

**HEALTH ADVISORY AND
GUIDELINES
FOR EATING FISH FROM
SILVERWOOD LAKE
(SAN BERNARDINO COUNTY)**

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LIST OF CONTRIBUTORS

Authors

Lori Lim, Ph.D.

Robert K. Brodberg, Ph.D.

Reviewer

Margy Gassel, Ph.D.

Final Reviewers

Anna Fan, Ph.D.

Lauren Zeise, Ph.D.

Allan Hirsch

Director

George V. Alexeeff, Ph.D.

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For further information about this report, contact:

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

1001 I Street, P.O. Box 4010
Sacramento, California 95812-4010
Telephone: (916) 327-7319

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

LIST OF ABBREVIATIONS

ATL	Advisory Tissue Level
CDFW	California Department of Fish and Wildlife (formerly California Department of Fish and Game)
DDT(s)	dichlorodiphenyltrichloroethane (DDT) (and its metabolites dichlorodiphenyldichloroethane (DDD) and dichlorodiphenyl- dichloroethylene (DDE))
MDL	method detection limit
mm	millimeter
OEHHA	Office of Environmental Health Hazard Assessment
PCB(s)	polychlorinated biphenyl (congeners)
ppb	parts per billion
RWB-6	Lahontan Regional Water Quality Control Board
SWAMP	Surface Water Ambient Monitoring Program
SWRCB	State Water Resources Control Board
USEPA	U.S. Environmental Protection Agency

PREFACE

The Office of Environmental Health Hazard Assessment (OEHHA), a department within the California Environmental Protection Agency, is responsible for evaluating potential public health risks from chemical contamination of sport fish. This task includes issuing health advisories, when appropriate, for the State of California. OEHHA's authorities to conduct these activities are based on mandates in the:

- California Health and Safety Code
 - Section 59009, to protect public health; and
 - Section 59011, to advise local health authorities.

- California Water Code
 - Section 13177.5, to issue health advisories.

The health advisories are published in the California Department of Fish and Wildlife Sport Fishing Regulations booklets under the Public Health Advisory on Fish Consumption section.

This report presents guidelines for eating fish from Silverwood Lake, a reservoir in San Bernardino County. It provides background information and a description of how the guidelines were developed. The resulting advice is summarized in the illustration after the Table of Contents.

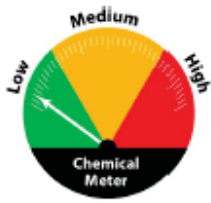
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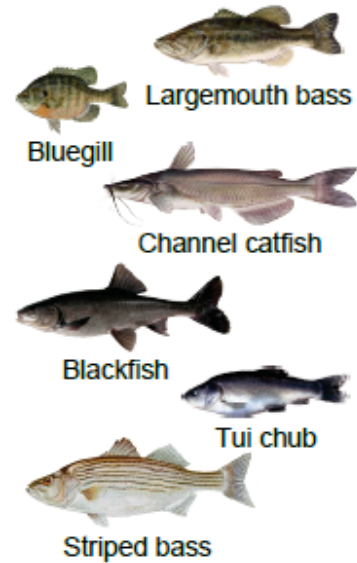
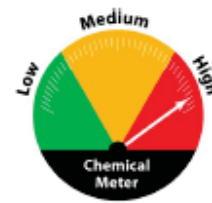
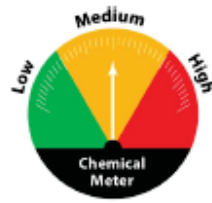
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A Healthy Guide to Eating Fish from Silverwood Lake



= High in Omega-3s



7 servings a week



1 serving a week

Do not eat
except women over 45 years
and men can eat largemouth
bass, bluegill, or catfish—
1 serving a week

Eat only the skinless fillet.
PCBs are in the fat and skin
of the fish.



- Remove and throw away the skin before cooking.
- Cook thoroughly and allow the juices to drain away.

What is a serving?



For Adults For Children

The recommended serving is the size and thickness of your hand. 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.

What is the concern?

