HEALTH ADVISORY AND CONSUMPTION GUIDELINES FOR FISH FROM LAKE OROVILLE (BUTTE COUNTY)

July 2013 Update

Office of Environmental Health Hazard Assessment
California Environmental Protection Agency

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LIST OF ABBREVIATIONS

AHA	American Heart Association
ATL	Advisory Tissue Level
CDFW	California Department of Fish and Wildlife
DDTs	dichlorodiphenyltrichloroethane (DDT) and its metabolites dichlorodiphenyldichloroethane (DDD) and dichlorodiphenyl-dichloroethylene (DDE)
DWR	Department of Water Resources
DWR I	Phase I of DWR project at Lake Oroville
DWR II	Phase II of DWR project at Lake Oroville
FERC	Federal Energy Regulatory Commission
IOM	Institute of Medicine
MDL	method detection limit
NorCal Lakes	Feather River Tributary Monitoring Project
OEHHA	Office of Environmental Health Hazard Assessment
PCBs	polychlorinated biphenyls
ppb	parts per billion
RfD	reference dose
RL	reporting limit
SWAMP	Surface Water Ambient Monitoring Program
SWRCB	State Water Resources Control Board
USDA	U.S. Department of Agriculture
US EPA	U.S. Environmental Protection Agency

PREFACE

The Office of Environmental Health Hazard Assessment (OEHHA) is the department within the California Environmental Protection Agency responsible for evaluating potential health risks from chemical contamination of sport fish and issuing health advisories and consumption guidelines. This authority is based on mandates in the California Health and Safety Code (Section 59009 to protect public health and Section 59011 to advise local health authorities), and the California Water Code (Section 13177.5, to issue health advisories). The consumption advice is published in the California Department of Fish and Wildlife Sport Fishing Regulations.

The health advisory and consumption guidelines report describes the evaluation of chemical contaminants in sport fish tested from water bodies in a certain location or region. The evaluation process also recognizes and integrates the health benefits from fish consumption. Fish consumers can use the information in the advisory to make choices about how frequently they can eat the fish in their catch, and to select fish low in contaminants and high in beneficial omega-3 fatty acids.

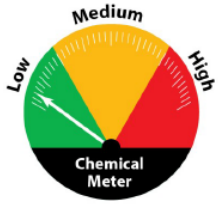
This is an update of the report issued in December 2012 for Lake Oroville. In 2013, the California Department of Fish and Wildlife changed the legal size for black bass to 12 inches or longer, instead of the previous slot limit of 12 to 15 inches. As a result, some bass that were legal to keep and consume in 2012 are now not legal to keep. The advisory and the report have been updated to reflect that only legal-sized fish have been used in the evaluation. The updated consumption advice is summarized in the illustration after the Table of Contents.

TABLE OF CONTENTS

LIST OF FIGURES AND TABLES

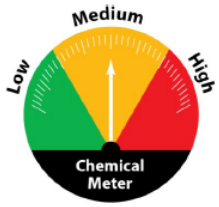
A Healthy Guide to Eating Fish from Lake Oroville

Women 18-45 years and children 1-17 years



Bluegill

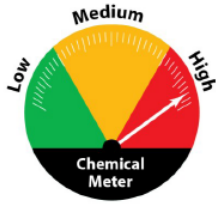
Green sunfish



Carp

Coho salmon

= High in Omega-3s



Largemouth, smallmouth, redeye, or spotted bass

Channel catfish

White catfish

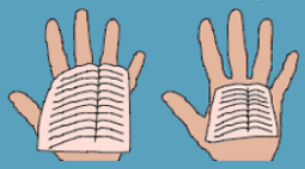
2 servings a week	OR	1 serving a week	Do not eat

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.

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A Healthy Guide to Eating Fish from Lake Oroville

Women over 45 years and men can safely eat more fish

Bluegill

Green sunfish

Carp

Coho salmon ♥

♥ = High in Omega-3s

Largemouth, smallmouth, redeye, or spotted bass ♥

Channel catfish

White catfish

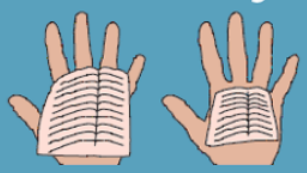
5 servings a week OR **2 servings a week** OR **1 serving a week**

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?



