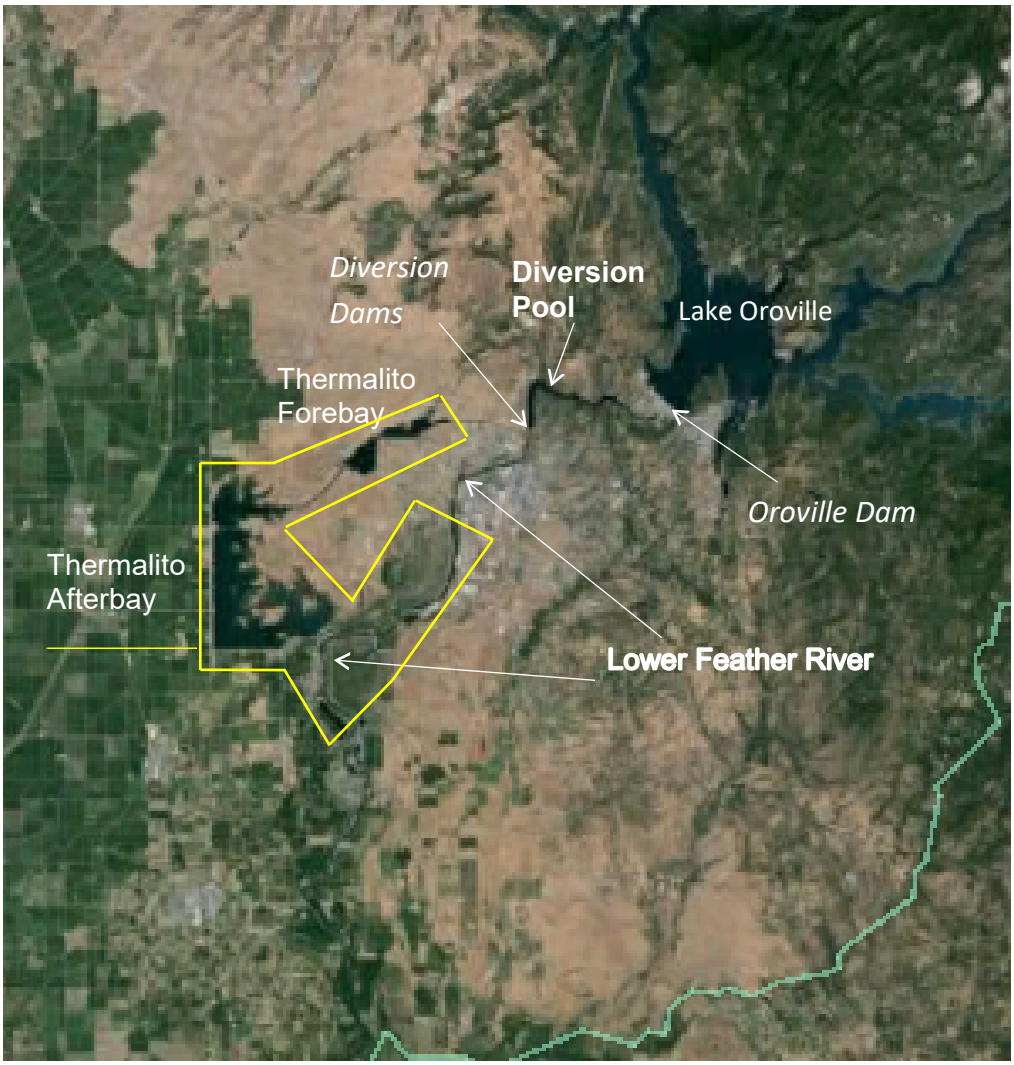


Image copied from Google Earth™. The approximate boundary of the Oroville Wildlife Area is indicated by the yellow lines.

2022 UPDATE

This advisory was updated in 2022 to include the revised advice for anadromous species based on the advisory for fish that migrate.[1]

[1] Online at: https://oehha.ca.gov/advisories/advisory-fish-migrate.

CONSUMPTION ADVICE APPROACH

OEHHA used the results from several monitoring projects described in this report to develop the updated advisory for the Lower Feather River. The process to develop consumption advice involves these steps:

1. Select the samples, chemical data, and fish species to be evaluated.
2. Calculate average (mean) chemical concentrations and other descriptive statistics as appropriate for each fish species.
3. Compare the chemical concentrations with the OEHHA Advisory Tissue Levels (ATLs) for each chemical of concern to develop the consumption advice.

OEHHA developed ATLs (Appendix II) that are acceptable exposure levels of specific contaminants in fish tissue based on the toxicity of each chemical for a range of consumption rates. The development of the ATLs included consideration of health benefits linked to eating fish (OEHHA, 2008).

CHEMICALS OF POTENTIAL CONCERN

Fish samples from the Lower Feather River have been analyzed for mercury (as a measure of methylmercury), polychlorinated biphenyl congeners[2] (PCBs), and the persistent pesticides dieldrin, chlordane, and dichlorodiphenyltrichloroethane and its metabolites (collectively referred to as DDTs).