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

INTRODUCTION

This report presents guidelines for eating fish from Silverwood Lake, a reservoir in San Bernardino County (Figure 1). It provides background information and a description of how the consumption advice was developed. The recommended advice is the maximum number of servings per week for each fish species evaluated.

Silverwood Lake was formed by the Cedar Springs Dam, which holds back the water from the west fork of the Mojave River (California Department of Parks and Recreation, 2013). It has 13 miles of shoreline and 979 acres of surface area. At 3,500 feet above sea level, it is the highest reservoir in the State Water Project. The water of Silverwood Lake originates from rain and snowmelt of the Feather River Basin that collects in Lake Oroville. When released, it flows down the Feather and Sacramento Rivers to the Sacramento-San Joaquin Delta and reaches Silverwood Lake via the California Aqueduct. The water is used to generate electricity, as well as for agricultural irrigation and recreational uses, including boat and shore fishing.

FIGURE 1. MAP SHOWING LOCATION OF SILVERWOOD LAKE



In 2010, the statewide lakes survey from the Surface Water Ambient Monitoring Program (SWAMP) of the State Water Resources Control Board (SWRCB) reported finding high mercury and polychlorinated biphenyl (PCB) concentrations in largemouth bass sampled at Silverwood Lake (Davis et al., 2010). The Lahontan Regional Water Quality Control Board (RWB-6), which oversees the region where this lake is located, conducted a follow-up study to characterize the extent of the contamination in bass and

other fish species. The sources of the chemicals in this water body that have accumulated in fish tissue are unknown. The RWB-6 study also documented the presence of PCBs in sediment samples collected from three sites in the lake.

The results from the SWAMP survey and the RWB-6 follow-up study provided sufficient sampling of representative fish species for the Office of Environmental Health Hazard Assessment (OEHHA) to develop this advisory for Silverwood Lake. The basic OEHHA process to develop consumption advice involves these steps:

1. Selection of the chemical data and fish species to be evaluated
2. Calculation of mean chemical concentrations and other descriptive statistics as appropriate for each fish species
3. Comparison of the chemical concentrations with the OEHHA Advisory Tissue Levels (ATLs) for each chemical of concern

OEHHA developed ATLs, which are acceptable exposure levels of specific contaminants in fish tissue based on chemical toxicity. The development of the ATLs included consideration of health benefits linked to eating fish (Klasing and Brodberg, 2008 and 2011; Appendix I).

FISH SPECIES IN SILVERWOOD LAKE

The common sport fish caught at Silverwood Lake include largemouth bass, bluegill, carp, catfish, crappie, striped bass, and trout (Stienstra, 2012; California Department of Parks and Recreation, 2013). California Department of Fish and Wildlife (CDFW¹) staff stocks the lake with hatchery-raised trout of catchable size, 10 to 14 inches in length, equivalent to 254-356 millimeters (mm). CDFW has established a minimum legal size of 15 inches for largemouth bass from Silverwood Lake; only fish with a total length of 15 inches or larger can be kept at this reservoir (CDFW, 2013-2014). Striped bass from this lake, as part of the CDFW Southern Sport Fishing District, are exempt from the state minimum legal size of 18 inches.

CHEMICALS OF POTENTIAL CONCERN

Fish samples from Silverwood Lake have been analyzed for mercury (as a measure of methylmercury), polychlorinated biphenyl congeners (PCBs), and the persistent pesticides dieldrin, chlordane, and dichlorodiphenyltrichloroethane and its metabolites (DDTs). Detailed discussion of the toxicity of these chemicals is presented in Klasing and Brodberg (2008).

Mercury and PCBs are the chemicals of concern in fish from Silverwood Lake. Under the proper environmental conditions, mercury in the sediment is transformed by bacteria

¹ New name effective January 1, 2013; formerly California Department of Fish and Game
Silverwood Lake Advisory

to the more toxic organic form, methylmercury. Methylmercury is then absorbed by fish when they eat smaller aquatic organisms. Methylmercury usually reaches the highest levels in predatory fish, such as bass. It can cause harm to the nervous system in humans. Unborn babies and children are particularly susceptible to this effect because their nervous systems are still developing.

