HEALTH ADVISORY AND GUIDELINES FOR EATING FISH AND SHELLFISH FROM CLEAR LAKE (LAKE COUNTY)

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(Updated August 2018)

California Environmental Protection Agency
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LIST OF ABBREVIATIONS AND ACRONYMS

ATL	Advisory Tissue Level
CDFW	California Department of Fish and Wildlife (formerly the California Department of Fish and Game)
CLERC	UC Davis Clear Lake Environmental Research Center
FL	fork length
km	kilometer
mm	millimeter
OEHHA	Office of Environmental Health Hazard Assessment
ppb	parts per billion
RWB-5	Regional Water Quality Control Board Central Valley Region
SBMM	Sulphur Bank Mercury Mine
SL	standard length
SWAMP	Surface Water Ambient Monitoring Program
TMDL	Total Daily Maximum Load
TL	total length
UC Davis	University of California at Davis

PREFACE

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

- California Health and Safety Code
  - Section 59009, to protect public health
  - Section 59011, to advise local health authorities
- California Water Code
  - Section 13177.5, to issue health advisories

The health advisories are published in the California Department of Fish and Wildlife Sport Fishing Regulations.

This report on the health advisory for eating fish and shellfish from Clear Lake (Lake County) is an update of the one issued in January 2005. This updated advisory resulted from OEHHA's analysis of additional data chiefly for species not included before in the advisory. OEHHA evaluated the added species in response to requests from members of the Big Valley Rancheria Band of Pomo Indians to address traditional Tribal aquatic resources at Clear Lake. This report describes how the new guidelines were developed. The updated advice is shown in the illustrations following the Table of Contents.

This advisory was updated in August 2018 to remove advice for Clear Lake Hitch. This species is currently listed as threatened under the California Endangered Species Act and take of Clear Lake Hitch is not permitted.[1]

Note: some of the numbers in the original version released on May 15, 2014 were corrected in this report in Tables 1 and 2.

[1] California Endangered Species Act. California FGC §2050-2069.

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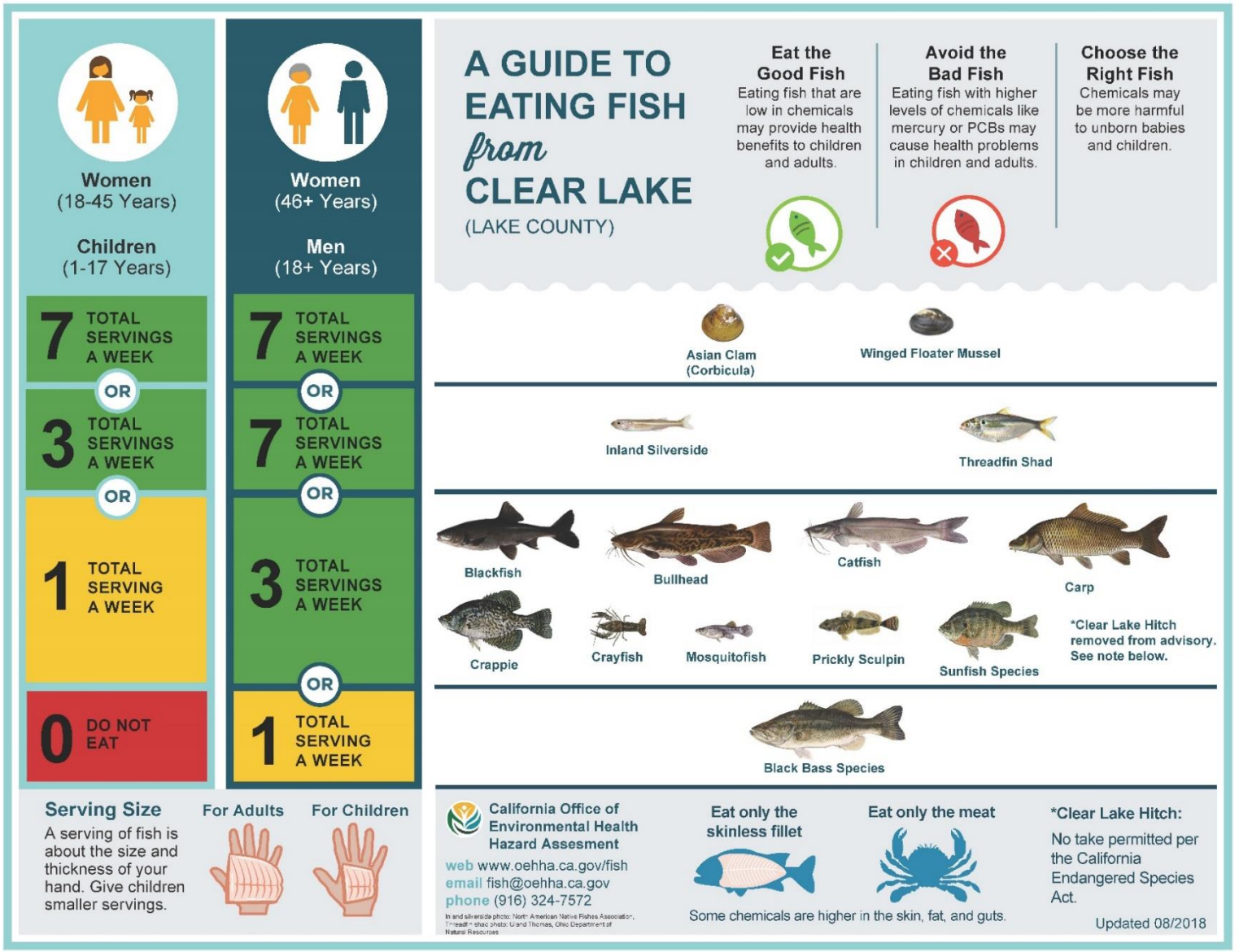