Mercury, a metal, is widely found in nature in rock and soil. Its presence in the aquatic environment is a result of mining activities, such as occurred in the Feather River watershed, and releases into the environment from industrial sources, including the burning of fossil fuels and solid wastes. Mercury in the sediment is transformed by bacteria to the more toxic organic form, methylmercury, which is taken up by aquatic organisms. Methylmercury builds up in fish when they eat small aquatic organisms. Depending on how much methylmercury is in the fish people eat, changes in the brain may occur, especially in fetuses and children as they grow.

PCBs are man-made 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 can cause cancer and other health effects, including neurotoxicity, in humans.

Chlordane, DDT, and dieldrin are pesticides that were banned from use in 1973 (DDT) and in the late 1980s (chlordane and dieldrin) but have been found in some fish in

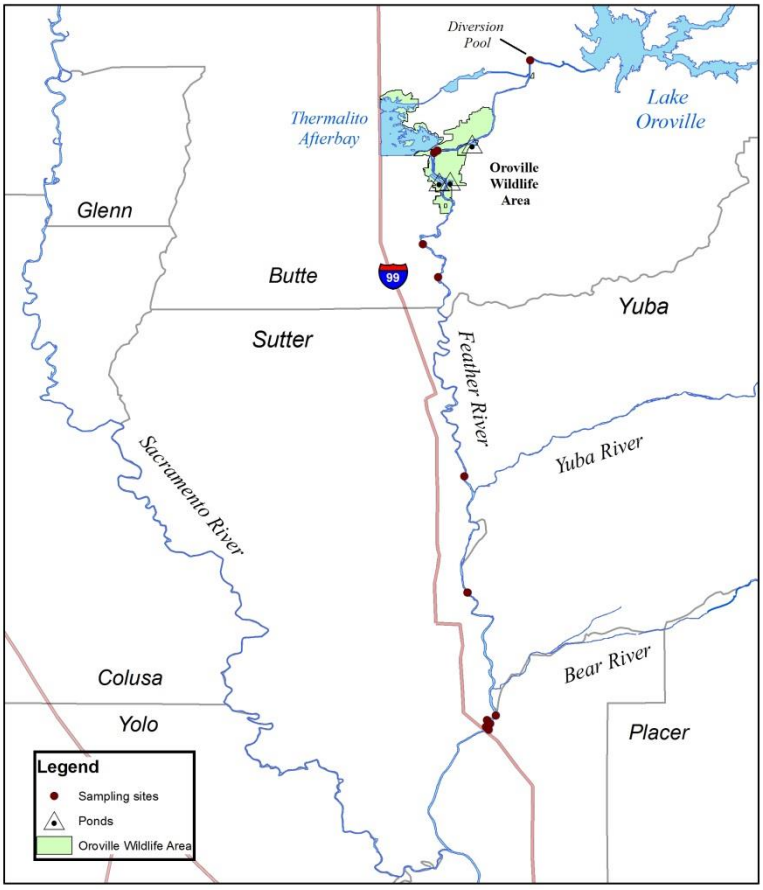
[2] Congeners are related compounds with similar chemical forms. Of the 209 possible PCB congeners, 54 are generally reported.

certain water bodies in California. Depending on the exposure level, these chemicals may cause cancer or other adverse effects on the nervous system. Detailed discussion of the toxicity of these chemicals is presented in OEHHA (2008).

DATA SOURCES

The guidelines for eating fish from the Lower Feather River were based on chemical analysis of fish samples by the monitoring projects described in this section. These projects had adequate documentation of sample collection, fish preparation, chemical analyses, and quality assurance, and low detection limits. Fish were collected from various locations on the Lower Feather River as shown in Figure 2. Table 1 shows the scientific and common names of fish species, the projects under which the samples used for this report were collected, and the years of sampling.

FIGURE 2. SAMPLING LOCATIONS ON THE LOWER FEATHER RIVER AND OROVILLE WILDLIFE AREA



Samples sites: on the river (red circle), at the ponds (triangles)

TABLE 1. FISH SAMPLES FROM THE LOWER FEATHER RIVER

Common Name	Scientific Name		Project	Year Sampled
	Family	*Genus*		
Black Bass (largemouth)	Centrarchidae	Micropterus	DWR FMP SFEI-CALFED SRWP SWAMP	2002-2004 2005-2006 1999-2000 1998-2003 2011
Bullhead	Ictaluridae	*Ameiurus*	DWR	2002
Carp	Cyprinidae	*Cyprinus*	DWR FMP SFEI-CALFED TSMP	2003 2005 2000 1988
Catfish, Channel	Ictaluridae	*Ictalurus*	DWR SFEI-CALFED TSMP	2002 1999-2000 1978-1993
Catfish, White	Ictaluridae	*Ameiurus*	SFEI-CALFED SRWP	1999-2000 1997
Crappie	Centrarchidae	*Pomoxis*	FMP	2005
Hardhead	Cyprinidae	*Mylopharodon*	DWR	2003
Pikeminnow	Cyprinidae	*Ptychocheilus*	DWR FMP SFEI-CALFED SRWP	2003 2005-2006 1999-2000 2000-2003
Sucker	Catostomidae	*Catostomus*	DWR FMP SFEI-CALFED SRWP SWAMP TSMP	2002 2005-2006 2000 2001 2011 1991
Sunfish (bluegill, redear)	Centrarchidae	*Lepomis*	DWR FMP SFEI-CALFED SRWP	2003 2005 1999-2000 2001

