OFFICE OF ENVIRONMENTAL HEALTH HAZARD ASSESSMENT

GOOD CATCH CALIFORNIA
Your Fish Advisor

Health Advisory and Guidelines for Eating Fish from Lower Putah Creek and Lake Solano (Solano and Yolo Counties)

Updated September 2024

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

LIST OF CONTRIBUTORS

Office of Environmental Health Hazard Assessment

Project Leads

Loren Chumney, M.S.
Huyen Tran Pham, M.P.H.

Primary Reviewers

Wesley Smith, Ph.D., Section Chief
Shannon R. Murphy, Ph.D.
Susan A. Klasing, Ph.D. (Retired Annuitant)

Final Reviewers

Elaine Khan, Ph.D., Pesticide and Environmental Toxicology Branch Chief
Kannan Krishnan, Ph.D., Assistant Deputy Director for Scientific Programs

Director

David Edwards, Ph.D., Acting Director

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For further information, contact:

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

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

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

LIST OF ACRONYMS AND ABBREVIATIONS

ATL	Advisory Tissue Level
CDFW	California Department of Fish and Wildlife
CEDEN	California Environmental Data Exchange Network
DDT(s)	dichlorodiphenyltrichloroethane (DDT) and its metabolites dichlorodiphenyldichloroethane (DDD) and dichlorodiphenyldichloroethylene (DDE)
DMA	direct mercury analyzer
FDA	United States Food and Drug Administration
Hg	mercury
ICP-MS	inductively coupled plasma-mass spectrometry
MDL	method detection limit
MeHg	methylmercury
mm	millimeters
MPSL	Marine Pollution Studies Laboratory at Moss Landing Marine Laboratories
OEHHA	Office of Environmental Health Hazard Assessment
PBDEs	polybrominated diphenyl ethers
PCBs	polychlorinated biphenyls
ppb	parts per billion
RL	reporting limit
Se	selenium
SRWP	Sacramento River Watershed Program
SWAMP	Surface Water Ambient Monitoring Program
SWRCB	State Water Resources Control Board
TSMP	Toxic Substances Monitoring Program
UCD	University of California at Davis
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.[1] 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's (CDFW) Inland and Ocean Sport Fishing Regulations in their respective sections on public health advisories.[2]

This report presents guidelines for eating fish from Lower Putah Creek and Lake Solano in Solano and Yolo Counties. 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 the List of Figures and Tables.

[1] Sport fish includes all fish and shellfish caught from California waters for non-commercial purposes (e.g., recreational, tribal/cultural, and subsistence practices).
[2] CDFW's Inland and Ocean Sport Fishing Regulations can be found online at: https://wildlife.ca.gov/Fishing/Inland and https://wildlife.ca.gov/Fishing/Ocean, respectively.

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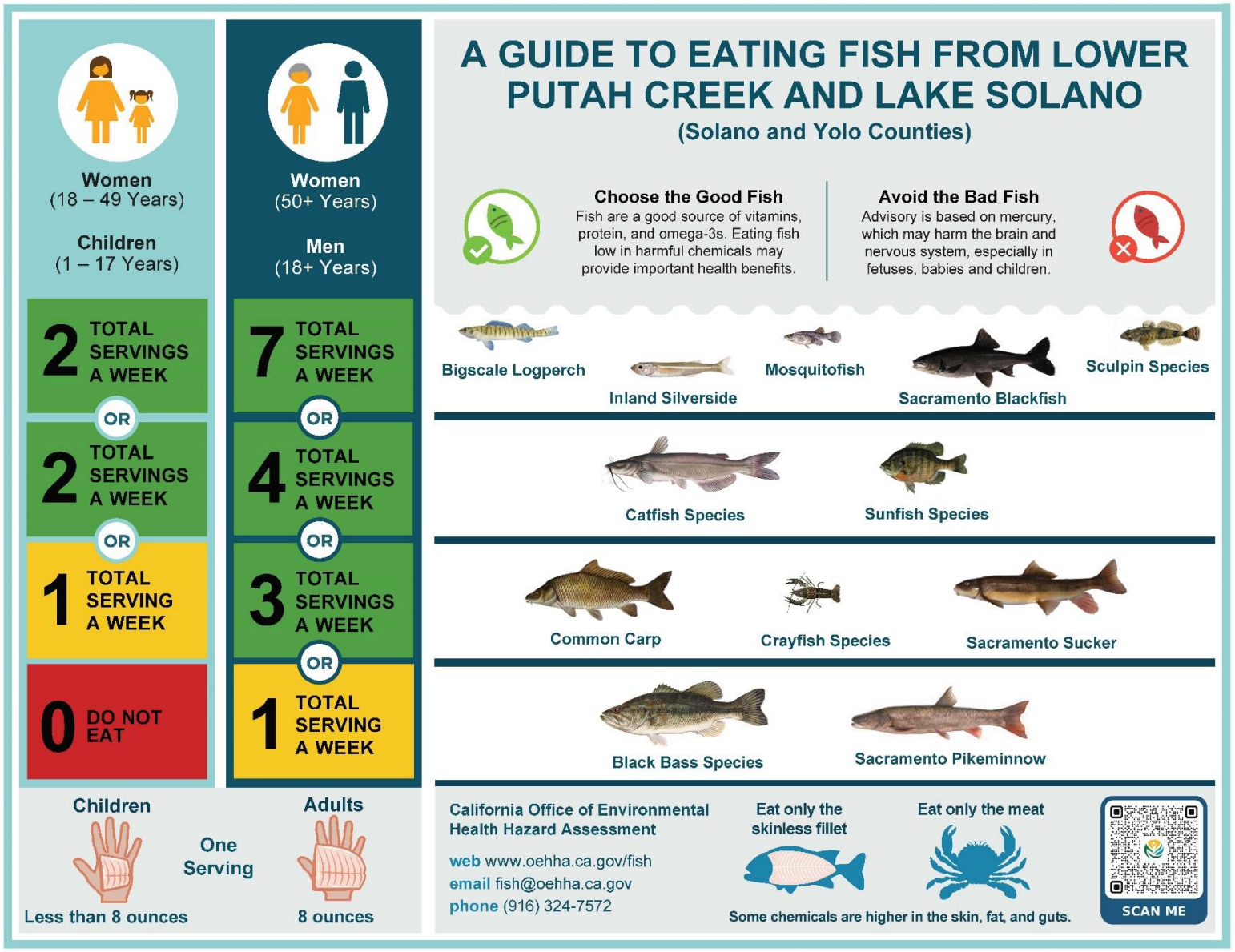

