OFFICE OF ENVIRONMENTAL HEALTH HAZARD ASSESSMENT

GOOD CATCH CALIFORNIA
Your Fish Advisor

Health Advisory and Guidelines for Eating Fish from Shasta Lake (Shasta County)

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Fish, Ecotoxicology, and Water Section
Pesticide and Environmental Toxicology Branch
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LIST OF ACRONYMS AND ABBREVIATIONS

ATL	Advisory Tissue Level
CDFW	California Department of Fish and Wildlife
DDT(s)	dichlorodiphenyltrichloroethane (DDT) and its metabolites dichlorodiphenyldichloroethane (DDD) and dichlorodiphenyldichloroethylene (DDE)
DWR	Department of Water Resources, California
DHA	docosahexaenoic acid
EPA	eicosapentaenoic acid
FDA	Food and Drug Administration
FMP	Fish Mercury Project
Hg	mercury
MDL	method detection limit
MLML	Moss Landing Marine Laboratories
mm	millimeters
n	sample size
NLFTS	National Lake Fish Tissue Study, US EPA
OEHHA	Office of Environmental Health Hazard Assessment
PBDEs	polybrominated diphenyl ethers
PCBs	polychlorinated biphenyls
ppb	parts per billion
RL	reporting limit
Se	selenium

SWAMP	Surface Water Ambient Monitoring Program
USDA	United States Department of Agriculture
USDHHS	United States Department of Health and Human Services
US EPA	United States Environmental Protection 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 guidelines for eating fish from Shasta Lake in Shasta County. 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.

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A Guide to Eating Fish from Shasta Lake

Women 18 - 45 years and Children 1 - 17 years

♥ Rainbow Trout

Sunfish species

♥ Black Bass species

Carp

♥ Chinook (King) Salmon

Channel Catfish

2 total servings a week of Rainbow Trout OR 3 total servings a week of Sunfish species	OR	1 total serving a week	Do not eat

Women 46 years and older and Men 18 years and older

♥ Rainbow Trout

Sunfish species

♥ Black Bass species

Carp

♥ Chinook (King) Salmon

Channel Catfish

6 total servings a week of Rainbow Trout OR 7 total servings a week of Sunfish species	OR	2 total servings a week of Black Bass species or Chinook Salmon OR 3 total servings a week of Carp	OR	1 total serving a week

What is a serving?

For Adults **For Children**

A serving is about the size and thickness of your hand for fish fillets. Give children smaller servings.

Why eat fish?

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

♥ = Fish high in omega-3s

What is the concern?

Some fish have high levels of mercury or PCBs. Mercury can harm the brain, especially in unborn babies and children PCBs can cause cancer.

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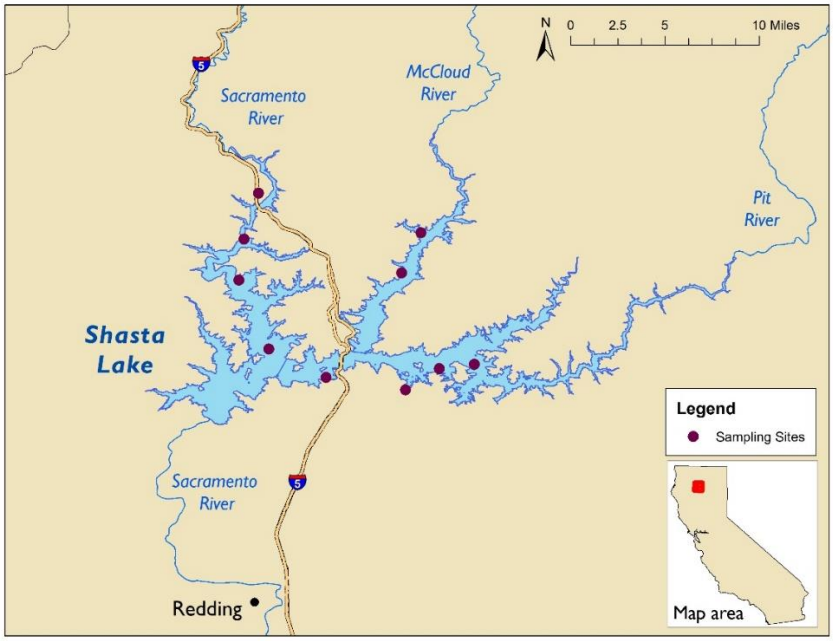
INTRODUCTION

This report presents guidelines for eating fish from Shasta Lake (Figure 1) in Shasta County, located approximately 12 miles north of Redding, California.

