OFFICE OF ENVIRONMENTAL HEALTH HAZARD ASSESSMENT

GOOD CATCH CALIFORNIA
Your Fish Advisor

Health Advisory and Guidelines for Eating Fish from Lake Havasu (San Bernardino County)

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Fish, Ecotoxicology, and Water Section
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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)
DHA	Docosahexaenoic acid
EPA	Eicosapentaenoic acid
FDA	Food and Drug Administration
Hg	mercury
MDL	method detection limit
MLML	Moss Landing Marine Laboratories
mm	millimeters
n	sample size
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
TSMP	Toxic Substances 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 Lake Havasu in San Bernardino 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 Lake Havasu

Women 18 - 45 years and Children 1 - 17 years

Carp

Catfish

Sunfish Species

♥ Black Bass Species

♥ Striped Bass

4 total servings a week OR 3 total servings a week OR 2 total servings a week

Women 46 years and older and Men 18 years and older

Catfish

♥ Black Bass Species

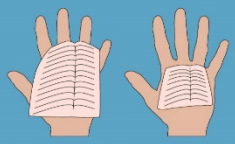
Carp

♥ Striped Bass

Sunfish Species

7 total servings a week OR 4 total servings a week OR 2 total servings a week of Striped Bass OR 3 total servings a week of Sunfish Species

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. High levels of selenium can cause health problems.

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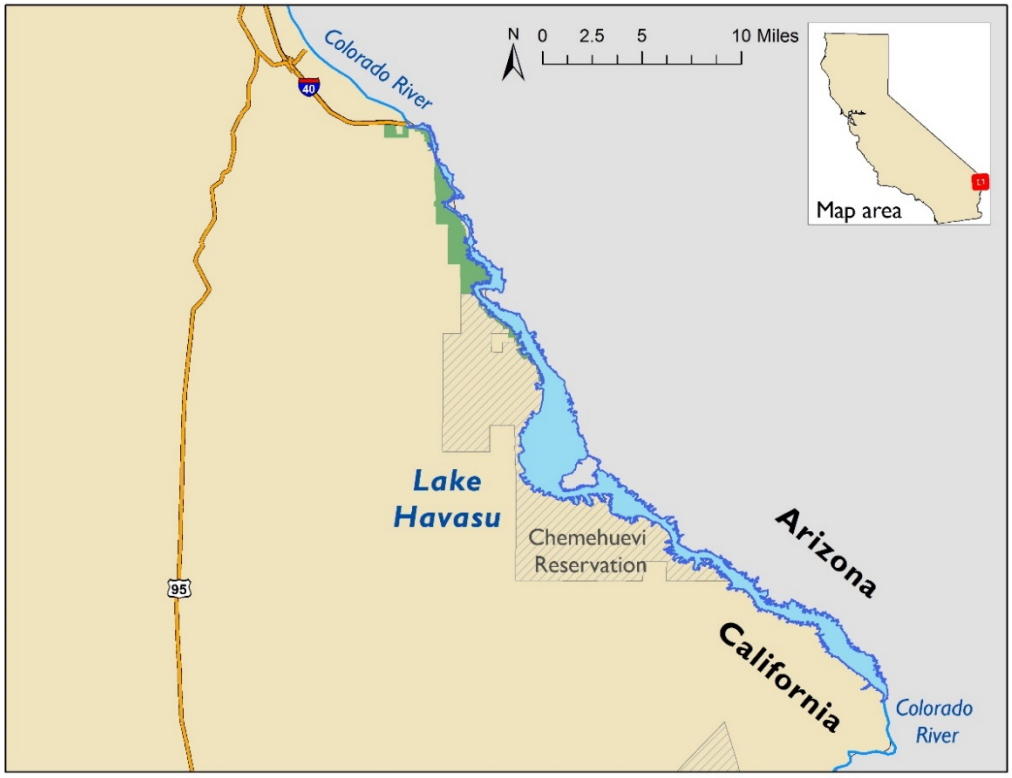
INTRODUCTION

This report presents guidelines for eating fish from Lake Havasu (Figure 1) in San Bernardino County, California, on the border between California and Arizona.