A GUIDE TO EATING FISH FROM LOWER PUTAH CREEK AND LAKE SOLANO
(Solano and Yolo Counties)
Women (18 – 49 Years)
Children (1 – 17 Years)
2 TOTAL SERVINGS A WEEK
OR
2 TOTAL SERVINGS A WEEK
OR
1 TOTAL SERVING A WEEK
0 DO NOT EAT
Women (50+ Years)
Men (18+ Years)
7 TOTAL SERVINGS A WEEK
OR
4 TOTAL SERVINGS A WEEK
OR
3 TOTAL SERVINGS A WEEK
OR
1 TOTAL SERVING A WEEK
Choose the Good Fish
Fish are a good source of vitamins, protein, and omega-3s. Eating fish low in harmful chemicals may provide important health benefits.
Avoid the Bad Fish
Advisory is based on mercury, which may harm the brain and nervous system, especially in fetuses, babies and children.
Bigscale Logperch
Inland Silverside
Mosquitofish
Sacramento Blackfish
Sculpin Species
Catfish Species
Sunfish Species
Common Carp
Crayfish Species
Sacramento Sucker
Black Bass Species
Sacramento Pikeminnow
Children
Less than 8 ounces
One Serving
Adults
8 ounces
California Office of Environmental Health Hazard Assessment
web www.oehha.ca.gov/fish
email fish@oehha.ca.gov
phone (916) 324-7572
Eat only the skinless fillet
Eat only the meat
Some chemicals are higher in the skin, fat, and guts.
SCAN ME

INTRODUCTION

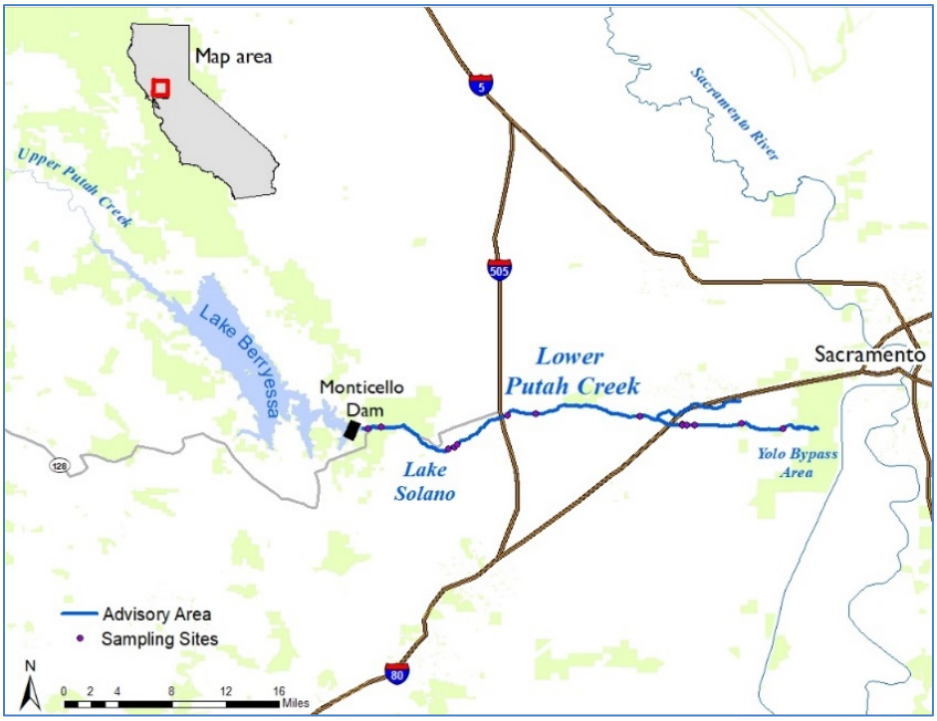
This report updates and supersedes the previous guidelines developed by the Office of Environmental Health Hazard Assessment (OEHHA, 2006 and 2009) for eating fish from Lake Berryessa and Putah Creek including Lake Solano. This report pertains only to Lower Putah Creek and Lake Solano (Figure 1). Advice for Lake Berryessa is published separately (OEHHA, 2024). The collection of additional data, along with changes in fishing regulations and analytical methodology made it necessary to update this advisory. Consumption advice is provided for eating Bigscale Logperch, black bass species, catfish species, Common Carp, crayfish species, Inland Silverside, Mosquitofish, Sacramento Blackfish, Sacramento Pikeminnow, Sacramento Sucker, sculpin species, and sunfish species. Advice for these species is based on levels of mercury (Hg) found in fish collected from Lower Putah Creek and Lake Solano.