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INTRODUCTION

Lake Oroville is a 3.5-million-acre-feet capacity storage reservoir in Butte County (Figure 1) and is fed by the Feather River (Department of Water Resources, DWR, 2004). It has a surface area of 15,810 acres at its normal maximum operating level. The lake is part of the State Water Project providing water to urban and agricultural water users, water recreation, power generation, and flood management. Fish species commonly caught by recreational anglers are black bass (largemouth, smallmouth, spotted, and redeye), catfish, small sunfish or panfish, black crappie, landlocked salmon, and hatchery trout.[1,2] Lake Oroville is considered by some to be the best bass fishing spot in California.[2] Rainbow trout are planted there as fingerlings by the California Department of Fish and Wildlife (CDFW).[3] The legal size limit for black bass is 12 inches or longer. Fish smaller than this size, when caught must be released back to the lake (CDFG, 2013-2014). Previously there was a slot limit of 12 to 15 inches for black bass. The lake and water bodies in the vicinity are the only places in California where catching and keeping Coho salmon is legal.[4] Coho salmon are bred at the Feather River Hatchery in the town of Oroville; both fingerlings and yearlings have been stocked in Lake Oroville.[5]

Fish and sediments from Lake Oroville are contaminated by metals and organic chemicals (DWR, 2004, 2006, and 2007; Davis et al., 2010). Contaminants are transported to the lake via sediments from the upper Feather River and tributaries (DWR, 2004 and 2006; Alpers et al., 2005). Lake Oroville is on the State Water Resources Control Board (SWRCB) Clean Water Act 303(d) list of impaired water bodies due to mercury and polychlorinated biphenyl contamination exceeding established water quality standards (SWRCB; 2012).

The finding of contaminants in fish tissues prompted the Office of Environmental Health Hazard Assessment (OEHHA) to develop this advisory report. 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 average chemical concentrations and other descriptive statistics as appropriate, and (3) comparison of the chemical concentrations with the OEHHA Advisory Tissue Levels (ATL) for each chemical of concern (Klasing and Brodberg, 2008 and 2011; Appendix A). The ATLs are acceptable exposure levels based on

[1] http://imaps.dfg.ca.gov/viewers/fishing_guide/app.asp

[2] http://www.water.ca.gov/recreation/locations/oroville/fishing.cfm

[3] http://nrm.dfg.ca.gov/PSEP/PublicWaters.aspx?size=2

[4] In 2012, the CDFW expanded the take of Coho salmon to the Oroville-Thermalito Complex (Diversion Pool, Forebay, and Afterbay) and the Feather River from the Diversion Pool Dam to the Fish Barrier Dam (CDFW, 2012; 2013-2014). There are specific areas along the Feather River below the Oroville Dam closed to the take of all salmon.

[5] http://www.rmpc.org/files/nwfcc/2009/04-OROVILLECOHO_NWFCC_Presentation_2009b.pdf

chemical toxicity with consideration of health benefits associated with including fish in the diet.

FIGURE 1. LOCATION OF LAKE OROVILLE IN BUTTE COUNTY, CALIFORNIA

CHEMICALS OF POTENTIAL CONCERN

Mercury and PCBs are the chemicals of concern in fish from Lake Oroville. Although most fish contain some mercury, local sources of mercury in Lake Oroville include past gold-mining activities and much smaller scale current mining operations in the upper Feather River watershed (DWR, 2006). Under the proper environmental conditions, mercury in the sediment is transformed by bacteria 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. High levels of methylmercury can adversely affect the brain, especially in developing fetuses and young children.

Polychlorinated biphenyl congeners (PCBs) are man-made chemicals previously used in electrical transformers and plastics and lubricating oils. Their presence in the lake is associated with prior leaks and spills. 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 may cause cancer and other health effects in humans.

Chlordane, dichlorodiphenyltrichloroethane (DDT) and dieldrin are pesticides that were banned from use many years ago but have persisted in the environment. These chemicals may cause cancer or adverse effects on the nervous system. Detailed discussion of the toxicity of these chemicals is presented in Klasing and Brodberg (2008).