PCBs are man-made chemicals previously used in electrical transformer, plastics, and lubricating oils. While PCBs were banned for use in the 1970s, they persist in the environment because they do not break down easily and can accumulate in fish. PCBs can cause cancer and other health effects in humans.

DATA SOURCES

The guidelines for eating fish from Silverwood Lake were based on chemical analysis of fish samples by the two programs described below. These two projects had adequate documentation of sample collection, fish preparation, chemical analyses, and quality assurance, and detection limits below levels of health concern. Table 1 shows the common and scientific names and numbers of fish sampled, the projects under which they were collected, as well as the years sampled.

SURFACE WATER AMBIENT MONITORING PROGRAM (SWAMP)

A statewide survey of inland water bodies was conducted by SWAMP, which sampled fish from 272 of California's more than 9,000 lakes and reservoirs from 2007 to 2008 (Davis et al., 2010). Of the surveyed lakes, 222 were targeted for sampling as popular fishing lakes and an additional 50 were selected using a random sampling draw to provide a statistical statewide assessment. In 2007, largemouth bass were collected from Silverwood Lake, designated as a targeted lake in this survey.

REGIONAL WATER QUALITY CONTROL BOARD 6 STUDY (RWB-6 Study)

The RWB-6 conducted a follow-up study to collect representative fish samples from Silverwood Lake. Fish species collected from this lake were: bluegill, brown bullhead, channel catfish, carp, largemouth bass, rainbow trout, Sacramento blackfish (commonly referred to as "blackfish"), striped bass, tui chub, and tule perch.

TABLE 1. FISH SAMPLES FROM SILVERWOOD LAKE

Fish Species	Scientific Name Genus (Family)	Number of Fish Collected	Project	Year Sampled
Blackfish	<i>Orthodon</i> (Cyprinidae)	7	RWB-6 Study	2011
Bluegill	<i>Lepomis</i> (Centrarchidae)	10	RWB-6 Study	2011
Brown bullhead	<i>Ameiurus</i> (Ictaluridae)	3	RWB-6 Study	2011
Channel catfish	<i>Ictalurus</i> (Ictaluridae)	9	RWB-6 Study	2011
Carp	<i>Cyprinus</i> (Cyprinidae)	3	RWB-6 Study	2011
Largemouth bass	<i>Micropterus</i> (Centrarchidae)	21	RWB-6 Study	2011
		26	SWAMP Lakes Study	2007
Rainbow trout	<i>Onchorhynchus</i> (Salmonidae)	9	RWB-6 Study	2011
Striped bass	<i>Morone</i> (Percichthyidae)	8	RWB-6 Study	2011
Tui chub	<i>Gila</i> (Cyprinidae)	5	RWB-6 Study	2011
Tule perch	<i>Hysterocarpus</i> (Embiotocidae)	12	RWB-6 Study	2011

CHEMICAL CONCENTRATIONS

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

Results selected for consideration of consumption advice were from those samples that met the CDFW's legal size requirements (largemouth bass) or OEHHA's criteria for minimum "edible" size. OEHHA used species size at maturity and professional judgment to set minimum edible sizes (Gassel and Brodberg, 2005). For composite samples, the total length of the smallest fish in the sample was at least 75 percent of the length of the largest fish in the composite. An exception was made for tule perch (composite ratio of 0.64) because there was only one sample.

For total mercury, the samples were combusted and analyzed by DMA (direct mercury analyzer) at the CDFW Moss Landing Marine Laboratories. The method detection limit

(MDL)² for total mercury was 12 ppb (parts per billion). OEHHA assumed all total mercury detected was methylmercury, the more toxic form that is present in fish, because nearly all mercury present in fish is methylmercury (Wiener et al., 2007). Table 2 shows the weighted means and ranges for total length and total mercury concentrations in each fish species collected from Silverwood Lake. Means were weighted by the number of fish in each sample.