LOCATION

Putah Creek is often divided by its “upper” and “lower” sections, which run for a total of 70 miles. Upper Putah Creek runs from its headwaters in the Mayacamas Mountains, about 30 miles northwest of Lake Berryessa, to Monticello Dam. Lower Putah Creek continues from the Dam to Lake Solano and terminates at the Yolo Bypass, west of Sacramento, and serves as the boundary between Solano and Yolo counties.[3] Lake Solano, created by the Putah Diversion Dam, is a slow-moving section of Lower Putah Creek that is supplied year round with cold, oxygenated water from the bottom of Lake Berryessa. A recreational park is situated at Lake Solano, providing easy public fishing access.

[3] Information regarding Putah Creek was obtained from the Sacramento River Watershed Program, online at: https://sacriver.org/explore-watersheds/westside-subregion/putah-creek-watershed/#:~:text=The%20Putah%20Creek%20Watershed%20encompasses,Napa%2C%20Solano%2C%20and%20Yolo.

FIGURE 1. LOCATION OF LOWER PUTAH CREEK AND LAKE SOLANO



APPROACH USED

The Office of Environmental Health Hazard Assessment (OEHHA) used the results from four monitoring studies described in this report to develop the Putah Creek and Lake Solano 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 or shellfish 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)[4] and other descriptive statistics of the contaminant data, as appropriate, for a chemical of concern for the selected fish or shellfish species.
4) Comparison of the chemical concentrations with the OEHHA Advisory Tissue Levels (ATLs) for each chemical of 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 or shellfish species.

[4] Means are an arithmetic average of individual values and/or composites weighted by number of fish. 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.

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 includes consideration of health benefits associated with including fish in the diet (OEHHA, 2008). The ATLs should not be interpreted as static “bright lines,” but as one component of a complex process of data evaluation and interpretation used by OEHHA in the assessment and communication of the benefits and risks of consuming sport fish.

CHEMICALS OF CONCERN

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

Mercury is an element found in some rocks and soil. Human activities, such as burning coal and the historical use of mercury to mine gold, also add mercury to the environment. If mercury enters waterways, it can be converted to a more toxic form known as methylmercury (MeHg), which can pass into and build up in fish. High levels of methylmercury can harm the brain, especially in fetuses and children, whose brains are still developing.

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

Selenium is an element 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.

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.

Chlordanes, dichlorodiphenyltrichloroethane (DDT), dieldrin, and toxaphene are pesticides that were banned from use in 1973 (DDT), the late 1980s (chlordanes and dieldrin) and 1990 (toxaphene), but are still found in some fish in certain California water

bodies. Depending on the exposure level, these chemicals may cause cancer or adverse effects on the nervous system.

A detailed discussion of the toxicity of these chemicals is 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).

All fish and shellfish species collected from Lower Putah Creek and Lake Solano and used in advisory development were analyzed for mercury. Some fish were also analyzed for PCBs and/or legacy pesticides as indicated in Table 1.

DATA SOURCES

The guidelines for eating fish from Lower Putah Creek and Lake Solano 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 methods (e.g., skinning or filleting), chemical analyses, quality assurance, and sufficiently low detection limits. “Sample,” as used in this report, refers to an individual fish or a composite of multiple fish for which contaminant data were reported. “Sampling” or “sampled” refers to the act of collecting fish for chemical analysis. The studies or entities contributing data to this advisory are described below.

CALFED Bay-Delta Program (CALFED)

The CALFED Bay-Delta Program was a state and federal interagency group, established in 1994, to develop strategies and provide funding for projects that improve water quality, increase water supply, and support ecosystem restoration and levee improvement in the San Francisco Bay-Delta (CALFED, 2005; Davis et al., 2004). This program was composed of more than 20 state and federal agencies including the California Environmental Protection Agency, the California Department of Fish and Wildlife (CDFW; then known as the California Department of Fish and Game), US Environmental Protection Agency, and the US Fish and Wildlife Service. CALFED funded Surface Water Ambient Monitoring Program (SWAMP) sampling efforts for historical bioaccumulation studies in fish. Sacramento Sucker were collected in 2000 from Lower Putah Creek and analyzed for mercury.

Sacramento River Watershed Program (SRWP)

The SRWP 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, 2006). The SRWP collected Bluegill, Largemouth Bass, Sacramento Sucker, and White Catfish from 1999 – 2000 in Lower Putah Creek, which were analyzed for mercury. Largemouth Bass and Sacramento Sucker were additionally analyzed for chlordanes, DDTs, dieldrin, PCBs, and toxaphene.