LOCATION

Lake Havasu straddles the border between California and Arizona and is part of the Colorado River Basin watershed. It is a 45-mile long reservoir created by the construction of Parker Dam, built by the US Bureau of Reclamation and completed in 1938. Lake Havasu serves as reservoir storage for the lower Colorado River and the Central Arizona Project Aqueducts, and encompasses 32 square miles, with a capacity of approximately 211 billion gallons.[1] This advisory applies to Lake Havasu and not the greater watershed region.

FIGURE 1. LOCATION OF LAKE HAVASU



[1] Information for Lake Havasu was obtained from the US Bureau of Reclamation, Lower Colorado Dams Office website. Online at http://www.usbr.gov/lc/hooverdam/parkerdam.html

APPROACH USED

The Office of Environmental Health Hazard Assessment (OEHHA) used the results from three monitoring studies described in this report to develop the Lake Havasu 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

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[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 Lake Havasu Advisory were analyzed for two 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], and toxaphene). Fish species that do not normally accumulate PCBs or other organic chemicals may not be analyzed for those contaminants in a particular monitoring study. Only mercury and selenium levels in fish tissue samples were sufficient to impact consumption advice; data for other contaminants are not shown in this report.

DATA SOURCES

The guidelines for eating fish from Lake Havasu are based on the chemicals detected in the fish collected for the three 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.

Toxic Substances Monitoring Program (TSMP)

The TSMP (1976-2003) was a state water quality-monitoring program managed by the State Water Resources Control Board (SWRCB, 2007 and Davis et al., 2010). Its objective was to provide statewide information on the occurrence of toxic substances by monitoring water bodies with known or suspected water quality impairment. The California Department of Fish and Wildlife (CDFW), then known as the California Department of Fish and Game, collected Bluegill from Lake Havasu in 1987 as part of the program. Fish samples were analyzed for mercury and selenium. (Because of the lengthly timespan between the TSMP and subsequent analysis, concentrations of selenium and mercury were evaluated and determined to be comparable between studies.)

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 Common Carp from Lake Havasu in 2007, which was analyzed for mercury, PDBEs, PCBs, dieldrin, DDTs, chlordanes, and selenium. The SWRCB used the data from this survey to characterize statewide water quality conditions (Davis et al., 2010).

Regional Water Quality Control Board, Colorado River Basin Sport Fish Monitoring Program (RWB7)

In 2014, SWAMP performed regional monitoring surveys of Lake Havasu to evaluate contaminants in commonly consumed sport fish and to gain information about contamination in the greater aquatic food web (RWQCB, 2013). The surveys collected Bluegill, Channel Catfish, Largemouth Bass, Redear Sunfish, and Striped Bass from Lake Havasu. Fish samples were analyzed for several common fish contaminants (mercury, chlordanes, DDTs, dieldrin, PCBs, selenium, and toxaphene).

Fish Sampled from Lake Havasu

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 this advisory 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 LAKE HAVASU ADVISORY

Common Name	Scientific Name	Number of Samples	Total Number of Fish	Project	Year Collected	Contaminants Analyzed
Bluegill	*Lepomis macrochirus*	1	5	TSMP	1987	Hg, Se
		3	15	RWB7	2014	Hg, Se
Channel Catfish	*Ictalurus punctatus*	4	20	RWB7	2014	Hg, Se
		1	20	RWB7	2014	Chlordanes, DDTs, Dieldrin, PCBs, Toxaphene
Common Carp	*Cyprinus carpio*	4	20	SWAMP	2007	Hg, Se
		1	20	SWAMP	2007	Chlordanes, DDTs, Dieldrin, PBDEs, PCBs
Largemouth Bass	*Micropterus salmoides*	35	35	RWB7	2014	Hg
		1	20	RWB7	2014	Chlordanes, DDTs, Dieldrin
		4	20	RWB7	2014	Se
Redear Sunfish	*Lepomis microlophus*	2	15	RWB7	2014	Hg, Se
Striped Bass	*Morone saxatilis*	40	40	RWB7	2014	Hg, Se
		1	20	RWB7	2014	Chlordanes, DDTs, Dieldrin, PCBs, Toxaphene

DDTs = dichlorodiphenyltrichloroethane (DDT) and its metabolites
dichlorodiphenyldichloroethane (DDD)
dichlorodiphenyldichloroethylene (DDE)
Hg = Mercury
PBDEs = polybrominated diphenyl ethers
PCBs = polychlorinated biphenyls
Se = Selenium