DATASET SELECTION

DATA SOURCES

Data for concentrations of chemicals of potential concern in fish from Lake Oroville were compiled from the three studies described below. These studies had adequate documentation of sample collection, fish preparation, chemical analyses, and quality assurance. Fish were collected throughout Lake Oroville at the sampling locations indicated in Figure 2. Note that not all fish species were collected from all locations.

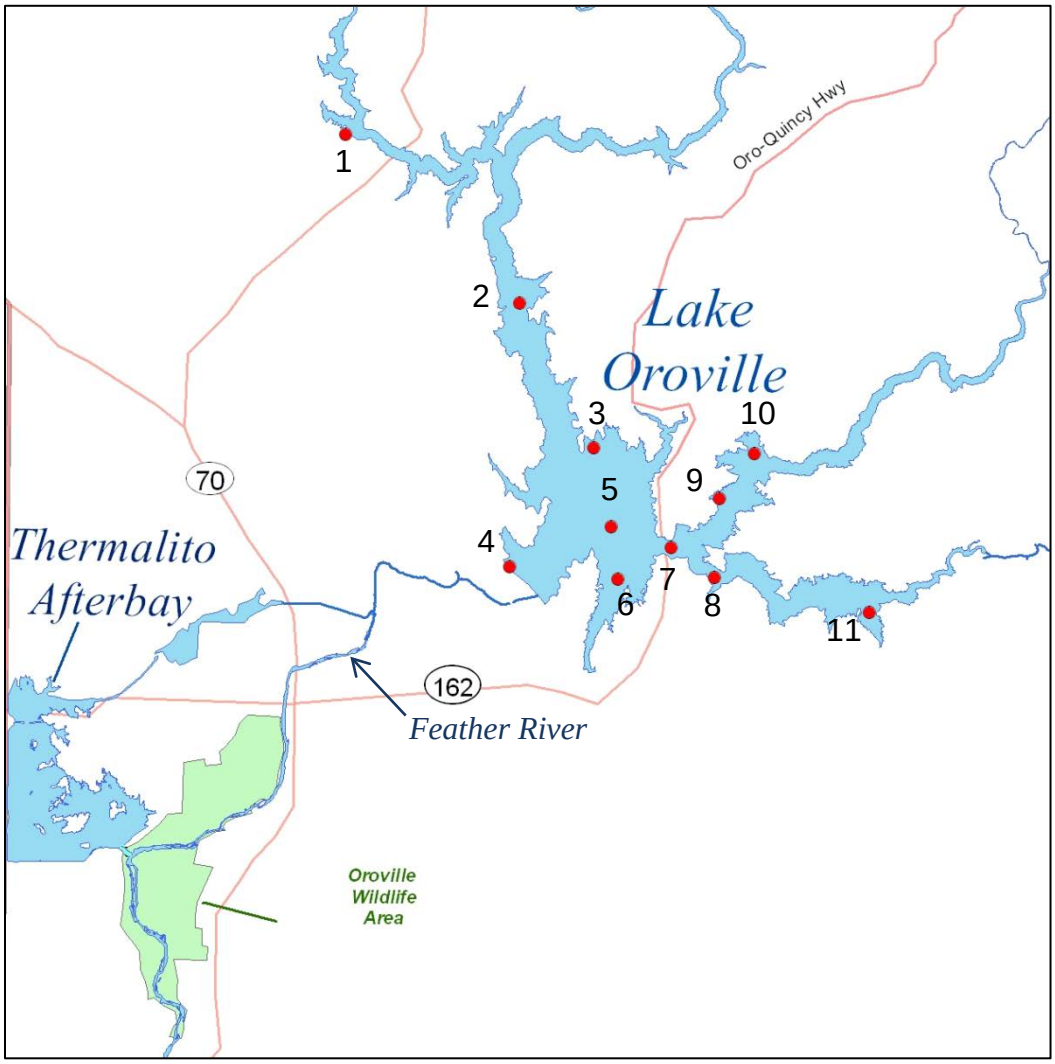
The specific chemicals in the dataset were: mercury (as a measure of methylmercury); PCB congeners; total DDTs including o,p' and p,p' DDT, o,p' and p,p' dichlorodiphenyldichloroethane (DDD), and o,p' and p,p' dichlorodiphenyldichloroethylene (DDE); total chlordanes including cis-chlordane, trans-chlordane, cis-nonachlor, trans-nonachlor, and oxychlordane; and dieldrin. Chemical concentrations in fish were reported in wet weights. The method detection limits (MDLs) and reporting limits (RLs)[6] in these studies were acceptable for use of the data in this health assessment.