Toxic Substances Monitoring Program (TSMP)

The TSMP operated from 1976 to 2003 as a state water quality-monitoring program managed by the State Water Resources Control Board (SWRCB, 2007 and 2013). Its objective was to provide statewide information on the occurrence of toxic substances by monitoring water bodies with known or suspected water quality impairment. CDFW collected Largemouth Bass, Sacramento Sucker, and sculpin species from 1978 – 1980 and 1999 in Lower Putah Creek, which were analyzed for mercury. Largemouth Bass and Sacramento Sucker were additionally analyzed for chlordanes, DDTs, dieldrin, and toxaphene.

University of California, Davis (UCD)

UCD conducted a CALFED-funded, survey-level study between 1998 and 2001 to assess the production and bioaccumulation of methylmercury in relation to wetland restoration efforts in the Sacramento-San Joaquin Delta. The study provided an initial understanding of ambient mercury trends in the Delta and how wetland restoration sites may impact trends (Slotton et al. 2002). Bigscale Logperch, Bluegill, Channel Catfish, Common Carp, Green Sunfish, Inland Silverside, Largemouth Bass, Mosquitofish, Red Swamp Crayfish, Redear Sunfish, Sacramento Blackfish, Sacramento Pikeminnow, Sacramento Sucker, sculpin species, Signal Crayfish, sunfish (hybrid), Virile Crayfish, and White Catfish were collected from Lower Putah Creek in 1998 and analyzed for mercury. Sacramento Sucker were also collected from Lake Solano and analyzed for mercury.

CHANGES FROM THE 2009 ADVISORY

This update includes the following changes and additions:

1) Consumption advice for Bigscale Logperch, Inland Silverside, Mosquitofish, and sculpin species were added to the advisory to reflect OEHHA's updated practice of providing advice for all species with suitable and sufficient data.
2) Advice for Hitch and Crappie were removed from the advisory to be consistent with OEHHA's required minimum sample size and updated standard practices. Exceptions to this practice are made in specific circumstances (see Sacramento Pikeminnow, page 19).
3) Advice for trout was removed from this advisory because trout species are not legal to take from Lower Putah Creek or Lake Solano.

4) While the Lower Putah Creek and Lake Solano dataset remained unchanged since the previous advisory, advice for catfish species, Sacramento Blackfish, and sunfish species were updated for the general population to allow for additional meal frequency categories.
5) Age ranges for women in the sensitive and general populations changed to 18–49 years and 50+ years, respectively.[5]

FISH AND SHELLFISH SAMPLED FROM LOWER PUTAH CREEK AND LAKE SOLANO

The fish and shellfish sampling data used in this advisory were retrieved from the California Environmental Data Exchange Network (CEDEN),[6] the state's repository for environmental data. 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, 2022). A summary of all fish or shellfish species evaluated for this advisory is shown in Table 1, including the name of the species, number of samples collected, total number of fish or shellfish, project name, year sampled, and contaminants analyzed.

TABLE 1. FISH AND SHELLFISH SAMPLES EVALUATED FOR THE LOWER PUTAH CREEK AND LAKE SOLANO ADVISORY

Common Name	Scientific Name	Number of Samples	Total Number of Fish	Project	Year Collected	Contaminants Analyzed[e]
Bigscale Logperch	*Percina macrolepida*	5	10	UCD[a]	1998	Hg
Bluegill	*Lepomis macrochirus*	6	30	SRWP[b]	1999 – 2000	Hg
		12	12	UCD	1998	Hg
Channel Catfish	*Ictalurus punctatus*	13	13	UCD	1998	Hg
Common Carp	*Cyprinus carpio*	15	15	UCD	1998	Hg
Green Sunfish	*Lepomis cyanellus*	2	2	UCD	1998	Hg
Inland Silverside	*Menidia beryllina*	6	12	UCD[a]	1998	Hg
Largemouth Bass	*Micropterus salmoides*	2	13	SRWP[b]	1999 – 2000	Chlordanes, DDTs, Dieldrin, PCBs, Toxaphene
		16	23	SRWP[b]	1999 – 2000	Hg

[5] In 2018, OEHHA updated the age ranges for women in each population group. The sensitive population changed from women ages 18–45 years to 18–49 years, and the general population from women 46 years and older to 50 years and older.
[6] Online at: http://ceden.waterboards.ca.gov/AdvancedQueryTool.