Abbreviations:
DWR=Department of Water Resources
FMP=Fish Mercury Project
SFEI-CALFED=San Francisco Estuary Institute-CALFED
SRWP=Sacramento River Watershed Program
SWAMP=Surface Water Ambient Monitoring Program
TSMP=Toxic Substances Monitoring Program

DEPARTMENT OF WATER RESOURCES (DWR)

DWR collected biota and sediment samples to evaluate chemical contamination of Lake Oroville and water bodies in the vicinity (Lower Feather River, the Oroville Wildlife Area including Thermalito Afterbay) for the Oroville Federal Energy Regulatory Commission (FERC) Relicensing Project No. 2100 (DWR, 2004 and 2006). The sampling sites with data included the Diversion Pool, ponds at the Oroville Wildlife Area (Mile Long Pond, Lower Pacific Heights Pond, and Robinson's Pond), and various locations along the Lower Feather River. Fish samples were analyzed for total mercury, PCBs, and persistent pesticides.

THE FISH MERCURY PROJECT (FMP)

The FMP was a three-year (2005 to 2007) sampling program funded by CALFED (www.calwater.ca.gov). CALFED is made up of California and federal agencies whose objectives are water quality, water supply, ecosystem restoration, and levee integrity of the Sacramento-San Joaquin Delta. Monitoring of sport fish for mercury contamination from Central Valley water bodies was planned and conducted by staff at the California Department of Fish and Wildlife (CDFW), OEHHA, California Department of Public Health, University of California at Davis, and San Francisco Estuary Institute. Tasks included sport fish monitoring, public outreach activities, and development of consumption advice and educational materials for the Sacramento River, San Joaquin River, and Delta. Fish samples were collected for mercury analysis from various fishing locations in the Feather River.

SAN FRANCISCO ESTUARY INSTITUTE-CALFED (SFEI-CALFED)

The SFEI conducted an assessment of the ecological and human health impacts of mercury in the Delta region (Davis et al., 2004). This project was funded by CALFED and sampled a wide variety of fish species for analysis of mercury. The fish were collected in 1999 and 2000, and included samples from the Lower Feather River.

SACRAMENTO RIVER WATERSHED PROGRAM (SRWP)

The SRWP[3] was founded in 1996 and certified as a California not-for-profit corporation in 2002. Its mission is to sustain, restore, and enhance current and potential resources in the Sacramento River watershed including the Sacramento, San Joaquin, Feather, and American rivers. The SRWP operates through collaborative partnerships and conducts coordinated research and monitoring activities to assess water quality and other indicators of watershed health. SRWP conducted fish tissue sampling from 1997-2003 and analyzed for mercury, PCBs, and persistent pesticides[4].

[3] www.sacriver.org

[4] http://www.sacramentoriver.org/srcaf/library/library_browse.php?subject=Water%20Quality

Surface Water Ambient Monitoring Program (SWAMP)

A statewide survey of California's rivers and streams was conducted by the State Water Resources Control Board (SWRCB) under its SWAMP program, which sampled fish from 63 locations in the year 2011 (Davis et al., 2013). SWAMP collected largemouth bass and sucker from the Lower Feather River. The fish samples were analyzed for mercury, PCBs, and persistent pesticides.

Toxic Substances Monitoring Program (TSMP)

The TSMP (1976-2003) was a state water quality-monitoring program managed by the SWRCB. The program objective was to provide statewide information on the occurrence of toxic substances by monitoring water bodies primarily targeted for known or suspected impaired water quality. CDFW staff collected fish and other aquatic life from multiple sites of fresh, estuarine, and marine waters throughout the state, including the Feather River. The fish samples were analyzed for mercury and organochlorine compounds. For PCBs and pesticides, only data collected after 1999 were used because they are more representative of current environmental concentrations following discontinued use of these chemicals. Mercury data from all years was used as mercury remains a ubiquitous environmental contaminant; local and global concentrations have not noticeably declined.

CHEMICAL CONCENTRATIONS

Chemical Analysis

Fish samples were prepared as skinless fillets for analysis of mercury, PCBs, and persistent pesticides. They were analyzed as individual fish or as composite samples from a species. Composite samples are prepared from equal amounts of tissues from several individual fish, all of the same species. Composite sampling is usually done for samples to be analyzed for organics to reduce the cost of analyses. The analytical result from a composite sample represents an average concentration. All results were reported in wet weight.

For total mercury, the samples were analyzed by inductively coupled plasma-mass spectrometry or atomic absorption spectrometry. PCBs and persistent pesticides were analyzed using gas chromatography. PCBs (46 to 50 congeners for each sample) were measured in all fish species, except for crappie. Some species (black bass, bullhead, catfish, pikeminnow, and sucker) were analyzed for DDTs, dieldrin, and chlordanes. The specific chemicals were: PCB congeners; total DDTs including o,p' and p,p' DDT, o,p' and p,p' dichlorodiphenyldichloroethane (DDD), and o,p' and p,p' dichlorodiphenyl-dichloroethylene (DDE); total chlordanes including cis-chlordane, trans-chlordane, cis-nonachlor, trans-nonachlor, and oxychlordane; and dieldrin.