LOCATION

Shasta Lake is California's largest artificial lake, formed by a southwest dam on the Sacramento River.[1] Initiated under the Central Valley Project and completed in 1945, the Shasta Lake dam construction project created the 4.5 million-acre-foot capacity lake. The US Bureau of Reclamation manages the Shasta Lake dam which functions to regulate water flow for irrigation, hydroelectric power and flood protection for the greater Sacramento Valley. Shasta Lake is primarily fed by the McCloud, Pit and Sacramento rivers and is also connected to minor creeks within the greater watershed. This advisory applies only to Shasta Lake and not adjacent water bodies.

FIGURE 1. LOCATION OF SHASTA LAKE



[1] Information regarding Shasta Lake and the Shasta Lake dam was obtained from various US Bureau of Reclamation web pages. Online at:

https://www.usbr.gov/projects/index.php?id=241;
https://www.usbr.gov/mp/slwri/docs/area_inventory/01_inventory_rpt.pdf;
https://www.usbr.gov/mp/ncao/shasta/virtual_tour.pdf.

APPROACH USED

The Office of Environmental Health Hazard Assessment (OEHHA) used the results from four monitoring studies described in this report to develop the Shasta Lake Advisory. OEHHA uses the following general process in developing consumption advice for sport fish:

1) Evaluation of all fish contaminant data available from a water body 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 an appropriate measure of central tendency (often a weighted arithmetic mean[2]) and other descriptive statistics of the contaminant data, as appropriate, for a chemical of potential concern for the selected fish species.
4) Comparison of the chemical concentrations with the OEHHA Advisory Tissue Levels (ATLs) for each chemical of potential concern.
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.

The ATLs (discussed further in a subsequent section of this report) are chemical levels 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 of a complex process of data evaluation and interpretation used by OEHHA in the assessment and communication of benefits and risks of consuming sport fish.

CHEMICALS OF POTENTIAL CONCERN

Certain chemicals are considered to be 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, followed by polychlorinated biphenyls (PCBs) and, in a few cases, selenium 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 historic 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

[2] Means are an arithmetic average of individual values and/or a weighted average of composites. A weighted average of composites is calculated by multiplying the chemical concentration in each composite by the number of fish in that composite for each species. Products are then summed and divided by the total number of fish in all composites for that species, combined.

known as methylmercury – which 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 water bodies in California. Depending on the exposure level, these chemicals may cause cancer or adverse effects on the nervous system.

Polybrominated diphenyl ethers (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).

Fish sampling data used for the Shasta Lake advisory were analyzed for one or more of the following contaminants: mercury (as a measure of methylmercury), PCBs, selenium, PBDEs and the legacy pesticides (chlordanes, dieldrin, DDTs [DDT and its metabolites]). Fish species that do not normally accumulate PCBs or other organic chemicals may not be analyzed for those contaminants in a particular monitoring study. Mercury and PCB levels in fish tissue samples from Shasta Lake were sufficient to impact consumption advice; data for other contaminants are not shown in this report.

DATA SOURCES

The guidelines for eating fish from Shasta Lake are based on the chemicals detected in the fish collected for the four monitoring studies described below. These studies met OEHHA's data quality criteria, including adequate documentation of sample collection,

fish preparation method (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 was reported. "Sampling" or "sampled" refers to the act of collecting fish for chemical analysis.

Mercury Contamination in Fish from Northern California Lakes and Reservoirs, California Department of Water Resources (DWR), 2000-2001

DWR conducts investigations throughout California to ensure that various state waters comply with the California Water Code. DWR, in cooperation with local California Department of Fish and Wildlife (CDFW) staff, then known as the California Department of Fish and Game, collected Spotted Bass from Shasta Lake in 2000, to evaluate mercury contamination levels in fish found in Northern California lakes and reservoirs (DWR, 2007).