Common Name	Scientific Name	Number of Samples	Total Number of Fish	Project	Year Collected	Contaminants Analyzed[e]
		1	5	TSMP[b]	1999	Chlordanes, DDTs, Dieldrin, Hg, Toxaphene
		6	6	UCD	1998	Hg
Mosquitofish	*Gambusia affinis*	6	12	UCD[a]	1998	Hg
Red Swamp Crayfish	*Procambarus clarkii*	35	35	UCD[c]	1998	Hg
Redear Sunfish	*Lepomis microlophus*	1	1	UCD	1998	Hg
Sacramento Blackfish	*Orthodon microlepidotus*	20	20	UCD	1998	Hg
Sacramento Pikeminnow	*Ptychocheilus grandis*	6	6	UCD	1998	Hg
Sacramento Sucker	*Catostomus occidentalis*	1	3	CalFed[d]	2000	Hg
		1	4	SRWP[b]	1999	Chlordanes, DDTs, Dieldrin, Hg, PCBs, Toxaphene
		1	4	TSMP[b]	1999	Chlordanes, DDTs, Dieldrin, Hg, Toxaphene
		14	14	UCD	1998	Hg
Sculpin Species	*Cottus spp.*	3	69	TSMP[b]	1978 – 1980	Hg
		2	4	UCD[a]	1998	Hg
Signal Crayfish	*Pacifastacus leniusculus*	30	30	UCD[c]	1998	Hg
Sunfish (hybrid)	*Lepomis spp.*	1	1	UCD	1998	Hg
Virile Crayfish	*Orconectes virilis*	15	15	UCD[c]	1998	Hg
White Catfish	*Ameiurus catus*	8	8	UCD	1998	Hg
		1	1	SRWP[b]	1999	Hg

Samples were analyzed as skinless fillets, with the following exceptions:
[a]Samples were analyzed as whole organisms, including head, skin, internal organs, muscle, and bones.
[b]Study report did not specify whether skin was removed from fillets prior to tissue analysis.
[c]Samples were analyzed using tail meat.
[d]Sample was analyzed as skin-on fillet.
[e]Data for organic chemicals (e.g., chlordanes, DDTs, dieldrin, PCBs or toxaphene) generated prior to 1998 were excluded from the analysis because data that are more recent are considered more reliable due to improved analytical methods and are likely to be more representative of fish caught today.

CHEMICAL CONCENTRATIONS

As shown in Table 1, samples were analyzed for one or more of the following: total mercury, PCBs (48 congeners), chlordanes (5 congeners), DDTs (6 congeners),

dieldrin, and toxaphene.[7] Among the chemicals analyzed in fish and shellfish tissue samples from Lower Putah Creek and Lake Solano, only mercury levels were sufficiently high to impact consumption advice.

Fish samples had several preparation methods (e.g. skin on, skin off, whole), as noted in the Table 1 footnotes. Crayfish species were prepared as shelled body meat. Samples were analyzed as individual fish or composites.

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

Mercury

Fish and shellfish samples were analyzed for total mercury, as either individual or composite samples; the analytical method was not reported. 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,[8] as well as mercury concentrations in each fish and shellfish species. Although the method detection limits (MDLs)[9] and reporting limits (RLs)[10] were not reported, mercury was detected at concentrations consistent with other studies. For this reason, these data were included in the calculation of sample means.

PCBs and Pesticides

Pesticides and PCBs were analyzed in fish as composite samples; the analytical method was not reported. Where applicable, the concentrations presented were the sum of the detected analytes (parent compound, congeners, or metabolites) for chlordanes, DDTs, and PCBs. Although the MDLs and RLs were typically not reported, chemical levels were detected at concentrations consistent with other studies, thus individual congeners or metabolites with concentrations reported as non-detects were assumed to be zero. This is a standard method of handling non-detect values for PCBs and other chemicals with multiple congeners or metabolites in a given sample when detection levels are adequate (US EPA, 2000a). Table 3 shows the averages and ranges for total length, as well as PCB concentrations in each fish species.

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[7] Congeners are related compounds with similar chemical forms. Five and six congeners are typically analyzed for chlordanes and DDTs, respectively. Of the 209 possible PBDE and PCB congeners, 6–7 and 48–54 are generally analyzed, respectively. See the OEHHA (2022) sampling protocol available online at https://oehha.ca.gov/media/downloads/fish/report/fishadvisorysamplinganalysisprotocolreport2022.pdf.

[8] 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. For crayfish species, the total carapace length was measured.

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

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

Concentrations of chlordanes, dieldrin, DDTs, and toxaphene were lower than the corresponding ATL threshold values for daily consumption (OEHHA, 2008 and 2011). PCB concentrations, where analyzed, did not impact advice. With the exception of assessing for multiple chemical exposures, these chemicals were not considered further for developing consumption advice and are not shown in this report.