Clear Lake Advisory May 2014; updated August 2018

INTRODUCTION

HISTORY OF CLEAR LAKE FISH ADVISORIES

The Office of Environmental Health Hazard Assessment (OEHHA) first provided advice for eating fish from Clear Lake (Lake County) in 1987[1]. The advice was based on findings of mercury in fish collected from the lake. Since the original advisory was issued, further studies of mercury in fish from Clear Lake were done. In the early 2000s, the Central Valley Regional Water Quality Control Board (RWB-5) compiled a large dataset comprised of historical and more recently collected fish tissue data from several studies. RWB-5 used the dataset and other information to develop a Total Daily Maximum Load (TMDL) for Clear Lake for mercury. The objective of the TMDL is to lower mercury levels in the watershed to protect human health and wildlife. The TMDL took effect in October 2003 and was updated in November 2010 (RWB-5, 2010). OEHHA reviewed the dataset received from RWB-5 and selected data suitable for developing fish consumption advisories. These data were used to update the Clear Lake advisory in 2005. OEHHA's 2005 advisory provided guidelines for eating fish from Clear Lake and Cache Creek (Lake and Yolo counties) and recommended no consumption of any fish or shellfish from Bear Creek (Colusa County). A map of these water bodies is shown in Appendix I.

In 2009, OEHHA updated its fish advisories, considering any new fish tissue data and applying Advisory Tissue Levels (ATLs) consistently to all advisories. No new data were available for Clear Lake at that time; however, the Clear Lake advisory was revised using the ATLs. ATLs (Appendix II) are acceptable levels of specific contaminants in fish tissue, based on chemical toxicity, for a range of consumption rates. OEHHA established ATLs for use in its fish advisory protocol. The development of the ATLs also considered health benefits linked to eating fish (Klasing and Brodberg, 2008). In 2009, OEHHA did not have new data for Clear Lake, Cache Creek, or Bear Creek but used the ATLs to update the advice. See OEHHA (2009) for details of the 2009 changes to the Clear Lake and Cache Creek advisory.

2014 UPDATE

In recent years, OEHHA received requests to include traditional Tribal foods (Appendix III) in its guidelines for Clear Lake. To do so, OEHHA needed data on chemical levels in the fish, shellfish, and other aquatic resources identified as important to Tribal members. In 2013, OEHHA received data from Tom Suchanek, Ph.D., United States Geological Survey, from long-term mercury studies he conducted at Clear Lake with his colleagues at the University of California at Davis (UC Davis). These data allowed OEHHA to add advice for some of the traditional foods and species of interest

[1] At that time, OEHHA was part of the Department of Health Services.

identified by the Big Valley Rancheria Band of Pomo Indians. The newly added species include several species of small fish (threadfin shad, prickly sculpin, mosquitofish, and inland silversides), winged floater mussels, and Asian clams[2].