US EPA National Lake Fish Tissue Study (NLFTS)

The US Environmental Protection Agency (US EPA) initiated a national screening-level survey of chemical residues in fish tissue from lakes and reservoirs in the lower 48 states (US EPA, 2013). Working with state, tribal, and federal partner agencies, samplers collected fish from 500 lakes and reservoirs, selected randomly, over a four-year period (2000-2003). Shasta Lake was one of the 19 lakes sampled in California. In most lakes, both a predator species and a bottom-dwelling species were collected. For Shasta Lake, Rainbow Trout were collected and samples were analyzed for mercury, chlordanes, DDTs, dieldrin, PCBs, and toxaphene.

Contaminants in Fish From California Lakes and Reservoirs, 2007-2008 (SWAMP)

The Surface Water Ambient Monitoring Program (SWAMP), operated by the SWRCB in cooperation with Regional Water Quality Control Board staff, monitors water quality in California's surface waters. The program collected Channel Catfish and Spotted Bass from Shasta Lake in 2007 to analyze mercury in both species, and chlordanes, DDTs, dieldrin, PBDEs, PCBs, and selenium in Channel Catfish, as part of a SWAMP statewide sampling effort to survey contaminants in sport fish found in California lakes and reservoirs (SWRCB, 2010).

Fish Mercury Project (FMP)

The FMP was a three-year (2005 to 2007) sampling program funded by CALFED[3] (SFEI, 2009). Monitoring of sport fish from Central Valley water bodies was planned

[3] The CALFED Bay Delta Program was a state and federal partnership to improve water quality, increase water supply, as well as support ecosystem restoration and levee improvement in the San Francisco Bay-Delta.

and conducted by staff at CDFW, OEHHA, California Department of Public Health, University of California at Davis, and the San Francisco Estuary Institute. More than 4,000 fish and 31 sport fish species were collected under the project objective to characterize spatial and temporal trends in mercury in fishery resources. Fish samples were collected from 146 popular sport fishing locations in the Delta watershed. Bluegill, Channel Catfish, Chinook (King) Salmon, Common Carp, Largemouth Bass, Pumpkinseed, Rainbow Trout, and Spotted Bass were collected from Shasta Lake in 2006 and fillets were analyzed for total mercury.

FISH SAMPLED FROM SHASTA LAKE

The fish sampling data used in these advisories were retrieved from the California Environmental Data Exchange Network (CEDEN). 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). A summary of all fish species included in these advisories is shown in Table 1, including the name of the species, number of samples collected, total number of fish, project name, year sampled, and contaminants analyzed.

TABLE 1. FISH SAMPLES EVALUATED FOR THE SHASTA LAKE ADVISORY

Common Name	Scientific Name	Number of Samples	Total Number of Fish	Project	Year Collected	Contaminants Analyzed
Bluegill	*Lepomis macrochirus*	25	25	FMP	2006	Hg
Channel Catfish	*Ictalurus punctatus*	4	4	FMP	2006	Hg
		2[a]	9	SWAMP	2007	Hg
		1[a]	9	SWAMP	2007	Chlordanes, DDTs, dieldrin, PBDES, PCBs, Se
Chinook (King) Salmon	*Oncorhynchus tshawytscha*	10	10	FMP	2006	Hg
Common Carp	*Cyprinus carpio*	11	11	FMP	2006	Hg
Largemouth Bass	*Micropterus salmoides*	29	29	FMP	2006	Hg
Pumpkinseed	*Lepomis gibbosus*	20	20	FMP	2006	Hg
Rainbow Trout	*Oncorhynchus mykiss*	2[b]	10	NLFTS	2002	Chlordanes, DDTs, dieldrin, Hg, PCBs, toxaphene
		11	11	FMP	2006	Hg
Spotted Bass	*Micropterus punctulatus*	4[c]	18	DWR	2000	Hg
		5	5	FMP	2006	Hg
		9	9	SWAMP	2007	Hg

DDTs = dichlorodiphenyltrichloroethane (DDT) and its metabolites
dichlorodiphenyldichloroethane (DDD)
dichlorodiphenyldichloroethylene (DDE)
Hg = Mercury
PBDEs = polybrominated diphenyl ethers
PCBs = polychlorinated biphenyls
Se = Selenium
[a]Samples did not meet the 75% minimum length rule for tissue composite samples.
[b]Skin was not removed from fillets prior to tissue analysis.
[c]Study report did not specify whether skin was removed from fillets prior to tissue analysis.