CHEMICAL CONCENTRATIONS

As shown in Table 1, samples were analyzed for two or more of the following: total mercury, chlordanes, DDTs, dieldrin, PBDEs, PCBs (54-55 congeners[3]), selenium, and toxaphene. All fish samples were prepared as skinless fillets, except for the TSMP study where the fillet preparation method for Bluegill was not recorded. 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 except a number of Common Carp, Channel Catfish, and Largemouth Bass met this requirement. Each of these three species (Common Carp, Channel Catfish, and Largemouth Bass) had one composite sample of 20 fish where the smallest fish in the sample was 74%, 74% or 73%, respectively, of the length of the largest fish. Common Carp, Channel Catfish, and Largemouth Bass are popular sport fish in Lake Havasu and among the most abundant species in the Colorado River basin. For these reasons, OEHHA included these data to develop consumption advice for these species.

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[4] as well as mercury concentrations in each fish species. The DMA method detection limit (MDL)[5] and the reporting limit (RL)[6] for total mercury were reported at 4 and 12 parts per billion (ppb), respectively, for the TSMP and RWB7 studies. The DMA method detection limit (MDL) and the reporting limit (RL) for total mercury were both reported at 12 parts per billion (ppb) for the SWAMP study.

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[3] Congeners are related compounds with similar chemical forms. Of the 209 possible PCB congeners, 54-55 are generally reported.
[4] 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.
[5] The MDL is the lowest quantity of a chemical that can be distinguished (as greater than zero) in a sample.
[6] 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 PBDEs, PCBs, chlordanes, and DDTs, 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). Total toxaphene concentrations were reported with a MDL/RL value of 400 ppb. Concentrations of chlordanes, DDTs, dieldrin, toxaphene, PBDEs and PCBs were not sufficiently high to alter consumption advice and are not shown.

Selenium

The CDFW MLML analyzed species collected from Lake Havasu for selenium, either as individual fish or 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 150 and 400 ppb, respectively. The selenium concentrations were sufficiently high to alter consumption advice and are shown in Table 3.

TABLE 2. MERCURY CONCENTRATIONS IN FISH FROM LAKE HAVASU

Species from Lake Havasu	Number of Samples	Total Number of Fish	Mean* Total Length (mm)	Range of Total Lengths** (mm)	Mercury (ppb)	
					Mean*	Range**
Bass, Largemouth	35	35	428	340-521	127	39-268
Bass, Striped	40	40	517	394-656	118	6-316
Catfish, Channel	4	20	714	619-836	66	39-101
Carp, Common	4	20	595	498-670	33	15-57
Sunfish Group***	6	35	173	126-382	36	8-87
Bluegill	4	20	143	126-180	34	8-45
Redear Sunfish	2	15	213	131-382	38	13-87

*Means are an arithmetic average of individual values and/or a weighted average of composites.
**Range of individuals and/or range of the composites.
***Bluegill and Redear Sunfish were combined ("Sunfish Group") for the purpose of developing consumption advice.

TABLE 3. SELENIUM CONCENTRATIONS IN FISH FROM LAKE HAVASU

Species from Lake Havasu	Number of Samples	Total Number of Fish	Mean* Total Length (mm)	Range of Total Lengths** (mm)	Selenium (ppb)	
					Mean*	Range**
Bass, Largemouth	4	20	398	340-466	1593	1310-2140
Bass, Striped	40	40	517	394-656	2666	1920-3740
Catfish, Channel	4	20	714	619-836	513	450-580
Carp, Common	4	20	595	498-670	1520	1170-1810
Sunfish Group***	6	35	173	126-382	1727	1080-2240
Bluegill	4	20	143	126-180	1640	1080-2240
Redear Sunfish	2	15	213	131-382	1843	1670-1930

*Means are an arithmetic average of individual values and/or a weighted average of composites.
**Range of individuals and/or range of the composites.
***Bluegill and Redear Sunfish were combined ("Sunfish Group") for the purpose of developing consumption advice.

DEVELOPMENT OF GUIDELINES FOR EATING FISH FROM LAKE HAVASU

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[7] "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 Environmental Protection Agency (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, or 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 may eat, for each species and at each location, to limit their exposure to these contaminants. Consumers may use

[7] "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 and selenium 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). For fish species where chlordanes, DDTs, PBDEs, PCBs, dieldrin and toxaphene were analyzed, mean concentrations of these chemicals were lower than the corresponding ATL threshold values for daily consumption (OEHHA, 2008). These chemicals were therefore not considered further for developing consumption advice.