In this update, OEHHA is providing an advisory for Clear Lake that is separate from advice for Cache Creek. This change will make each advisory more specific to the individual water body. While there is some overlap in species, the characteristics of the lake and the creek support somewhat different fish populations. OEHHA is currently developing updated advice for Cache Creek. Advice for Bear Creek (Colusa County) remains the same: no consumption of any fish or shellfish because of very high mercury levels.

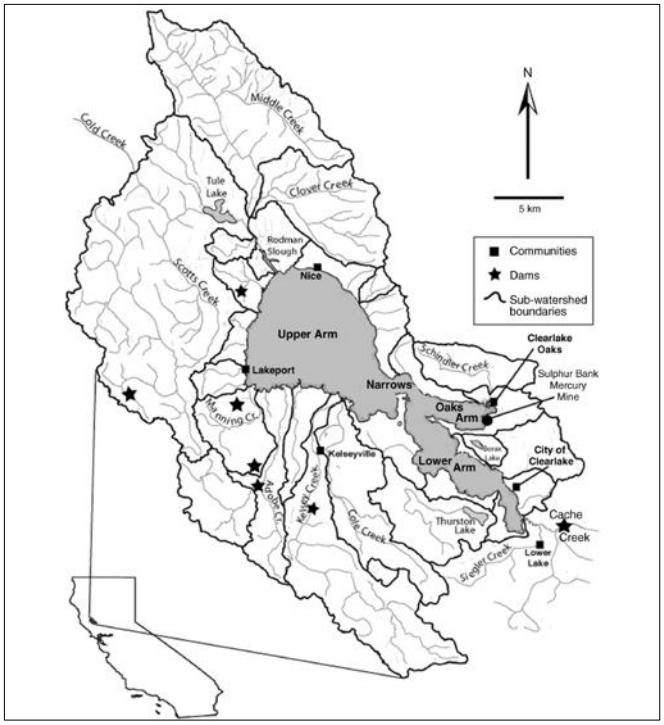
2018 UPDATE

This advisory was updated in 2018 to remove Clear Lake Hitch. This species is currently listened as threatened under the California Endangered Species Act and take of Clear Lake Hitch is not permitted.

BACKGROUND INFORMATION

Clear Lake is a large natural lake located in the California Coast Range in Lake County, California. It is comprised of three basins: the large northern Upper Arm, the long southeast Lower Arm, and the small eastern Oaks Arm (Figure 1).

FIGURE 1. CLEAR LAKE, LAKE COUNTY, CALIFORNIA



From Suchanek et al., 2008a

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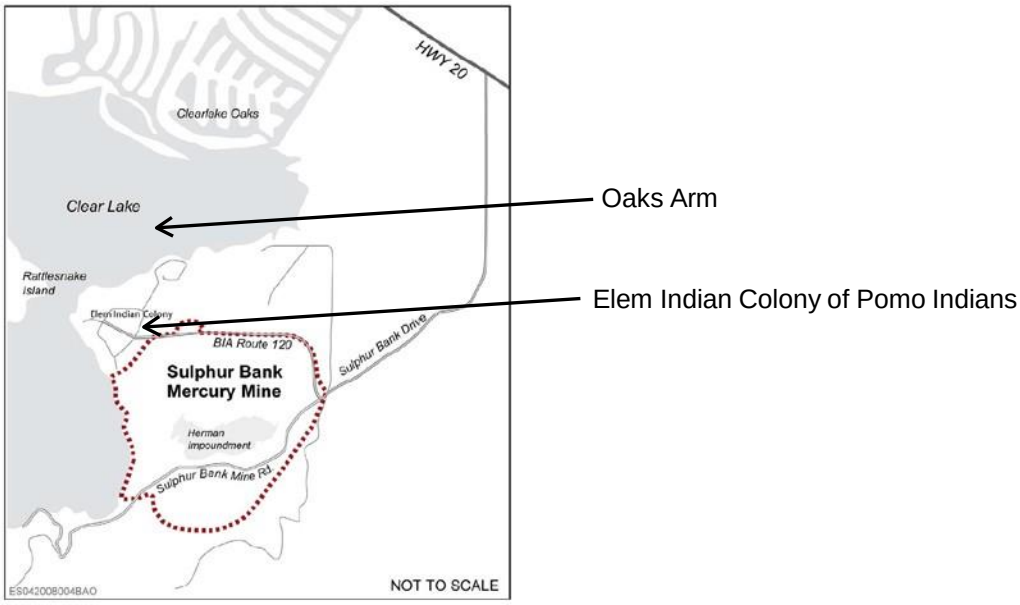
[2] The Tribe did not identify these particular species of mussels and clams, but these are the ones for which OEHHA has data.