CHEMICAL CONCENTRATIONS

As shown in Table 1, samples were analyzed for total mercury, selenium, chlordanes, DDTs, dieldrin, PBDEs, PCBs (54-55 congeners[4]), and toxaphene. All fish samples were prepared as skinless fillets, including Rainbow Trout in the FMP study, except for the DWR study where the fillet preparation method for Spotted Bass was not recorded, and the NLFTS study where the skin was not removed from Rainbow Trout fillet samples. Samples were analyzed as individual fish or composites.

Composites were prepared from equal amounts of tissue from several similarly sized individual fish of a species. For composite samples, the total length of the smallest fish in a composite sample must be at least 75% of the length of the largest fish in the sample (US EPA, 2000a). Composite samples for all species from Shasta Lake except Channel Catfish met this requirement. There were three Channel Catfish composite samples of four, five or nine fish where the smallest fish in the sample was 69%, 63%, or 58%, respectively, of the length of the largest fish. Channel Catfish comprise a major fraction of the overall sport fish catch in Shasta Lake, making this lake a popular sport fishing location for this species (USDA, 2015). For this reason, OEHHA included these data to develop consumption advice for Channel Catfish.

For this advisory, OEHHA used the weighted (by the number of individual fish) arithmetic mean (average) of the chemical concentrations (in wet weight) for each fish species to estimate average human exposure.

MERCURY

Samples were analyzed for total mercury, either as 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). Table 2 shows the averages and ranges for total length[5], as well as mercury concentrations in each fish species. Both the DMA method detection limit (MDL)[6] and the reporting limit (RL)[7] for total mercury were reported at 12 parts per billion (ppb).

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[4] Congeners are related compounds with similar chemical forms. Of the 209 possible PCB congeners, 54-55 are generally reported.

[5] Total length is the maximum length of the fish, measured from the tip of the closed mouth to the tip of the pinched tail fin.

[6] The MDL is the lowest quantity of a chemical that can be distinguished (as greater than zero) in a sample.

[7] The RL is the lowest quantity of a chemical that can be accurately quantified in a sample.

PBDEs, PCBs and Pesticides

Some composite samples were analyzed for legacy pesticides (chlordanes, DDTs, dieldrin, and toxaphene), PBDEs, and PCBs. Pesticides, PBDEs and PCBs were analyzed by gas chromatography at the CDFW Water Pollution Control Laboratory. For PCBs, chlordanes, DDTs and PBDEs, each of the concentrations presented was the sum of the detected parent compound, congeners, or metabolites, where applicable. Since the MDLs or RLs were relatively low, ≤ 0.9 and ≤ 5 ppb, respectively, 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). Concentrations of chlordanes, dieldrin, DDTs, PBDEs, and toxaphene were not sufficiently high to alter consumption advice and are not shown.

Selenium

The CDFW MLML analyzed species collected from Shasta Lake for selenium, as composite samples, using inductively coupled plasma-mass spectrometry (ICP-MS). The ICP-MS method utilizes desolvation, atomization and ionization with ion separation based on a mass-to-charge ratio to detect the total selenium concentration in a sample. The ICP-MS method detection limit (MDL) and the reporting limit (RL) for total selenium were reported at 100 and 300 ppb, respectively. The selenium concentrations were not sufficiently high to alter consumption advice and are not shown.