TABLE 2. MERCURY CONCENTRATIONS IN FISH AND SHELLFISH FROM LOWER PUTAH CREEK AND LAKE SOLANO

Species from Lower Putah Creek and Lake Solano	Number of Samples[a]	Total Number of Fish	Mean[b] Total Length (mm)	Range of Total Lengths[c] (mm)	Mercury (ppb)	
					Mean[b]	Range[c]
Bigscale Logperch	5	10	NR	NR	88	60 – 120
Catfish Species	22	22	439	294 – 620	143	70 – 340
Channel Catfish	13	13	461	294 – 620	145	70 – 340
White Catfish	9	9	407	352 – 474	141	100 – 190
Common Carp	15	15	480	342 – 682	180	120 – 250
Crayfish Species	80	80	34	5 – 106	210	50 – 610
Red Swamp Crayfish	35	35	26	5 – 43	139	50 – 280
Signal Crayfish	30	30	46	11 – 106	241	80 – 610
Virile Crayfish	15	15	29	9 – 40	314	180 – 520
Inland Silverside	6	12	NR	NR	85	60 – 120
Largemouth Bass	23	34	373	306 – 498	457	200 – 816
Mosquitofish	6	12	NR	NR	80	30 – 230
Sacramento Blackfish	20	20	377	299 – 461	88	40 – 230
Sacramento Pikeminnow	6	6	327	255 – 498	442	170 – 730
Sacramento Sucker	17	25	412	239 – 542	212	100 – 520
Sculpin Species[d]	5	73	83	69 – 123	61	0 – 130
Sunfish Species	22	46	143	109 – 202	146	70 – 330
Bluegill	18	42	142	109 – 186	144	70 – 330
Green Sunfish	2	2	113	113 – 113	170	150 – 190
Redear Sunfish	1	1	202	n/a	150	n/a
Sunfish (hybrid)	1	1	187	n/a	190	n/a

[a]Samples were prepared multiple ways (i.e., skin-on, skin-off, whole) as noted in the Table 1 footnotes.
[b]Means are an arithmetic average of individual values and/or a weighted average of composites.
[c]Range of individuals and/or range of the composites.
[d]Samples were analyzed as both fillets and whole organisms; total length mean and range do not include two samples for which length data were not reported.
n/a = not applicable due to a single sample
NR = Not Reported

TABLE 3. PCB CONCENTRATIONS IN FISH FROM LOWER PUTAH CREEK AND LAKE SOLANO

Species from Lower Putah Creek and Lake Solano	Number of Samples[a]	Total Number of Fish	Mean[b] Total Length (mm)	Range of Total Lengths[c] (mm)	PCBs (ppb)	
					Mean[b]	Range[c]
Largemouth Bass	2	13	363	348 – 387	5	4 – 6
Sacramento Sucker	1	4	383	n/a	21	n/a

[a]Study report did not specify whether skin was removed from fillets prior to tissue analysis.
[b]Means are an arithmetic average of individual values and/or a weighted average of composites.
[c]Range of individuals and/or range of the composites.
n/a = not applicable due to a single sample

DEVELOPMENT OF GUIDELINES FOR EATING FISH AND SHELLFISH FROM LOWER PUTAH CREEK AND LAKE SOLANO

The OEHHA fish advisory process considers the health benefits of fish and shellfish 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 and shellfish contain many nutrients that are important for general health and, in particular, help promote optimal growth and development of babies and young children, and may reduce the incidence of heart disease in adults (FDA/US EPA, 2017; American Heart Association, 2016; OEHHA, 2008; Institute of Medicine, 2007; Kris-Etherton et al., 2002). Fish and shellfish are a significant source of the beneficial omega-3 fatty acids, docosahexaenoic acid (DHA) and eicosapentaenoic acid (EPA) (USDA/USDHHS, 2020; Weaver et al., 2008).

As part of a healthy US-style dietary pattern at the 2,000-calorie level, the “Dietary Guidelines for Americans, 2020 – 2025” (USDA/USDHHS, 2020) recommends consuming eight ounces of seafood[11] per week. Young children are advised to eat proportionately smaller amounts. “Women who are pregnant or lactating should consume at least 8 and up to 12 ounces of a variety of seafood per week from choices that are lower in methylmercury.” Additionally, “based on FDA [US Food and Drug Administration] and EPA’s [US Environmental Protection Agency] advice,[12] depending on body weight, some women should choose seafood lowest in methylmercury or eat less seafood than the amounts in the Healthy U.S.-Style Dietary Pattern” and avoid certain species (USDA/USDHHS, 2020). The species of fish or shellfish 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 FDA and the US EPA recommend

[11] Seafood as used here refers to fish and shellfish from freshwater and marine environments.
[12] Online at: https://www.fda.gov/food/consumers/advice-about-eating-fish.

that women who are pregnant (or might become pregnant) or breastfeeding, and young children avoid consuming shark, Swordfish, tilefish (Gulf of Mexico), Bigeye Tuna, marlin, Orange Roughy, and King Mackerel (FDA/US EPA, 2017).

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

There are two sets of ATLs for methylmercury in fish and shellfish 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 18–49 years of age) and children 1–17 years of age, are lower than those for women 50 years and older and men 18 years and older. The lower ATL values for the sensitive population provide additional protection to allow for normal growth and development of the brain and nervous system of unborn babies and children. Detailed discussion about the toxicity of common fish contaminants and health benefits of fish consumption, as well as derivation of the ATLs, are provided in "Development of Fish Contaminant Goals and Advisory Tissue Levels for Common Contaminants in California Sport Fish: Chlordane, DDTs, Dieldrin, Methylmercury, PCBs, Selenium, and Toxaphene" (OEHHA, 2008) and "Development of Fish Contaminant Goals and Advisory Tissue Levels for Common Contaminants in California Sport Fish: Polybrominated Diphenyl Ethers (PBDEs)" (OEHHA, 2011). A list of the ATLs used in this report is presented in the Appendix.