TABLE 2. MERCURY CONCENTRATIONS IN FISH FROM SILVERWOOD LAKE

Fish Species	Mean Total Length (mm)	Range of Total Lengths (mm)	Mean Mercury (ppb)	Range of Mercury (ppb)	Number of Samples	Total Number of Fish ^a
Blackfish	494	493-495	745	706-797	2	7
Bluegill	185	174-203	402	320-543	3	10
Brown bullhead	317	NA	771	NA	1	3
Channel catfish	580	573-585	372	299-448	3	9
Carp	305	NA	70	NA	1	3
Largemouth bass ≥ 15 inches	432	384-513	955	350-1540	15	15
Rainbow trout	326	325-327	21	20-22	3	9
Striped bass	543	480-564	1002	886-1310	3	8
Tui chub	389	NA	632	NA	1	5
Tule perch	131	NA	172	NA	1	12
Combined Blackfish and Tui chub	450	389-495	698	632-797	3	12

NA Not applicable because only one sample was analyzed

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

Samples from all species were analyzed for PCBs, while a few species were analyzed for DDTs, dieldrin, and chlordane at the CDFW Water Pollution Control Laboratory. The specific chemicals were: PCBs (54 congeners); total DDTs including o,p' and p,p' DDT, o,p' and p,p' dichlorodiphenyldichloroethane (DDD), and o,p' and p,p' dichlorodiphenyldichloroethylene (DDE); total chlordanes including cis-chlordane, trans-chlordane, cis-nonachlor, trans-nonachlor, and oxychlordane; and dieldrin. The analytes were detected by gas chromatography and the MDLs are shown in Table 3. The broader ranges of MDLs for DDTs and PCBs reflect the differing limits for the multiple individual compounds measured.

² The MDL is the lowest concentration of a chemical that can be distinguished (as greater than zero) in a sample.

TABLE 3. METHOD DETECTION LIMITS

Chemical	SWAMP Study	RWB-6 Study
PCBs	0.025 to 0.208 ppb	0.19 to 2.98 ppb
DDTs	0.092 to 0.473 ppb	0.095 to 0.474 ppb
Dieldrin	0.413 to 0.426 ppb	0.427 ppb
Chlordanes	0.185 to 0.467 ppb	0.192 to 0.468 ppb

For PCBs, chlordanes, and DDTs, each of the concentrations presented was the sum of the detected parent compound, congeners, and metabolites, where applicable. Since the MDLs were relatively low, ≤ 3 ppb, individual congeners or metabolites with concentrations reported as non-detects were assumed to have no residue. This is a standard method of handling non-detect samples for PCBs and other chemicals with multiple congeners or metabolites when detection levels are adequate (U.S. Environmental Protection Agency, USEPA, 2000a).

Table 4 shows weighted means and ranges for PCBs. Samples analyzed for the pesticides were limited to those discussed below for largemouth bass and tui chub. The largemouth bass samples were 14 inches, shorter than the legal size of 15 inches. While the length was shorter than the legal size, the results provided information on the extent of contamination. In these two samples of bass (total 10 fish), the concentrations were: 1.2 ppb (chlordanes), 11 ppb (DDTs), and <0.4 ppb (dieldrin). There was one sample of tui chub (5 fish), and the concentrations were 0.3 ppb (chlordanes), 14 ppb (DDTs), and 0.5 ppb (dieldrin).

TABLE 4. PCB CONCENTRATIONS IN FISH FROM SILVERWOOD LAKE

Fish Species	Mean Total Length (mm)	Range of Total Lengths (mm)	Mean PCBs (ppb)	Range of PCBs (ppb)	Number of Samples	Total Number of Fish
Blackfish	494	493-495	1039	758-1250	2	7
Bluegill	184	174-203	50	47-53	3	10
Brown bullhead	317	NA	109	NA	1	3
Channel catfish	580	573-585	82	66-104	3	9
Carp	305	NA	43	NA	1	3
Largemouth bass ≥ 15 inches	427	426-428	70	47-88	3	9
Rainbow trout	326	325-327	6	4-7	3	9
Striped bass	543	480-564	174	163-188	3	8
Tui chub	389	NA	176	NA	1	5
Tule perch	131	NA	69	NA	1	12
Blackfish and Tui chub	450	389-495	679	176-1250	3	12

NA Not applicable because only one sample was analyzed

DEVELOPMENT OF GUIDELINES FOR EATING FISH FROM SILVERWOOD LAKE

GENERAL INFORMATION

Consumption advice was developed for fish species that meet OEHHA's criterion for sufficient samples (at least nine fish) to represent the population in the water body. When appropriate, fish species were combined as a single group based on their taxonomy (i.e., they are in the same Family and/or genus).