TABLE 2. MERCURY AND PCB CONCENTRATIONS IN FISH FROM SHASTA LAKE

Species from Shasta Lake	Number of Samples	Total Number of Fish	Mean* Total Length (mm)	Range of Total Lengths** (mm)	Mercury (ppb)	
					Mean*	Range**
Black Bass species***	47	61	358	305 - 522	344	158 - 814
Bass, Largemouth	29	29	350	310 - 425	315	158 - 562
Bass, Spotted	18	32	366	305 - 522	370	166 - 814
Carp, Common	11	11	626	370 - 759	207	65 - 290
Channel Catfish	6	13	605	376 - 766	489	88 - 795
Chinook (King) Salmon	10	10	505	465 - 556	300	237 - 396
Rainbow Trout	13	21	379	325 - 467	88	26 - 138
Sunfish species***	45	45	123	100 - 205	68	22 - 215
Bluegill	25	25	125	101 - 205	67	31 - 102
Pumpkinseed	20	20	120	100 - 140	70	22 - 215
Species from Shasta Lake	Number of Samples	Total Number of Fish	Mean* Total Length (mm)	Range of Total Lengths** (mm)	PCB (ppb)	
					Mean*	Range**
Channel Catfish	1	9	632	440 - 766	18	n/a
Rainbow Trout	2	10	392	387 - 396	10	7 - 12

*Means are an arithmetic average of individual values and/or a weighted average of composites.
**Range of individuals and/or range of the composites.
***Largemouth and Spotted bass were combined for “Black Bass species,” and Bluegill and Pumpkinseed were combined for “Sunfish species” for the purpose of developing consumption advice.
n/a = not applicable due to a single sample.

DEVELOPMENT OF GUIDELINES FOR EATING FISH FROM SHASTA LAKE

GENERAL INFORMATION

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, 2014; OEHHA, 2008; Institute of Medicine, 2007; Kris-Etherton et al., 2002). Fish are a significant source of the specific omega-3 fatty acids, docosahexaenoic acid (DHA) and eicosapentaenoic acid (EPA) thought to be associated with these beneficial health effects (USDA/USDHHS, 2015; Weaver et al., 2008).

The 2015-2020 U.S. Dietary Guidelines recommend that 1) the general population "consume eight or more ounces per week (less for young children)" of a variety of seafood[8] "for the total package of nutrients that seafood provides, including its EPA and DHA content" and 2) "women who are pregnant or breastfeeding should consume at least eight and up to twelve ounces of a variety of seafood per week from choices that are lower in methylmercury" (USDA/USDHHS, 2015). 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 US EPA 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).

In order 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

[8] "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" (USDHHS/USDA, 2015).

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 45 years of age) and children 1-17 years, are lower than those for women 46 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 Sport Fish: Polybrominated Diphenyl Ethers (PBDEs)" (OEHHA, 2011). A list of the ATLs used in this report is presented in Appendix I.

For each fish species in this advisory, OEHHA compared the mean mercury concentrations detected in the fillet to the corresponding ATLs to establish the maximum number of servings per week that could be consumed (see Appendix I).

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 multiple chemical exposure methodology (US EPA, 1989 and 2000b). If two or more chemicals with similar adverse effects are present in fish tissue at levels above the corresponding ATL values for daily consumption, 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. For the Shasta Lake Advisory, the concentrations of chlordanes, DDTs, dieldrin, PBDEs, selenium, and toxaphene were below the corresponding ATL values for daily consumption. Thus, the potential effect of multiple chemical exposures was only evaluated for mercury and PCBs. Advice for all species in this advisory was based on mercury concentrations and, when available, PCB concentrations.

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 advice on consuming a particular fish species can be extended to other closely related fish species[9] known to accumulate similar levels of contaminants.

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 (including commercial) 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, or eat one 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.

CONSUMPTION ADVICE FOR FISH FROM SHASTA LAKE

OEHHA's advisory protocol requires at least nine fish of a species to be collected from a water body before an advisory can be developed for the primary contaminant of concern. This is to ensure the sample dataset is representative of the fish species population in the water body. In some cases, an exception is made for species that are commonly caught and consumed from a given water body but where available data may be limited. For Shasta Lake, the sample size criterion was met for the following species: Bluegill, Channel Catfish, Chinook (King) Salmon, Common Carp, Largemouth Bass, Pumpkinseed, Rainbow Trout, and Spotted Bass. There were not sufficient data to evaluate other species that may be found in this water body.