The Northern California Coast Range is naturally rich in mercury and other ores. The Clear Lake Mining District was one of the primary producing mercury districts in the late 1800s. It included mines and properties in the south central and southeast portion of Lake County. Mercury properties were typically located along Clear Lake or tributaries that fed into the lake (RWB-5, 2010). Additional smaller mines, now inactive, were also located in the Clear Lake watershed. The Sulphur Bank Mine was established in 1865 on the shore of Oaks Arm to mine sulfur (Suchanek et al., 2008a). After deeper deposits of mercury were discovered, the mine was converted to a mercury mine in 1873 and renamed the Sulphur Bank Mercury Mine (SBMM) (Figures 1 and 2) (Suchanek et al., 2008a). SBMM was a highly productive source of mercury between 1872 and 1957. Open pit mining, in particular, resulted in significant mercury contamination of Clear Lake beginning in 1927 and continuing intermittently until 1957 (Suchanek et al., 2008a[3]).

Lake County is home to several bands of Pomo Indians and other Native American peoples. The Elem Indian Colony of Pomo Indians (originally the Sulphur Bank Rancheria) is located adjacent to the SBMM near the town of Clearlake Oaks on the eastern shore of Clear Lake, Oaks Arm (Figure 2). The Big Valley Rancheria Band of Pomo Indians is located near Finley, west of Clear Lake. Robinson Rancheria includes land on the north side of Clear Lake near Nice, North Lakeport, and Upper Lake. Middletown Rancheria is located near Upper Putah Creek and Middletown. Scotts Valley Rancheria is situated in the north Lakeport area. Koi Nation is situated in the Lower Lake area. The Habematolel Pomo of Upper Lake are located near Middle Creek and Robinson Rancheria.

[3] The publication by Suchanek et al. (2008a) is part of a special issue of Ecological Applications 18(8) Supplement, 2008 devoted entirely to Clear Lake, thereby providing a wealth of information about Clear Lake and mercury.

FIGURE 2. LOCATION OF ELEM INDIAN COLONY OF POMO INDIANS RANCHERIA



From U.S. EPA (2008)

The U.S. Environmental Protection Agency (U.S. EPA) declared SBMM a federal Superfund site in 1991. U.S. EPA has completed a number of cleanup and remediation activities at the site. U.S. EPA is also conducting additional studies currently including a pilot study on capping sediments (U.S. EPA, 2012).

CHEMICALS OF POTENTIAL CONCERN

Tissues from many fish species in Clear Lake, and some shellfish, have been tested for mercury as a measure of methylmercury, the more toxic form found in fish and shellfish. High levels of methylmercury can cause subtle changes in the brain, especially in fetuses and children as they grow.

OEHHA found limited samples of two species, largemouth bass and carp, from Clear Lake that were analyzed for other chemicals in addition to mercury. These samples were tested for persistent chlorinated compounds, including polychlorinated biphenyl congeners (PCBs), and the pesticides dieldrin, chlordanes, and dichlorodiphenyltrichloroethane and metabolites (DDTs). PCBs are man-made chemicals previously used in electrical transformers, lubricating oils, and plastics. PCBs can cause cancer and other health effects in humans. Dieldrin, chlordanes, and DDTs are persistent legacy pesticides that were banned from use many years ago but have been found in some fish in certain water bodies in California. These pesticides 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).

DATA SOURCES

The updated advisory for Clear Lake presented in this report was based on 1) data for fish sampled from Clear Lake and evaluated in prior advisories, and 2) more recent data received by OEHHA, mainly for species not included in past advice. The sources of newly obtained data are described below.