Feather River Tributary Monitoring Project

Spotted bass and largemouth bass were collected in 2000 and 2001 from Lake Oroville in a survey of northern California lakes (referred to as NorCal Lakes) in the Feather River Tributary Monitoring Project (DWR, 2007). The skinless fillets from either individual fish or composites (4 or 5 fish per composite) were analyzed for total mercury by cold-vapor atomic absorption spectrometry, and for PCBs and other organochlorines by gas chromatography. The RLs were: mercury 0.022 ppm, PCBs 0.2 ppb, chlordanes 2 ppb, DDTs 2 to 5 ppb (DDTs), and dieldrin 2 ppb.

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

FIGURE 2. SAMPLING LOCATIONS IN LAKE OROVILLE



Sampling locations were: (1) Lime Saddle, (2) Bloomer Canyon, (3) Foreman Creek, (4) Spillway Structure, (5) Lake Oroville, (6) Bidwell Marina, (7) Middle Fork mouth, (8) Lower South Fork, (9) Lower Middle Fork, (10) Upper Middle Fork, and (11) South Fork McCabe Cove.

Federal Energy Regulatory Commission (FERC) Relicensing Project No. 2100

DWR collected biota and sediment samples to evaluate chemical contamination of Lake Oroville and water bodies in the vicinity (Feather River, the Oroville Wildlife Area including Thermalito Afterbay) for the Oroville FERC Relicensing Project No. 2100 (DWR, 2004 and 2006).

Phase I of the project (referred to as DWR I) evaluated the contaminants in biota and sediments in 2002 (DWR, 2004). Fish collected included spotted bass, channel catfish, white catfish, and carp. Samples were either individual fish or composites (2 to 9 fish/composite).

In 2003, Phase II (referred to as DWR II) evaluated sources of the contamination and extent of downstream effects (DWR, 2006). The fish collected were spotted bass, largemouth bass, carp, green sunfish, bluegill, channel catfish, black crappie, and adult Coho salmon. Samples for chemical analyses were either individual fish or composites (3 to 10 fish/composite).

The skinless fillets were analyzed for total mercury by inductively coupled plasma-mass spectrometry, and the PCBs by gas chromatography. Other organochlorines were measured only in Coho salmon and were detected by gas chromatography. The RLs were: mercury 0.01 ppm, PCBs 0.6 ppb, chlordanes 1 ppb, DDTs 2 ppb, and dieldrin 1 ppb.

The Lakes Survey

A statewide survey of inland water bodies was conducted by the Surface Water Ambient Monitoring Program (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 this survey, smallmouth bass and carp were collected from Lake Oroville, as a targeted lake, in 2007.[7] The skinless fillet samples were either individual fish (smallmouth bass) or composites (5 or 20 carp in a composite). They were analyzed for total mercury by atomic absorption spectrometry. Carp was also analyzed for PCBs and other organochlorines by gas chromatography. The minimum detection limits (MDL) were: mercury 0.01 ppm, PCBs 0.09 to 0.24 ppb, chlordanes 0.19 to 0.46 ppb, DDTs 0.09 to 0.47 ppb, and dieldrin 0.42 ppb.