Sample Selection

Results selected for the chemical concentration calculations were from samples taken from fish that met CDFW's legal size requirement (largemouth bass, CDFW 2014-2015) or OEHHA's criteria for minimum "edible" size. OEHHA used species size at maturity and professional judgment to set minimum edible sizes (OEHHA, 2005). Fish were measured as total length (in millimeters [mm]).[5] For composite samples, the length of the smallest fish in the sample was at least 75 percent of the length of the largest fish in the composite.

Sample Concentration Calculation

OEHHA combined the data from the Lower Feather River and Diversion Pool to calculate the arithmetic mean (average) concentrations of samples for each chemical as the representative mean chemical concentration to estimate human exposure. The means were computed (weighted) by taking into account the number of fish in each composite sample.

For the calculation of mercury concentrations in fish tissue, OEHHA assumed all total mercury detected was methylmercury, the more toxic form that is present in fish, because nearly all mercury present in fish is methylmercury (Wiener et al., 2007). Table 2 shows the weighted means of total fish length and mercury concentration for each fish species collected from the Lower Feather River.

For PCBs, chlordanes, and DDTs, each of the concentrations presented was the sum of the detected parent compound, congeners, and metabolites, where applicable. Since the method detection limits (MDLs) or reporting limits (RLs) were relatively low, ≤5 parts per billion (ppb), individual congeners or metabolites with concentrations reported as non-detects were assumed to have no residue (See Appendix III for more information on MDLs and RLs). This is a standard method of handling non-detect samples for PCBs and other chemicals with multiple congeners or metabolites when detection levels are adequate (U.S. Environmental Protection Agency, US EPA, 2000a). Table 3 and Table 4 show the weighted means of total length and mean chemical concentrations of PCBs and the measured pesticides, respectively, for each species. Data are available for only a few species.

[5] Total length refers to the length from the tip of the snout to the tip of the longer lobe of the caudal fin. Length measurements from the SRWP were assumed to be total length since length type was not specified from the data source.

TABLE 2. MERCURY CONCENTRATIONS IN FISH FROM THE LOWER FEATHER RIVER

Fish Species	Number of Samples	Total Number of Fish[a]	Mean Total Length (mm)	Mercury (ppb)	
				Mean	Range
Black Bass	63	105	349	612	170-2350
Carp	7	16	502	288	120-517
Hardhead	5	5	361	260	90-830
Combined	**13**	**26**	**494**	**289**	**90-830**
Catfish, Channel	12	33	509	362	170-729
Catfish, White	10	14	360	613	391-1254
Combined	**22**	**47**	**465**	**437**	**170-1254**
Crappie	5	5	165	213	135-285
Pikeminnow	50	74	339	626	57-2261
Sucker	41	63	421	240	23-610
Sunfish					
Bluegill	6	10	170	186	130-443
Redear	12	20	172	179	90-519
Combined	**18**	**30**	**172**	**182**	**90-519**

[a] The number of fish can be greater than the number of samples because some samples are composites consisting of more than one fish for the chemical analysis.

TABLE 3. PCB CONCENTRATIONS IN FISH FROM THE LOWER FEATHER RIVER

Fish Species	Number of Samples	Number of Fish[a]	Mean Total Length (mm)	PCBs (ppb)	
				Mean	Range
Black Bass	7	38	365	10	1.5-15.6
Catfish, White	1	5	264	11	NA
Pikeminnow	3	17	300	21	9-31
Sucker	4	20	497	27	1.9-66.4

[a] The number of fish (in parenthesis) can be greater than the number of samples because some samples are composites consisting of more than one fish for the chemical analysis.
NA=no or only one sample was analyzed for PCBs.

TABLE 4. PESTICIDE CONCENTRATIONS IN FISH FROM THE LOWER FEATHER RIVER

Fish Species	Number of Samples	Number of Fish[a]	Mean Total Length (mm)	Mean Concentrations (ppb)		
				Chlordanes	DDTs	Dieldrin
Black Bass	5	31	369	<1	7	<1
Pikeminnow	2	10	294	<0.5	25	<2
Sucker	4	20	497	0.7	18	<1

[a] The number of fish (in parenthesis) can be greater than the number of samples because some samples are composites consisting of more than one fish for the chemical analysis.

DEVELOPMENT OF GUIDELINES FOR EATING FISH FROM THE LOWER FEATHER RIVER

GENERAL INFORMATION

The OEHHA advisory process considers the health benefits of fish consumption as well as the risk from exposure to chemical contaminants that may be 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, 2014; American Heart Association, 2016; OEHHA, 2008; Institute of Medicine, 2007; Kris-Etherton et al., 2002). Fish is a significant source of the specific omega-3 fatty acids, docosahexaenoic acid (DHA) and eicosapentaenoic acid (EPA), thought to be associated with many of these beneficial effects (USDA/USDHHS, 2010; Weaver et al., 2008).