UC DAVIS CLEAR LAKE ENVIRONMENTAL RESEARCH CENTER (CLERC) MONITORING PROGRAM 1992-2001

Upon request, OEHHA received a dataset for this update with results from mercury studies at the UC Davis Clear Lake Environmental Research Center (CLERC). The samples were primarily collected during the ten-year CLERC Monitoring Program (1992 to 2001). Other samples were collected by UC Davis researchers in 1988 and 2004. Fish were collected using trawl, seine, or electrofishing. Mussels and clams were opportunistically harvested at several shoreline locations in 1994. Crayfish were collected from 1992 to 1999 using minnow traps. The fish and shellfish samples were analyzed for total mercury and, in crayfish, for total mercury and methylmercury. OEHHA evaluated the CLERC data to develop advice for species not previously included in the advisory.

The CLERC dataset also included historical samples collected through other programs, primarily by the California Department of Fish and Wildlife[4] (CDFW), as early as 1976. OEHHA had already evaluated most of the samples collected through 1992 and used those data for the 2005 advisory.[5] Therefore, OEHHA selected data for this current evaluation that had not been used before, including additional data for the following species in the 2009 advisory: largemouth bass, channel catfish, crappie, bluegill, carp, and Sacramento blackfish. OEHHA compared and then combined the mean mercury levels from the CLERC dataset and the preceding advisory datasets for species already included in the advisory.

SURFACE WATER AMBIENT MONITORING PROGRAM (SWAMP)

The State Water Resources Control Board operates the Surface Water Ambient Monitoring Program (SWAMP) to monitor water quality in California's surface waters. In 2007 and 2008, the program performed a statewide survey of fish from 272 of California's lakes and reservoirs (Davis et al., 2010). This lakes survey included analysis of total mercury in largemouth bass and carp from Clear Lake. These data had not been used in the previous advisory. One sample of carp was also analyzed for

[4] Formerly the California Department of Fish and Game (CDFG)

[5] See the OEHHA 2005 advisory report for further information on those data sources.

persistent chlorinated compounds. OEHHA included data from SWAMP in determining overall mean concentrations for this update.

U.S. EPA National Lake Fish Tissue Study (NLFTS)

U.S. EPA initiated a national screening-level survey of chemical residues in fish tissue from lakes and reservoirs in the lower 48 states (U.S. EPA, 2013). Working with state, Tribal, and federal partner agencies, samplers collected fish from 500 lakes and reservoirs, selected randomly, over a four-year period (2000-2003). Clear Lake was one of the 19 lakes sampled in California. Composite samples consisted of one predator species and one bottom-dwelling species at each lake. For Clear Lake, those were largemouth bass (predator) and goldfish (bottom-dwelling). Samples were analyzed for mercury and persistent chlorinated compounds. Predator fish were analyzed as fillets and bottom-dwelling species as whole fish. OEHHA did not evaluate the goldfish results because only three goldfish were collected from Clear Lake. The results for largemouth bass were included in this evaluation.

Table 1 summarizes the data sources and shows the total numbers of fish in the samples used in the 2014 advisory.

TABLE 1. NUMBER OF FISH[A] AND SOURCES OF DATA FOR THE 2014 ADVISORY

Advisory species	Sampled Species	2009 Advisory	2014 advisory		
			Added samples from:		Total
			CLERC	Other	
Asian clam	Asian clam	–	64 (64)	–	64 (64)
Bass, largemouth	Largemouth bass	143 (121)	30 (30)	SWAMP: 42 (42) NLFTS: 5 (1)	220 (194)
Blackfish, Sacramento	Blackfish, Sacramento	22 (22)	8 (8)	–	30 (30)
Bullhead	Black bullhead	–	6 (6)	–	48 (45)
	Brown bullhead	35 (32)[b]	7 (7)	–	
Carp	Carp	30 (15)	7 (7)	SWAMP: 20 (4)	57 (26)
Catfish	Channel catfish	77 (64)	13 (13)	–	139 (111)
	White catfish	49 (34)	–	–	
Crappie	Crappie (small)	–	*[10 (10)*[c]	–	82 (73)
	Black crappie (large)	53 (44)	19 (19)	–	
	White crappie	10 (10)	–	–	
Crayfish	Crayfish	95 (27)	113 (113)		208 (140)
Inland silversides	Inland silversides	–	–	–	(486)
Mosquitofish	Mosquitofish	–	–	–	11 (11)
Prickly sculpin	Prickly sculpin	–	6 (6)	–	6 (6)
Sunfish	Bluegill (small)	–	*[21 (21)]*[c]	–	42 (38)
	Bluegill (large)	8 (4)	31 (31)	–	
	Green sunfish	–	3 (3)	–	
Threadfin shad	Threadfin shad	–	23 (23)	–	23 (23)
Winged floater mussel	Winged floater mussel	–	22 (22)	–	22 (22)

[A] Total number of fish or shellfish sampled. Some samples were combined into composite samples then analyzed. Total number of samples analyzed given in parentheses.
[b] In 2009, brown bullhead and catfish samples were combined because they are related species.
[c] Italicized numbers indicate fish sampled but not used directly in the advisory (see text).