[7] California Environmental Data Exchange Network, http://www.ceden.us/AdvancedQueryTool

FISH SPECIES

Fish species with tissue chemical data are presented in Table 1. Data for some species are combined for the advisory as a single group based on their taxonomy (i.e., they are in the same Family and/or genus) and/or placed in groups due to previously observed similarities or differences in their level of contamination. The bass group consists of taxonomically related largemouth, smallmouth, and spotted bass. OEHHA had previously developed unified consumption advice for these three species of black bass. The data for channel catfish and white catfish may be grouped together. These fish are in the same family, but separate genera, and physically they may not be distinguishable by fishers. Their contaminant levels generally resulted in similar consumption advice in other water bodies evaluated by OEHHA. The sunfish group consists of small sunfish, also called panfish, such as blue gill and green sunfish. Black crappies are generally not included in this group even though they are of the same Family. In OEHHA advisories, crappies sometimes have been found to be more contaminated than the other small sunfish.

TABLE 1. FISH SPECIES IN THE LAKE OROVILLE DATASET

Fish Species or Group	**Species included in group**	**Scientific Name Genus (Family)**
Bass	Largemouth bass, smallmouth bass, spotted bass	*Micropterus* (Centrarchidae)
Catfish	White catfish Channel catfish	*Ameiurus* (Ictaluridae) *Ictalurus* (Ictaluridae)
Carp	Carp	*Cyprinus* (Cyprinidae)
Crappie	Black crappie	*Pomoxis* (Centrarchidae)
Coho salmon	Coho salmon	*Onchorhynchus* (Salmonidae)
Sunfish (panfish)	Bluegill, green sunfish	*Lepomis* (Centrarchidae)

After the data from the studies were compiled into a dataset, the individual sample results were screened to retain only those of acceptable fish size. Fish size was measured as total length or fork length.[8] Fork length was converted to total length, as the standard measurement, using conversion factors OEHHA estimated from limited available length data for select species and by considering the degree of fork in the tail, which corresponds to the difference between these two length measurements. Fish total length had to meet legal limits or edible size criteria. For bass, only data for fish size 12 inches or longer were

[8] Total length refers to the length from the tip of the snout to the tip of the longer lobe of the caudal fin. Fork length refers to the length from the tip of the snout to the end of the middle caudal fin rays.

considered because this is the current CDFW legal limit for black bass statewide. For other fish species, the total length had to meet the minimum “edible” size, predetermined by OEHHA based on species size at maturity and professional judgment (Gassel and Brodberg, 2005). OEHHA had not established an edible size for Coho salmon and thus all size was used in the report. The fish lengths of >12 inches (>305 mm) in the dataset met acceptable size criteria for trout (also in the Salmonidae) and were considered sufficiently large to be "edible." For the composites, the minimum sized fish should be greater or equal to 75% of the length of the maximum fish in that composite (Gassel and Brodberg, 2005).

CHEMICAL CONCENTRATIONS

CHEMICAL CALCULATION

Total mercury concentration reported was assumed to be 100% methylmercury because almost all mercury present in fish is methylmercury (Wiener et al., 2007). For PCBs, chlordanes, and DDTs, the concentration was the sum of the detected compounds (parent and congeners, or metabolites, if applicable). Since the MDLs and RLs were relatively low, ≤ 2 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 (U.S. Environmental Protection Agency, US EPA, 2000a).

The arithmetic mean of the detected concentrations for all samples of each fish species was calculated to represent the average human exposure. The mean is weighted with the number of fish in the composite samples. In general, arithmetic means for environmental chemical exposures are more health-protective than geometric means, and are commonly used in human health risk assessments (Parkhurst, 1998).

CHEMICAL CONCENTRATIONS IN FISH SPECIES

Table 2 shows the number of samples and fish in each fish species or group from each of the data sources. The weighted average (mean) and range of fish total lengths and chemical concentrations are presented in Tables 3 and 4. In these tables, the total concentration is indicated as “less than” the value for MDL or RL of the chemical, when the calculated mean is lower than the applicable limit.