For each fish and shellfish species in this advisory, OEHHA compared the mean chemical concentrations detected in the fillet or tail meat, respectively, to the corresponding ATLs to establish the maximum number of servings per week that can be safely consumed (see Appendix). For fish fillets, a serving size is considered to be 8 ounces, prior to cooking, or about the size and thickness of a hand. For crayfish, a serving size is considered 8 ounces of shelled tail meat. Children should be given smaller servings. For smaller fish species, several individual fish may be required to yield a serving.

The consumption advice for a fish or shellfish 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 or shellfish tissue, multiple chemical exposure methodology involving hazard index calculations is employed. This may result in advising fewer servings per week than would be the case for the presence of either chemical alone, in

a similar concentration. The potential effect of multiple chemical exposures (DDTs, mercury, PCBs) was assessed in Sacramento Sucker and did not affected advice. Advice for all species in this advisory was based solely on mercury concentrations.

OEHHA recommends that individuals strive to meet the US dietary guidelines' seafood consumption recommendations,[13] while also adhering to federal and OEHHA recommendations to limit the consumption of fish or shellfish with higher contaminant levels. The advice discussed in the following section represents the maximum recommended number of servings per week for listed fish and shellfish species. People should eat no more than the recommended number of servings for each fish or shellfish species or species group. When noted, OEHHA's consumption advice for a particular fish species can be extended to other closely related fish species[14] known to accumulate similar levels of contaminants.

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

CONSUMPTION ADVICE FOR FISH AND SHELLFISH FROM LOWER PUTAH CREEK AND LAKE SOLANO

OEHHA's sampling and analysis protocol (OEHHA 2022) requires that a minimum of nine edible-size fish or shellfish of a species that may be legally caught are collected and analyzed before an advisory can be developed for the primary contaminant of concern. This is to ensure the sample dataset is representative of the fish or shellfish species population in the water body. The majority of fish consumption advisories in California are based on mercury, which is typically analyzed in individual fish, rather than as composites. Mercury analysis is relatively inexpensive and mercury concentrations in fish are more likely to be positively correlated with fish size than other contaminants. Other contaminants, such as PCBs, pesticides, and selenium, may also impact advice. These contaminants are often analyzed as a composite of a smaller subset of fish (usually at least five individuals) as a cost-saving mechanism, a common practice that is considered acceptable. In some cases, an exception is made regarding the minimum sample size. This is particularly true if the advice is based on a chemical

[13] Online at: https://www.dietaryguidelines.gov/.
[14] Fish species within the same genus are most closely related, and family is the next level of relationship.

other than mercury where sample size is often limited, and/or if doing so leads to more health-protective advice than would otherwise be provided.

For Lower Putah Creek and Lake Solano, the sample size criterion was met for mercury for all species except Sacramento Pikeminnow. Although only six Sacramento Pikeminnow were collected from Lower Putah Creek, OEHHA considers it health-protective to offer consumption advice for this species because of its relatively high mercury concentration.

With the exception of five Sacramento Sucker collected in Lake Solano, all samples were collected from other sections of Lower Putah Creek. Because Lake Solano is contiguous with Lower Putah Creek, advice for all species collected from Lower Putah Creek is extended to Lake Solano. For fish species found in Lower Putah Creek and Lake Solano that are not included in this advisory, OEHHA recommends following the statewide advisory for rivers, streams, and creeks without site-specific advice.[15]

OEHHA elected to offer advice based on data mostly collected pre-2000 because the mean mercury concentrations in Lower Putah Creek and Lake Solano are lower than statewide mean concentrations and therefore allow for more consumption. Further, mean mercury concentrations are not expected to change significantly over time.

The following advice is based solely on mercury concentrations. The sensitive population is defined as women ages 18 to 49 years and children ages 1 to 17 years, and the general population is defined as women 50 years and older and men 18 years and older.

Bigscale Logperch

The mean mercury concentration in Bigscale Logperch from Lower Putah Creek was 88 ppb. OEHHA recommends a maximum of two servings a week of Bigscale Logperch for the sensitive population, and a maximum of seven servings a week for the general population.

Black Bass Species (Based on Largemouth Bass)

Black bass species are one of the most targeted species of freshwater game fish in California. OEHHA groups black bass species because they have similar predatory diets and likely a comparable chemical uptake (Long and Fisher, 2000). They are also known to hybridize (Pierce and Van Den Avyle, 1997), largely due to species introductions for angling purposes and weak genetic barriers between members of the genus (Thongda et al., 2020). OEHHA has also evaluated mercury concentrations in black bass species in many water bodies in California and has found a similar range of mercury concentrations when two or more of these species were caught from the same

[15] Online at: https://oehha.ca.gov/advisories/statewide-advisory-eating-fish-california-rivers-streams-and-creeks-without-site-specific.

water body. Therefore, OEHHA extends the consumption advice for Largemouth Bass to other black bass species, including Redeye, Smallmouth, and Spotted Bass.

The mean mercury and PCB concentrations in Largemouth Bass from Lower Putah Creek were 457 ppb and 5 ppb, respectively. Based on the mean mercury concentration, OEHHA recommends no consumption of black bass species from Lower Putah Creek and Lake Solano for the sensitive population, and a maximum of one serving a week for the general population.