The 2010 U.S. Dietary Guidelines recommend that consumers eat at least eight ounces of cooked seafood[6] per week ("young children need less depending on age and calorie needs") and that "women who are pregnant or breastfeeding consume eight to twelve ounces of seafood per week from a variety of seafood types" (USDA/USDHHS, 2010). However, 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, 2008). Accordingly, because of the high mercury content of these fish species, the Dietary Guidelines recommend that women who are pregnant or breastfeeding do not consume shark, swordfish, tilefish, or king mackerel, and limit consumption of albacore tuna to six ounces per week (USDA/USDHHS, 2010).

Catching and eating sport fish (i.e., fish and shellfish that people catch for themselves, friends or family) can be an important and economical way for consumers to meet the seafood consumption recommendations of the Dietary Guidelines. However, the mercury (and other contaminant) content of sport fish can vary widely by species and location. In order to address the potential health concerns associated with consuming contaminants in sport fish, OEHHA has established ATLs (Advisory Tissue Levels, i.e., acceptable exposure levels) 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

[6] "Seafood is a large category of marine animals that live in the sea and in freshwater lakes and rivers. Seafood includes **fish,** such as salmon, tuna, trout, and tilapia, and **shellfish,** such as shrimp, crab, and oysters" (USDA/USDHHS, 2010).

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 women who might become pregnant (typically 18 to 49 years of age) and children 1 to 17 years (the sensitive population) are lower than for women 50 years and older and men 18 years and older. The lower ATL values for the sensitive population provide 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 available in OEHHA, 2008. A list of ATLs used in this report is presented in Appendix II.

Data for fish species may be combined as a single group based on their taxonomy (i.e., they are in the same taxonomical Family and/or genus) and other considerations when specified in the following discussion of the water-body specific advice. For each fish species or group of related species in this advisory[7], OEHHA compared the average concentration of each chemical detected in fish fillet to the ATL for that chemical in order to establish the maximum number of servings per week that could be consumed. When there is more than one chemical of concern, OEHHA provides advice based on the chemical that leads to the most restrictive consumption advice (i.e., the lowest number of servings per week). In addition, because mercury and PCBs cause similar adverse effects in the sensitive population (developmental neurotoxicity), OEHHA uses multiple chemical exposure methodology (US EPA, 1989 and 2000b) to minimize potential additive effects of these chemicals. Thus, consumption advice may be more restrictive for the sensitive population when both chemicals are present in the same fish than it would be for either chemical alone.

OEHHA recommends that individuals strive to meet the U.S. Dietary Guidelines seafood consumption recommendations, while also adhering to federal and OEHHA recommendations to limit the consumption of high-contaminant fish. The advice discussed in the following section represents the maximum recommended number of servings per week for different fish from this water body. People should eat no more than the recommended number of servings for each fish species or species group. Consumption advice should not be combined. That is, if a person chooses to eat a fish from the "one-serving-a-week'' category, then they should not eat any other fish from any source until the next week. If a person chooses to eat a fish from the "two-servings-per-week" category, they can combine fish species from that category for a total of two servings in that week. Then they should not eat any other fish from any source until the next week.

[7] A species group includes related species. Fish species within the same genus are most closely related, and Family is the next level of relationship.

Consumption Advice for Fish from the Lower Feather River

OEHHA determined the following advice for each species or species group after comparing the mean mercury and PCB concentrations to the ATLs. The advice, summarized in Table 5, shows the maximal number of servings. The concentrations of the tested pesticides were close to or lower than the ATL threshold value for daily consumption (OEHHA, 2008). These pesticides were therefore not considered further for developing consumption advice.

Black Bass

Largemouth bass was the only type of black bass in the Lower Feather River dataset. The mean concentrations were 612 ppb mercury and 10 ppb PCBs. The advice is based on mercury. OEHHA recommends “do not eat” for the sensitive population and one serving per week for women 50 years and older and men 18 years and older. This advice can be extended to other black bass, which could be caught from the Lower Feather River. An OEHHA evaluation of mercury concentrations in three black bass species (largemouth, smallmouth, and spotted bass) showed a similar range of concentrations when two or more of these species are present in the same water body.

Carp and Hardhead

The data for carp and hardhead were combined because they belong to the same Family and the mercury concentrations were similar in magnitude. Only mercury data were available and the mean concentration was 282 ppb mercury. OEHHA recommends one serving per week for the sensitive population and two servings per week for women 50 years and older and men 18 years and older.

Catfish, Channel and White

OEHHA combined the data for channel catfish and white catfish because they belong to the same Family. For both species combined, the mean concentrations were 437 ppb mercury and 11 ppb PCBs. For the sensitive population, the consumption frequency would be one serving per week based on mean mercury. However, multiple chemical exposure assessment showed that the recommended frequency of consumption needed to be reduced. Thus, OEHHA recommends that the sensitive population not eat channel or white catfish. For women 50 years and older and men 18 years and older, the advice is one serving per week, determined by mercury concentration.

Crappie

There were only 5 crappie sampled, and thus OEHHA did not give advice for this fish species.