Fish consumption frequency (number of servings of fish per week) is determined for each fish species or group by comparing the chemical's mean concentration to the ATLS. For exposure to methylmercury in fish, there are two sets of ATLS because of age-related toxicity (Klasing and Brodberg, 2008). The ATLS (summarized in Appendix I) for the sensitive population (women of child bearing age at 18 to 45 years, and children 1 to 17 years of age) are lower than for women over 45 years and men. This lower value provides protection for the brain and nervous system of unborn babies and children during growth and development. Women ages 18-45 years are included in the sensitive population because these women are of childbearing age. A complete description of the process of developing ATLS can be found in Klasing and Brodberg (2008).

The consumption advice for a fish species is initially based on the chemical with the lowest allowable number of fish servings per week. When both mercury and PCBs are detected in the fish tissues, an assessment of potential additive toxicity is conducted for the sensitive population using multiple chemical exposure methodology (USEPA, 1989 and 2000b), based on the concern for developmental neurotoxicity.

OEHHA's advisory process and ATLS also consider the health benefits from fish consumption. There is considerable evidence and scientific consensus that fish consumption is an important part of a healthy well-balanced diet and provides many health benefits (American Heart Association, 2011; Klasing and Brodberg, 2008; Institute of Medicine, 2007; Kris-Etherton et al., 2002). Fish is a significant source of the specific omega-3 fatty acids, docosahexaenoic acid and eicosapentaenoic acid, associated with these beneficial effects (U.S. Department of Agriculture, 2011; Weaver et al., 2008).

CONSUMPTION ADVICE FOR FISH FROM SILVERWOOD LAKE

After evaluating the chemical concentrations in these fish species, OEHHA used mercury and PCB concentrations as the basis for advice for eating fish from Silverwood Lake. While there were limited data, the concentrations of the tested pesticides were lower than the ATLs for daily consumption (Klasing and Brodberg, 2008) and were not considered further for developing consumption advice. In the following discussion of the data and advice for individual species, the chemicals and their respective no consumption ATL thresholds³ are: methylmercury (440 ppb for the sensitive population and 1310 ppb for women over 45 years and men) and PCBs (120 ppb for both population groups). A list of all the ATLs is in Appendix I. The recommended maximum number of servings per week for each fish species with sufficient data is presented in Table 5, following the discussion.

BLACKFISH AND TUI CHUB

The results for blackfish and tui chub were combined (a total of 3 samples and 12 fish) because these two species belong to the same family and had high mean mercury concentrations (745 ppb and 632 ppb, respectively). Mean PCB concentration was much higher in blackfish (1039 ppb) than in tui chub (176 ppb). OEHHA recommended advice for both population groups (all consumers) is not to eat blackfish or tui chub because both mercury and PCB concentrations were above their respective ATL thresholds for no consumption.

BLUEGILL

For the sensitive population, the consumption frequency was one serving per week of bluegill based on either mean mercury (402 ppb) or PCB (50 ppb) concentrations. However, co-exposure assessment showed that the consumption needed to be reduced because of the high mercury and moderate PCB concentrations for this consumption frequency. Thus, the advice for the sensitive population is not to eat bluegill. For women over 45 years and men, the advice is one serving per week, determined by PCB concentration which allows less consumption than the mercury concentration.

BROWN BULLHEAD

There was only one sample (3 fish), which was not sufficient information to develop consumption advice for this species. The result for bullhead could not be grouped with those for the related channel catfish because bullhead had a much higher mercury concentration than that for catfish.

³ Chemical concentrations, that when exceeded, result in an OEHHA recommendation of no consumption of a fish species

CHANNEL CATFISH

For the sensitive population, the consumption frequency was one serving per week based on either mean mercury (372 ppb) or PCB (82 ppb) concentrations. However, co-exposure assessment showed that the consumption needed to be reduced because of high mercury and PCB concentrations. Thus, the advice for the sensitive population is not to eat channel catfish. For women over 45 years and men, the advice is one serving per week, the lower consumption frequency as determined by PCB concentration.