BLACK BASS SPECIES (LARGEMOUTH, SPOTTED)

Based on the mean mercury concentration of 344 ppb, OEHHA recommends a maximum of one serving a week of black bass species for the sensitive population (women 18 to 45 years and children 1 to 17 years), and a maximum of two servings a week for the general population (women 46 years and older, and men 18 years and older). The mean mercury levels in individual black bass species were 315 (Largemouth) and 370 (Spotted) ppb, respectively. Black bass species include Largemouth, Smallmouth, Redeye, and Spotted Bass, all members of the same genus. PCBs were not evaluated in black bass species from Shasta Lake.

OEHHA has evaluated mercury concentrations in black bass species in many water bodies in California and found a similar range of mercury concentrations when two or more of these species were caught from the same water body. Therefore, OEHHA extends the consumption advice for Largemouth Bass and Spotted Bass to other black bass species.

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

Channel Catfish

The mean mercury and PCB concentrations in catfish from Shasta Lake were 489 and 18 ppb, respectively. OEHHA recommends no consumption of catfish for the sensitive population (women 18 to 45 years and children 1 to 17 years), and a maximum of one serving a week for the general population (women 46 years and older, and men 18 years and older), based on mercury. PCBs did not impact advice for catfish from Shasta Lake.

Chinook (King) Salmon

The mean mercury level in Chinook (King) Salmon from Shasta Lake was 300 ppb. OEHHA recommends a maximum of one serving a week of Chinook (King) Salmon for the sensitive population (women 18 to 45 years and children 1 to 17 years) and a maximum of two servings a week for the general population (women 46 years and older, and men 18 years and older), based on mercury. PCBs were not evaluated in Chinook (King) Salmon from Shasta Lake.

Common Carp

The mean mercury level in Common Carp from Shasta Lake was 207 ppb. OEHHA recommends a maximum of one serving a week of carp for the sensitive population (women 18 to 45 years and children 1 to 17 years) and a maximum of three servings a week for the general population (women 46 years and older, and men 18 years and older), based on mercury. PCBs were not evaluated in carp from Shasta Lake.

Rainbow Trout

The mean mercury and PCB concentrations in Rainbow Trout from Shasta Lake were 88 and 10 ppb, respectively. OEHHA recommends a maximum of two servings a week of Rainbow Trout for the sensitive population (women 18 to 45 years and children 1 to 17 years) based on mercury, and a maximum of six servings a week for the general population (women 46 years and older, and men 18 years and older), based on PCBs.

Sunfish Species (Bluegill, Pumpkinseed)

Based on the mean mercury concentration of 68 ppb, OEHHA recommends a maximum of three servings a week of sunfish species for the sensitive (women 18 to 45 years and children 1 to 17 years) and a maximum of seven servings a week for the general (women 46 years and older, and men 18 years and older) population, based on mercury. The mean mercury levels in individual sunfish species were 67 (Bluegill) and 70 (Pumpkinseed) ppb, respectively. Sunfish species include Bluegill, Green Sunfish, Pumpkinseed, and Redear Sunfish, all members of the same genus. PCBs were not evaluated in sunfish species from Shasta Lake.

OEHHA evaluated mercury concentrations in sunfish species in many water bodies in California and found a similar range of mercury concentrations when two or more of these species were caught from the same water body. Therefore, OEHHA extends the consumption advice for Bluegill and Pumpkinseed to other sunfish species.

RECOMMENDED MAXIMUM NUMBER OF SERVINGS

The recommended maximum numbers of servings per week for fish from Shasta Lake are shown in Table 3.

TABLE 3. RECOMMENDED MAXIMUM NUMBER OF SERVINGS PER WEEK FOR FISH FROM SHASTA LAKE

Fish Species	Women 18–45 years and Children 1–17 years	Women 46 years and older and Men 18 years and older
Black Bass species	1	2
Carp	1	3
Channel Catfish	0	1
Chinook (King) Salmon	1	2
Rainbow Trout	2	6
Sunfish species	3	7

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APPENDIX I. ADVISORY TISSUE LEVELS

Advisory Tissue Levels (ATLs) 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 average daily reference dose[10] 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 Shasta Lake are followed, exposure to chemicals in fish from Shasta Lake 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 18-45 and children 1-17)	≤ 31	>31-36	>36-44	>44-55	>55-70	>70-150	>150-440	>440
MeHg (Women > 45 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.

[10] 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.