Pikeminnow

In pikeminnow, the mean mercury concentration was 626 ppb, and the mean PCB concentration was 21 ppb. The advice is based on mercury. OEHHA recommends “do not eat” for the sensitive population and one serving per week for women 50 years and older and men 18 years and older.

Sucker

In sucker, the mercury and PCB concentrations were 240 ppb and 27 ppb, respectively. OEHHA recommends one serving per week for the sensitive population and two servings per week for women 50 years and older and men 18 years and older.

Sunfish (Bluegill and redear)

The data for sunfish species were combined because these species are related. The mean mercury concentration in sunfish was 182 ppb, and PCBs were not measured. OEHHA recommends one serving per week for the sensitive population and three servings per week for women 50 years and older and men 18 years and older.

Anadromous Species (Sturgeon, salmon, striped bass, trout, and shad)

The advice developed for anadromous fish species is discussed in OEHHA (2022) and included in Table 5.

Recommended Maximum number of servings per week

The following table presents the consumption advice developed for fish species found in the Lower Feather River, including the Diversion Pool.

Table 5. Recommended Maximum Number of Servings per Week for fish from the Lower Feather River

Fish Species	Women 18 – 49 Years and Children 1 – 17 Years	Women 50 Years and older and Men 18 Years and older
Black Bass	0	1
Catfish: Channel or White	0	1
Pikeminnow	0	1
*Striped Bass	0	1
*White Sturgeon	0	1
Carp	1	2
Hardhead	1	2
Sucker	1	2
Sunfish: Bluegill or Redear	1	3
*Chinook (King) Salmon	2	5
*Steelhead Trout	2	5
*American Shad	2	7

* Based on the advisory for fish that migrate, online at: https://oehha.ca.gov/advisories/advisory-fish-migrate.

REFERENCES

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.

CDFW (2014-2015). Freshwater Sport Fishing Regulations. Fish and Game Commission, Department of Fish and Wildlife, Natural Resources Agency, Sacramento, CA. http://www.dfg.ca.gov/regulations/

Davis, J. A., B. K. Greenfield, G. Ichikawa, and M. Stephenson (2004). Mercury in Sport Fish from the Delta Region (Task 2A). Final Report submitted to the CALFED Bay-Delta Program for the Project: An Assessment of the Ecological and Human Health Impacts of Mercury in the Bay-Delta Watershed. San Francisco Estuary Institute and Moss Landing Marine Laboratory. http://loer.tamug.tamu.edu/calfed/Report/Final/Task%202A%20Final%20Report.pdf.

Davis, J.A., J.R.M. Ross, S.N. Bezalel, J.A. Hunt, G. Ichikawa, A. Bonnema, W.A. Heim, D. Crane, S. Swensen, and C. Lamerdin (2013). Contaminants in Fish from California Rivers and Streams, 2011. A report of the Surface Water Ambient Monitoring Program (SWAMP). California State Water Resources Control Board, Sacramento, CA. http://www.waterboards.ca.gov/water_issues/programs/swamp/docs/rivers_study/rs_rpt only.pdf

DWR (2004). Contaminant Accumulation in Fish, Sediments, and the Aquatic Food Chain. Study Plan W2, Phase 1 Draft Report. Oroville Facilities Relicensing FERC Project No. 2100. Department of Water Resources, the Resources Agency, Sacramento, CA.

DWR (2006). Contaminant Accumulation in Fish, Sediments, and the Aquatic Food Chain. Study Plan W2, Phase 2 Report. Oroville Facilities Relicensing FERC Project No. 2100. Department of Water Resources, the Resources Agency, Sacramento, CA.

FDA (Food Drug Administration)/US EPA (2014). Fish: What Pregnant Women and Parents Should Know. Draft Updated Advice by FDA and EPA/June 2014. http://www.fda.gov/downloads/Food/FoodborneIllnessContaminants/Metals/UCM400358.pdf

Institute of Medicine (2007). Seafood Choices, Balancing Benefits and Risks. Committee on Nutrient Relationships in Seafood: Selections to Balance Benefits and Risks 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. Circulation 106:2747-2757.

OEHHA (2005). General Protocol for Sport Fish Sampling and Analysis. Office of Environmental Health Hazard Assessment, California Environmental Protection Agency, Sacramento, CA.
http://oehha.ca.gov/fish/pdf/fishsampling121406.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, CA.
http://www.oehha.ca.gov/fish/gtlsv/pdf/FCGsATLs27June2008.pdf

OEHHA (2013a). Health Advisory and Consumption Guidelines for Fish from Lake Oroville (Butte County). Office of Environmental Health Hazard Assessment, California Environmental Protection Agency, Sacramento, CA.
http://www.oehha.ca.gov/fish/special_reports/pdf/071613LakeOrovilleReport.pdf

OEHHA (2013b). 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, CA.
http://www.oehha.ca.gov/fish/pdf/CALakeResAdvisory080113.pdf

OEHHA (2014a). Health Advisory and Consumption Guidelines for Eating Fish from Thermalito Forebay and Thermalito Afterbay (Butte County). Office of Environmental Health Hazard Assessment, California Environmental Protection Agency, Sacramento, CA.