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 Lake Havasu Advisory, the concentrations of DDTs, PBDEs, and PCBs were below the corresponding ATL values for daily consumption, and thus the potential effect of multiple chemical exposures was not evaluated. Advice for all species in this advisory was based solely on mercury and selenium concentrations, which are not known to have additive effects.

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 may be extended to other closely related fish species[8] 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 may 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 LAKE HAVASU

OEHHA's advisory protocol requires at least nine fish of a species or species group (e.g., sunfish) to be collected from a water body before an advisory may 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. For Lake Havasu, the sample size criterion was met for the following species: Bluegill, Channel Catfish, Common Carp, Largemouth Bass, Redear Sunfish, and Striped Bass. There were not sufficient data to evaluate other species that may be found in this waterbody. Bluegill and Redear sunfish data were analyzed both as individual species and as a species group. Consumption advice is presented for this species group as "Sunfish Species." This advice may be extended to other small sunfish species present in Lake Havasu (e.g., Green Sunfish).

BLACK BASS SPECIES (LARGEMOUTH)

The mean mercury and selenium levels in Largemouth Bass from Lake Havasu were 127 and 1593 ppb, respectively. OEHHA recommends a maximum of two servings a week of Largemouth Bass for the sensitive population (women 18 to 45 years and children 1 to 17 years), based on mercury, and a maximum of four servings a week for the general population (women 46 years and older, and men 18 years and older) , based on selenium.

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 to other black bass species.

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

Channel Catfish

The mean mercury and selenium levels in Channel Catfish from Lake Havasu were 66 and 513 ppb, respectively. OEHHA recommends a maximum of three servings a week of Channel Catfish for the sensitive population (women 18 to 45 years and children 1 to 17 years), based on mercury, and a maximum of seven servings a week for the general population (women 46 years and older, and men 18 years and older), based on mercury or selenium.

Common Carp

The mean mercury and selenium levels in Common Carp from Lake Havasu were 33 and 1520 ppb, respectively. OEHHA recommends a maximum of four servings a week of Common Carp for both the sensitive population (women 18 to 45 years and children 1 to 17 years) and the general population (women 46 years and older, and men 18 years and older), based on selenium.

Striped Bass

The mean mercury and selenium levels in Striped Bass from Lake Havasu were 118 and 2666 ppb, respectively. OEHHA recommends a maximum of two servings a week of Striped Bass for the sensitive population (women 18 to 45 years and children 1 to 17 years), based on mercury or selenium, 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 selenium.

Sunfish Species (Bluegill, Redear)

Small sunfish species, such as Bluegill and Redear, generally have similar contaminant levels and are thus evaluated as a group. The mean mercury and selenium concentrations for the sunfish species group were 36 and 1727 ppb, respectively, which would result in a recommendation to limit consumption to no more than 4 servings a week for both the sensitive population (women 18 to 45 years and children 1 to 17 years) and the general population (women 46 years and older, and men 18 years and older), based on selenium. Analyzed separately, however, Redear Sunfish had a higher average selenium concentration than bluegill (1843 and 1640 ppb, respectively), which would result in a recommendation to limit consumption of Redear to no more than three servings per week for both the sensitive and general populations. For ease of risk communication and to account for the potentially similar appearance of different sunfish species, OEHHA recommends that the more health protective consumption advice developed for Redear Sunfish be extended to other sunfish species. Therefore, consumption advice for all sunfish species in Lake Havasu is a maximum of 3 servings a week for both the sensitive and general populations, based on selenium.

RECOMMENDED MAXIMUM NUMBER OF SERVINGS

The recommended maximum numbers of servings per week for fish Lake Havasu are shown in Table 4.

TABLE 4. RECOMMENDED MAXIMUM NUMBER OF SERVINGS PER WEEK FOR FISH FROM LAKE HAVASU

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	2	4
Catfish	3	7
Carp	4	4
Striped Bass	2	2
Sunfish Species	3	3

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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[9] 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 Lake Havasu are followed, exposure to chemicals in fish from Lake Havasu 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.

[9] 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.