TABLE 2. SUMMARY OF SAMPLING DATA FOR FISH FROM LAKE OROVILLE

Fish Species or Group		Project	Mercury		PCBs		Chlordanes, DDTs, or Dieldrin	
			N Samples	# Fish	N Samples	# Fish	N Samples	# Fish
Bass (includes largemouth, smallmouth, and spotted bass)		DWR I	8	52	8	52	8	52
		DWR II	41	41	3	3	0	0
		Lakes Survey	28	28	0	0	0	0
		NorCal Lakes	6	18	1	5	1	5
		Total	**83**	**139**	**12**	**60**	**9**	**57**
Carp		DWR I	2	7	2	7	2	7
		DWR II	4	4	2	9	0	0
		Lakes Survey	4	20	1	20	1	20
		Total	**10**	**31**	**5**	**36**	**3**	**27**
Catfish	Channel catfish	DWR I	7	26	7	26	7	26
		DWR II	11	11	7	10	0	0
	White catfish	DWR I	1	3	1	3	1	3
	Combined[b]	**Total**	**19**	**40**	**15**	**39**	**8**	**29**
Black crappie		DWR II	2	2	0	NA	0	NA
Sacramento sucker		DWR I	0	NA	1	5	1	5
Coho salmon		DWR II	16	22	3	9	3	9
Sunfish	Green sunfish	DWR II	1	1	0	NA	0	NA
	Bluegill	DWR II	13	13	0	NA	0	NA
	Combined[c]	**Total**	**14**	**14**	0	NA	0	NA

NA-Not applicable because no samples taken.

TABLE 3. LENGTH AND MERCURY AND PCB CONCENTRATIONS IN FISH FROM LAKE OROVILLE

Fish Species or Group	Mercury Samples		PCB Samples	
	Mean Fish Total Length[d] (range[e]) in mm	Mean Concentration[d] (range[e]) in ppb	Mean Fish Total Length[d] (range[e]) in mm	Mean Concentration[d] (range[e]) in ppb
Bass[a]	358 (306-529)	502 (143-1260)	352 (313-456)	12 (0.7-35)
Carp	522 (481-598)	277 (150-721)	528 (481-563)	24 (7-94)
Catfish				
Channel catfish	574 (389-647)	675 (160-1614)	580 (420-647)	50 (10-89)
White catfish	383	380	383	7
Combined[b]	560 (383-647)	653 (160-1614)	564 (383-647)	47 (7-89)
Black crappie	256 (248-263)	245 (240-250)	NA	No data
Sacramento sucker	NA	No data	564	66
Coho salmon	427 (318-478)	337 (80-640)	447 (422-461)	7 (6-8)
Sunfish				
Green sunfish	145	70	NA	No data
Bluegill	137 (108-180)	112 (70-140)	NA	No data
Combined[c]	137 (108-180)	109 (70-140)	NA	No data

a/ Includes largemouth bass, smallmouth bass, and spotted bass. The legal size is 12 inches or longer.
b/ Includes channel catfish and white catfish.
c/ Includes bluegill and green sunfish.
d/ Fish lengths and concentrations were weighted by the number of fish in each sample.
e/ Values in the range were not weighted. No range is given when there is only one sample.

NA-Not applicable because no samples taken.

TABLE 4. LENGTH AND CONCENTRATIONS OF PESTICIDES IN FISH FROM LAKE OROVILLE

Fish Species or Group	Mean Fish Total Length[d] (range[e]) in mm	Mean Concentration[d] (range[e]) in ppb		
		Chlordanes	DDTs	Dieldrin
Bass[a]	347 (313-380)	<1 (0)	3 (0-8)	<1 (0)
Carp	517 (481-521)	<1 (0.4-2)	8 (5-17)	<1 (0-0.5)
Catfish				
Channel catfish	617 (590-647)	2 (2-3)	24 (17-36)	<1 (0-0.8)
White catfish	383	<1	3	<1
Combined[b]	592 (383-647)	2 (0-3)	22 (3-36)	<1 (0-0.8)
Black crappie	NA	No data	No data	No data
Sacramento sucker	564	3	21	<1
Coho salmon	447 (422-461)	<1 (0)	5 (4-5)	<1 (0)
Sunfish[c]	NA	No data	No data	No data

a/ Includes largemouth bass, smallmouth bass, and spotted bass. The legal size is 12 inches or longer.
b/ Includes channel catfish and white catfish
c/ Includes bluegill and green sunfish
d/ Fish lengths and concentrations were weighted by the number of fish in each sample. "<1" means the weighted mean is less than the RL.
e/ Values in the range were not weighted. No range is given when there is only one sample

NA-Not applicable because no samples taken.