Catfish Species (Based on Channel Catfish, White Catfish)

The mean mercury concentration in catfish species from Lower Putah Creek was 143 ppb. Mercury concentrations for individual catfish species were 145 ppb for Channel Catfish and 141 ppb for White Catfish. OEHHA recommends a maximum of two servings per week for the sensitive population, and a maximum of four servings per week for the general population.

Common Carp

The mean mercury concentration in Common Carp from Lower Putah Creek was 180 ppb. OEHHA recommends a maximum of one serving a week of Common Carp for the sensitive population, and a maximum of three servings a week for the general population.

Crayfish Species

The mean mercury concentration in crayfish species from Lower Putah Creek was 210 ppb. Mercury concentrations for individual crayfish species were as follows: Red Swamp Crayfish, 139 ppb; Signal Crayfish, 241 ppb; and Virile Crayfish, 314 ppb. OEHHA recommends a maximum of one serving a week of crayfish species for the sensitive population, and a maximum of three servings a week for the general population.

Inland Silverside

The mean mercury concentration in Inland Silverside from Lower Putah Creek was 85 ppb. OEHHA recommends a maximum of two servings a week of Inland Silverside for the sensitive population, and a maximum of seven servings a week for the general population.

Mosquitofish

The mean mercury concentration in Mosquitofish from Lower Putah Creek was 80 ppb. OEHHA recommends a maximum of two servings a week of Mosquitofish for the sensitive population, and a maximum of seven servings a week for the general population.

Sacramento Blackfish

The mean mercury concentration in Sacramento Blackfish from Lower Putah Creek was 88 ppb. OEHHA recommends a maximum of two servings a week of Sacramento Blackfish for the sensitive population, and a maximum of seven servings a week for the general population.

Sacramento Pikeminnow

The mean mercury concentration in Sacramento Pikeminnow from Lower Putah Creek was 442 ppb. OEHHA recommends no consumption of Sacramento Pikeminnow for the sensitive population, and a maximum of one serving a week for the general population.

Sacramento Sucker

The mean mercury concentration in Sacramento Sucker collected from Lower Putah Creek and Lake Solano was 212 ppb. OEHHA recommends a maximum of one serving a week of Sacramento Sucker for the sensitive population, and a maximum of three servings a week for the general population.

Sculpin Species

The mean mercury concentration in sculpin species from Lower Putah Creek was 61 ppb. At this concentration, OEHHA would typically recommend of a maximum of three servings a week of sculpin species for the sensitive population. To simplify risk communication through the reduction of different meal frequency categories, OEHHA reduced the number of recommended servings a week of sculpin species from three to two for the sensitive population. OEHHA recommends a maximum of seven servings a week of sculpin species for the general population.

Sunfish Species (Based on Bluegill, Green Sunfish, Hybrid, and Redear Sunfish)

OEHHA groups sunfish species due to a known ability to hybridize (Avise and Smith, 1974) and extensive dietary overlap (Kirby, 1982), which suggests a similar contaminant uptake. OEHHA has evaluated mercury concentrations in sunfish species from many water bodies in California and has 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, Green Sunfish, hybrid sunfish, and Redear Sunfish to other sunfish species, including Pumpkinseed.

The mean mercury concentration in sunfish species from Lower Putah Creek was 146 ppb. Mercury concentrations for individual sunfish species were as follows: Bluegill, 144 ppb; Green Sunfish, 170 ppb; hybrid sunfish, 190 ppb; Redear Sunfish, 150 ppb. OEHHA recommends a maximum of two servings a week of sunfish species for the sensitive population, and a maximum of four servings a week for the general population.

RECOMMENDED MAXIMUM NUMBER OF SERVINGS

The recommended maximum numbers of servings per week for fish and shellfish from Lower Putah Creek and Lake Solano are shown in Table 4.

TABLE 4. RECOMMENDED MAXIMUM NUMBER OF SERVINGS PER WEEK FOR FISH AND SHELLFISH FROM LOWER PUTAH CREEK AND LAKE SOLANO

Fish or Shellfish Species	Women 18–49 years and Children 1–17 years		Women 50 years and older and Men 18 years and older	
	Number of Servings	Risk Driver	Number of Servings	Risk Driver
Bigscale Logperch	2	Hg	7	Hg
Black Bass Species	0	Hg	1	Hg
Catfish Species	2	Hg	4	Hg
Common Carp	1	Hg	3	Hg
Crayfish Species	1	Hg	3	Hg
Inland Silverside	2	Hg	7	Hg
Mosquitofish	2	Hg	7	Hg
Sacramento Blackfish	2	Hg	7	Hg
Sacramento Pikeminnow	0	Hg	1	Hg
Sacramento Sucker	1	Hg	3	Hg
Sculpin Species	2	Hg	7	Hg
Sunfish Species	2	Hg	4	Hg

Hg, mercury

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APPENDIX. 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[16] 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 risk level 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.

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[b] (Women 18–49 and children 1–17)	≤ 31	>31–36	>36–44	>44–55	>55–70	>70–150	>150–440	>440
MeHg (Women ≥ 50 and men ≥ 18)	≤ 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	≤ 1,000	>1,000–1,200	>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.
[b]All mercury detected is assumed to be methylmercury, which is the most common form found in fish and is also the more toxic form (Bloom, 1992).

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