OEHHA (2014b). Health Advisory and Consumption Guidelines for Eating Fish from the Upper Feather River (Butte and Plumas Counties). Office of Environmental Health Hazard Assessment, California Environmental Protection Agency, Sacramento, CA.

OEHHA (2022). Statewide Health Advisory and Guidelines for Eating Fish that Migrate: American Shad, Chinook (King) Salmon, Steelhead Trout, Striped Bass, and White Sturgeon Caught in California Rivers, Estuaries, and Coastal Waters. Office of Environmental Health Hazard Assessment, California Environmental Protection Agency, Sacramento, CA.
https://oehha.ca.gov/advisories/advisory-fish-migrate

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.

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.

USDA (U.S. Department of Agriculture)/USDHHS (U.S. Department of Human Health Services) (2010). Dietary Guidelines for Americans, 2010. 7th Edition, Washington, DC: U.S. Government Printing Office, December 2010.
http://www.health.gov/dietaryguidelines/dga2010/DietaryGuidelines2010.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: http://www.epa.gov/oswer/riskassessment/ragse/index.htm

US EPA (2000a). Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories. Vol.1. Fish Sampling and Analysis. 3rd Ed. EPA 823-B00-007.

US EPA (2000b). Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories. Vol.2. Risk Assessment and fish consumption limits. 3rd Ed. EPA 823-B00-008.

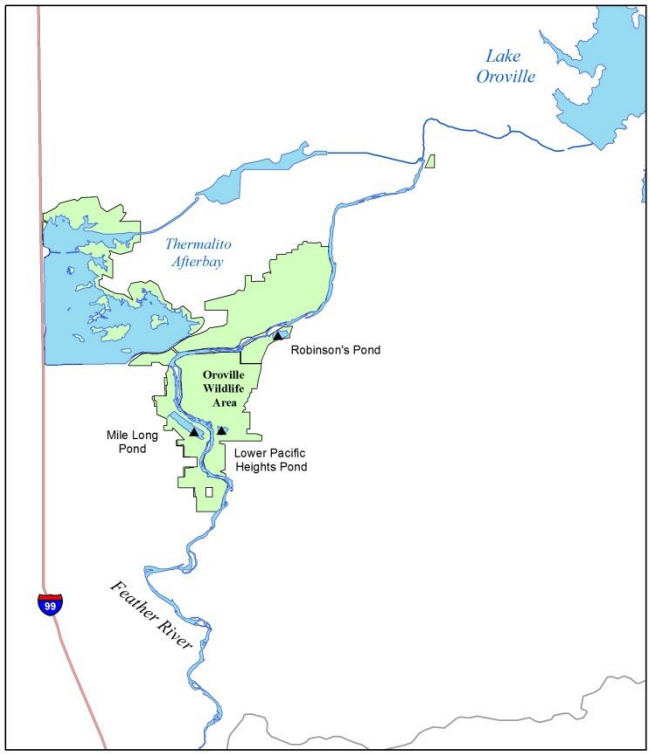
Weaver, K.L., P. Ivester, J.A. Chilton, M.D. Wilson, P. Pandey, and F.H. Chilton (2008). The content of favorable and unfavorable polyunsaturated fatty acids found in commonly eaten fish. J. American Dietetic Association 108:1178-1185.

Wiener, J.G.; R.A. Bodaly; S.S. Brown; M. Lucotte; M.C. Newman; D.B. Porcella; R.J. Reash; and E.B. Swain (2007). Monitoring and evaluating trends in methylmercury accumulation in aquatic biota. Chapter 4 in Ecosystem Responses to Mercury Contamination: Indicators of Change (R.C. Harris, D. P. Krabbenhoft, R.P. Mason, M.W. Murray, R.J. Reash, and T. Saltman, editors). SETAC Press, Pensacola, Florida.

APPENDIX I. EVALUATION OF DATA FROM OROVILLE WILDLIFE AREA PONDS

Data for three ponds (Robinson's Pond, Lower Pacific Heights Pond, and Mile Long Pond, Figure 3) in the Oroville Wildlife Area were available from the DWR phrase I and II projects (DWR, 2004 and 2006). The Robinson's Pond is next to a former gravel mining pit. A channel of the Feather River enters the pond directly and flows back into the river. The Mile Long Pond is connected to the Feather River only during very high river flow (S. McReynolds, personal communications, 2014). The Lower Pacific Heights Pond is farther away, east of the Feather River.

FIGURE 3. SAMPLING LOCATIONS AT THE OROVILLE WILDLIFE AREA



Summary data for mercury and PCBs from these sites, as well as the Lower Feather River, is presented in Tables 6 and 7. Only sunfish were sampled of sufficient number (9 or more fish) and analyzed for mercury and PCBs. Data for persistent pesticides were available for few species: channel catfish (Lower Pacific Heights Pond), black bass and bullhead (Mile Long Pond). The pesticide levels were low and were not of health concern.

For mercury, the mean concentrations for black bass and sunfish sampled from the Mile Long Pond were much lower, at least 2-fold, than those from Robinson's Pond or the Lower Feather River. On the other hand, mercury concentrations for carp were similar

for the two ponds and the Feather River. Mercury level in bullhead was available only for the Mile Long Pond.