CARP

There was only one sample (3 fish), which was not sufficient information to develop consumption advice for this species. Carp was not combined with fish species of the same family, blackfish and tui chub, because of the much lower mercury concentration in carp than in the other two species.

LARGEMOUTH BASS

Only the results from largemouth bass of legal size (≥ 15 inches, or ≥ 381 mm) could be used to develop the consumption advice. The advice for the sensitive population is not to eat bass because of very high mean mercury concentration (955 ppb), above the no consumption ATL threshold. For women over 45 years and men, the advice is one serving per week, determined by either mercury or PCB concentrations.

RAINBOW TROUT

Mercury (21 ppb) and PCB (6 ppb) concentrations in rainbow trout were low enough that daily consumption can be recommended for all consumers based on assessment of each chemical concentration separately or together. Rainbow trout is also a good choice to eat because it is high in beneficial omega-3 fatty acids.

STRIPED BASS

There were 3 samples (total 8 fish) of striped bass, close to the 9 fish criteria. The advice for all consumers is not to eat striped bass because both mean mercury (1002 ppb) and PCB (174 ppb) concentrations were above their respective ATL threshold for no consumption.

TULE PERCH

There was only one sample (12 fish) of tule perch. The composite ratio was 0.64, lower than the value of 0.75 in the OEHHA guidelines. Since this is the only sample, the data for mercury (172 ppb) and PCBs (69 ppb) were used to develop consumption advice. For the sensitive population, consumption advice is one serving per week based on mercury and PCB concentrations considered separately or in co-exposure. For women over 45 years and men, the advice is also one serving per week, the lower consumption frequency determined by PCB concentration.

MISSING SPECIES

Crappie was not sampled at Silverwood Lake. When the protocol for the RWB-6 study was developed, the plan was to use the bluegill chemical data for crappie. However, the data showed that bluegill had higher mercury concentrations than expected and also moderate PCB concentrations. Existing OEHHA advisories generally showed crappie with the same or higher chemical concentrations than those detected in bluegill. Without enough information to estimate both mercury and PCB concentrations, OEHHA decided not to issue advice for crappie based on the bluegill data. OEHHA plans to consult with RWB-6 about sampling studies to collect data for crappie, as well as for carp, and brown bullhead.

TABLE 5. RECOMMENDED MAXIMUM NUMBER OF SERVINGS PER WEEK

Fish Species	Women 18–45 Years and Children 1 to 17 Years	Women over 45 Years and Men
	# Servings/Week	# Servings/Week
Blackfish	0	0
Tui chub	0	0
Striped bass	0	0
Largemouth bass	0	1
Bluegill	0	1
Channel catfish	0	1
Tule perch	1	1
Rainbow trout	7	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 show maximum numbers of recommended fish servings that correspond to the chemical levels found in fish. OEHHA uses ATLs to provide advice to prevent consumers from being exposed to:

- More than the average daily reference dose⁴ 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 USEPA (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 three servings per week. When the guidelines for eating fish from Silverwood Lake are followed, exposure to chemicals in fish from this lake would be at or below the average daily reference dose or the cancer risk probability of one in 10,000.

Advisory Tissue Levels (ATLs) for Selected Fish Contaminants Based on Cancer or Non-Cancer Risk Using an 8-Ounce Serving Size				
Contaminant	Consumption Frequency Categories^a and ATLs^b (in ppb)			
	Three 8-ounce Servings per Week	Two 8-ounce Servings per Week	One 8-ounce Serving per Week	No consumption
Chlordanes	>140-190	>190-280	>280-560	>560
DDTs	>390-520	>520-1,000	>1,000-2,100	>2,100
Dieldrin	>11-15	>15-23	>23-46	>46
Methylmercury (Women 18 to 45 years and children 1 to 17 years)	>55-70	>70-150	>150-440	>440
Methylmercury (Women over 45 years and men)	>160-220	>220-440	>440-1,310	>1,310
PCBs	>15-21	>21-42	>42-120	>120

^{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/} When residue data are compared to this table they should also first be rounded to the second significant digit.

⁴ 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.