The results from Table 2 were evaluated to determine which species included a sufficient number of fish to develop fish consumption advice, and to establish appropriate fish groups. OEHHA generally requires at least 9 fish per species for each chemical to be minimally representative of the average concentration in the fish population of the water body.

The chemical concentration results showed that mercury and PCBs were present in the fish at sufficient concentrations to be the basis for the advisory for Lake Oroville. Following the advisory will protect consumers from significant exposure to mercury and PCBs. Dieldrin was not detected in any fish samples from Lake Oroville. Concentrations of chlordanes and DDTs (shown in Table 4) in all fish evaluated will not be discussed further because their levels were lower than the ATLs for daily consumption (Klasing and Brodberg, 2008), and thus would not result in any restriction in consumption of these fish. Exposure to these low levels as a result of eating fish from Lake Oroville would be far below the average daily reference dose or cancer risk probability of one in ten thousand (see Appendix A on the use of ATLs to develop consumption advice).

Bass (*Micropterus spp.*)

There were 15 bass (largemouth, smallmouth, and spotted bass) for each of the chemicals evaluated (Table 2). The mean mercury concentration was 502 ppb (Table 3). The PCB levels for bass were relatively low. The mean concentration was 12 ppb.

These chemical concentrations were considered applicable for the redeye bass, which is of the same family and species but has not been sampled. Redeye bass are subject to the same CDFW regulations and size limits as other bass from Lake Oroville.

Carp (*Cyprinus spp.*)

There were at least 27 carp analyzed for mercury and PCBs (Table 2). The mean concentrations were 277 ppb mercury and 24 ppb PCBs (Table 3). The PCB concentration range was wide due to one higher sample at 94 ppb, while the other four samples were in a lower range from 7 to 27 ppb.

Catfish Group (Ictaluridae Family)

The catfish group consisted of at least 26 channel catfish and 3 white catfish (1 sample) (Table 2).

The mercury and PCBs in the channel catfish were relatively high with mean concentrations of 675 ppb mercury and 50 ppb PCBs (Table 3). In the DWR Phase I study, the catfish length ranged from 23 to 25 inches (590 to 647 mm) and the concentrations ranges of 343 to 1614 ppb for mercury and 29 to 89 ppb for PCBs. In

comparison, the DWR Phase II project had smaller fish (15 to 23 inches; 389-580 mm) with lower concentrations, ranging from 210 to 620 ppb for mercury and 10 to 62 ppb for PCBs.

There was only one sample of white catfish (3-fish composite, mean total length of 15 inches, 383 mm) with a mercury concentration of 380 ppb (Tables 2 and 3). This sample was grouped with the channel catfish because its mercury concentration (380 ppb) was similar to the level (210 ppb) in channel catfish of similar size (389 mm). The combined catfish group mean concentrations were 653 ppb mercury and 47 ppb PCBs.

Salmon, Coho (*Onchorhynchus kisutch*)

There were 9 or more adult Coho salmon analyzed for mercury and PCBs (Table 2). The mean concentrations were 337 ppb for mercury and 7 ppb for PCBs (Table 3). The moderate mercury level in the adult Coho salmon collected from the Lake was considered evidence for a direct link between mercury in the Lake Oroville sediment and bioaccumulation in the food chain (DWR, 2006). The DWR Phase II project reported a mercury level of 20 ppb in two composite samples (12-fish per composite) of age zero Coho salmon, one each from the Feather River Main Hatchery and the Annex (DWR, 2006).

Sunfish (*Lepomis spp.*)

The sunfish group consisted of bluegill (13 fish) and green sunfish (1 fish) (Table 2). Only mercury data were available for these sunfish (Table 3). The mercury concentrations were 112 ppb (mean, range 70 to 140 ppb) for blue gill and 70 ppb for green sunfish. The sunfish group mean mercury concentration was 109 ppb. The PCB levels are expected to be low in sunfish. As a comparison, the PCB level was only 4 ppb in the bass group shorter than 12 inches, another species in the sunfish Family (Centrarchidae).

Other species

There were insufficient numbers of fish (<9 fish per species) sampled for black crappie and Sacramento sucker to develop consumption advice. Therefore, the data for these fish species were not considered for consumption advice.