High levels of PCBs were found in fish sampled from two of the ponds. Black bass and carp from Robinson's Pond had much higher PCB mean concentrations than those from Mile Long Pond or the Lower Feather River. The difference was more than 10-fold between Robinson's Pond and Mile Long Pond, and almost 3-fold between Robinson's Pond and the Lower Feather River. PCBs were also high in carp sampled from Lower Pacific Heights Pond. There were sufficient numbers of sunfish sampled from the Mile Long Pond and they showed levels below the detection limit. There were no data for these two fish species from other sites for comparison.

These ponds, which are close to or intermittently connected with the Feather River, showed variable mercury and PCB concentrations in the fish sampled among the ponds. The concentration in species in the ponds also varied from that observed in the same species from the Feather River. Thus, OEHHA decided not to combine data for the ponds with those from the Feather River. Except for sunfish from Mile Long Pond, there were insufficient numbers of fish analyzed for the development of consumption advice for individual ponds, and the variability in concentrations in species among ponds also rules out combining data from the ponds to develop advice. The statewide advice for lakes and reservoirs (Table 8; OEHHA, 2013b) could be used as an interim consumption guide until more monitoring data are available.

TABLE 6. COMPARISON OF MEAN MERCURY CONCENTRATIONS IN FISH

Common Name	Robinson's Pond		Lower Pacific Heights Pond		Mile Long Pond		Lower Feather River	
	Number of Fish	Mean (ppb)	Number of Fish	Mean (ppb)	Number of Fish	Mean (ppb)	Number of Fish	Mean (ppb)
Black Bass	7	766	0	NA	3	240	105	612
Bullhead	0	NA	0	NA	4	62	0	NA
Carp	2	390	0	NA	5	320	16	288
Channel Catfish	0	NA	5	355	0	NA	33	362
Sunfish	0	NA	0	NA	10	71	30	182

NA=no data, Sunfish=bluegill, hybrid sunfish, or redear sunfish.

TABLE 7. COMPARISON OF MEAN PCB CONCENTRATIONS IN FISH

Common Name	Robinson's Pond		Lower Pacific Heights Pond		Mile Long Pond		Lower Feather River	
	Number of Fish	Mean (ppb)	Number of Fish	Mean (ppb)	Number of Fish	Mean (ppb)	Number of Fish	Mean (ppb)
Black Bass	7	27	0	NA	8	2	7	10
Bullhead	0	NA	0	NA	4	2	0	NA
Carp	2	220	0	NA	5	4	0	NA
Channel Catfish	0	NA	5	49	0	NA	0	NA
Sunfish	0	NA	0	NA	10	<0.6	0	NA

NA=no data, Sunfish=bluegill, hybrid sunfish, or redear sunfish.

TABLE 8. RECOMMENDED MAXIMUM NUMBER OF SERVINGS PER WEEK IN THE STATEWIDE 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	0	1
Carp	0	1
Bullhead	1	2
Channel Catfish	1	2
Sunfish	1	2

Sunfish=any small sunfish such as bluegill, hybrid sunfish, or redear sunfish. From OEHHA, 2013b.

APPENDIX II. 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[8] 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 that water body would be at or below the average daily reference dose or the cancer risk probability of one in 10,000.

TABLE 9. ADVISORY TISSUE LEVELS FOR METHYLMERCURY AND PCBS

Number of servings per week[a]	**Advisory Tissue Levels (ATLs, in ppb)**		
	Methylmercury		PCBs
	Women 18 – 49 years and children 1 – 17 years	Women 50 years and older and men 18 years and older	
0	>440	>1,310	>120
1	>150-440	>440-1,310	>42-120
2	>70-150	>220-440	>21-42
3	>55-70	>160-220	>16-21
4	>44-55	>130-160	>13-16
5	>36-44	>109-130	>10-13
6	>31-36	>94-109	>9-10
7	≤ 31	≤ 94	≤ 9

[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. When residue data are compared to this table they should also first be rounded to the second significant digit.

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

APPENDIX III. DETECTION LIMITS

Table 10 shows the detection limits of the projects used in this report. The method detection limit (MDL) is the lowest concentration of a chemical that can be distinguished (as greater than zero) in a sample. The reporting limit (RL) is the lowest concentration of a chemical that can be accurately quantified in a sample. When both MDL and RL are available, the MDL (lower value) is selected for this table.

TABLE 10. METHOD DETECTION LIMITS AND REPORTING LIMITS

Chemicals	**DWR RL (ppb)**	**FMP MDL (ppb)**	**SRWP RL (ppb)**	**SWAMP MDL (ppb)**
Mercury	10	12-18	7	12
PCBs	0.6	NA	0.2	0.197-0.295
Chlordanes	1	NA	1-2	0.1-0.55
DDTs	2	NA	2-5	0.095-0.473
Dieldrin	1	NA	2	0.425

Neither MDL nor RL was available from SFEI-CALFED and TSMP. Only mercury levels were measured in these projects, and they were all at detectable levels. NA=information not available or samples not analyzed for this chemical.