While rainbow trout and brown trout were reported to be found in the lake, no chemical data were available to evaluate for developing consumption advice.

DEVELOPMENT OF CONSUMPTION ADVICE

GENERAL PROCEDURE

Fish consumption frequency advice (recommended maximal number of servings of fish per week) is determined for each fish species by comparing the chemical's mean concentration to its ATL. The process of developing ATLs, including toxicological information on methylmercury and other chemical contaminants is described in Klasing and Brodberg (2008 and 2011; also Appendix A in this document). For exposure to methylmercury in fish, there are two sets of ATLs because of age-related toxicity (Klasing and Brodberg, 2008). The ATLs for the sensitive population (women of child-bearing age 18 to 45 years, and children age 1 to 17 years) are established to protect for developmental neurotoxicity. The reference dose (RfD) for this early life-stage endpoint is 3 times lower than that for the general neurotoxicity endpoint used for adults, referred to as the general population (women more than 45 years old and men more than 17 years old).

The ATL determination and advisory process incorporate the positive health effects of fish in the diet. 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, AHA, 2011; Klasing and Brodberg, 2008; Institute of Medicine, IOM, 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, USDA, 2011; Weaver et al., 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 using multiple chemical exposure methodology (US EPA, 1989 and 2000b). For these two chemicals, the concern is for enhanced development neurotoxicity.

CONSUMPTION ADVICE

The consumption advice for fish species taken from Lake Oroville was determined by mercury and PCB concentrations (Table 5). It was not necessary to reduce the recommended number of servings per week for any fish species to address the concern of co-exposure to mercury and PCBs for women 18-45 and children 1-17 years of age. When the consumption advice is followed, the exposure to mercury and PCBs from eating fish caught at Lake Oroville would be at or below the average daily reference dose or cancer risk probability of one in 10,000 (see Appendix A on the use of ATLs on consumption advice).

TABLE 5. CONSUMPTION FREQUENCY BY FISH SPECIES FROM LAKE OROVILLE

Fish Group	Mean Mercury (ppb)[a]	Mean PCBs (ppb)[a]	Number of Servings per Week			
			Women 18 to 45 years and children 1 to 17 years of age		Women over 45 years of age and men	
			Number of meals/week	Chemical Basis[b]	Number of meals/week	Chemical Basis[b]
Black bass (Largemouth, smallmouth, spotted, and redeye bass)	502	12	0	Mercury	1	Mercury
Channel catfish and White catfish	653	47	0	Mercury	1	Mercury, PCBs
Carp	277	24	1	Mercury	2	Mercury, PCBs
Coho Salmon	337	7	1	Mercury	2	Mercury
Bluegill and Green sunfish	109	No Data	2	Mercury	5	Mercury

a/ Weighted mean values from Table 3.
b/ Denotes which chemical concentration determined the consumption frequency.

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APPENDIX A. ADVISORY TISSUE LEVELS

Advisory Tissue Levels (ATLs) guide the development of fish consumption advice for individuals eating sport fish (Klasing and Brodberg, 2008). They provide a maximal number of recommended fish servings that correspond to the range of contaminant concentrations found in fish and are used to provide consumption advice to prevent consumers from being exposed to more than the average daily reference dose for non-carcinogens or to a risk level greater than $1x10^{-4}$ for carcinogens (not more than one additional cancer case in a population of 10,000 people consuming fish at the given consumption rate over a lifetime, the maximum acceptable risk level established by the US EPA for fish advisories (2000[9]). For each chemical, the ATLs were calculated separately for cancer and non-cancer risk, if appropriate, for consumption frequency categories of from one to seven eight-ounce servings per week. The following table contains the most health-protective ATLs, selected from either cancer or non-cancer based risk, for no consumption and up to three servings per week for selected fish contaminants.

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 of age)	>55-70	>70-150	>150-440	>440
Methylmercury (Women over age 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.

[9] USEPA (2000). Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories. Volume 2. Risk Assessment and Fish Consumption Limits, 3rd Edition. EPA 823-B-00-007. Office of Water, U.S. Environmental Protection Agency, Washington, D.C.
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