CHEMICAL CONCENTRATIONS

MERCURY

Most fish samples were analyzed for total mercury as skinless fillets (muscle tissue). Inland silversides, most threadfin shad, all but one prickly sculpin, and presumably all mosquitofish were analyzed as whole bodies for total mercury. Smaller size classes of bluegill and crappie were analyzed either as whole fish or muscle tissue. Soft tissues were analyzed for total mercury in mussels and clams, and tail muscle was analyzed for total mercury and methylmercury in crayfish. Chemical analysis was performed either

on individuals or composite samples of several individuals of a species, usually similar in size. The result for a composite sample represents the average for the fish or shellfish in that sample.

Total mercury was analyzed for fish collected through 1998 using cold-vapor atomic absorption at one of the following laboratories: Brooks Rand (Seattle, Washington), Battelle Northwest Marine Sciences Laboratory (Sequim, Washington), or the UC Davis Environmental Mercury Laboratory (Suchanek et al., 2008b). Mercury in fish collected after 1998 was analyzed using a Direct Mercury Analyzer (DMA), a combination of thermal decomposition and atomic absorption. The method detection limit for total mercury was 5 parts per billion (ppb) (Eagles-Smith et al., 2008; Suchanek et al., 2008b).

Nearly all total mercury in fish is in the form of methylmercury (Bloom, 1992). OEHHA therefore assumes all mercury detected in fish samples is methylmercury. The ratio of methylmercury to total mercury in shellfish can be much lower, as discussed below. Methylmercury analysis was performed by Brooks Rand or Battelle Northwest Marine Sciences Laboratory using gas chromatography with cold-vapor atomic fluorescence detection (Suchanek et al., 2008b).

Results are reported here in wet weight. In some cases, CLERC samples were analyzed as dry weight and converted to wet weight using an average moisture content of 77.8 percent (Suchanek, personal communication).

Table 2 summarizes the mean (average) and range of mercury concentrations in fish and shellfish samples from Clear Lake. For crayfish, the results shown are methylmercury concentrations. The mean values were determined from all available data including CLERC and other historical projects, SWAMP, and NLFTS. The mean values were weighted by the reported number of individuals per sample unless otherwise indicated. It was not possible to calculate mean lengths because different length measures were reported. CLERC measured fish samples in standard length (SL). With the exception of data from SWAMP and NLFTS, the other samples were measured as fork length (FL). SWAMP and NLFTS samples were measured in total length (TL)[6]. The ranges of lengths reported for each species are shown in Appendix IV.

[6] Standard length is measured from the tip of the lower jaw to the end of the fleshy part of the body. Fork length is measured from the tip of the snout with closed mouth to the center of the fork in the tail. Total length is the maximum length of the fish, with the mouth closed and the tail fin pinched together. See Appendix V for an illustration of fish measurements.

TABLE 2. MERCURY CONCENTRATIONS IN FISH AND SHELLFISH FROM CLEAR LAKE

Species	Tissue Type	Number of Samples	Total Number of Fish or Shellfish	Mean Mercury (ppb wet weight[7])	Mercury Range (ppb wet weight)
Asian clam	soft	64	64	26	10-786
Bass, largemouth	M	194	220	589	100-1910
Blackfish, Sacramento	M	30	30	278	80-450
Bullhead, black	M	6	6	223	120-370
Bullhead, brown	M	39	42	266	120-580
Bullhead, species combined	M	45	48	261	120-580
Carp	M	26	57	179	50-656
Catfish, channel	M	77	90	417	80-1500
Catfish, white[8]	M	34	49	415	100-860
Catfish, species combined	M	111	139	416	80-1500
Crappie[9] (small)	W,M	19[10]	19	98	42-199
Crappie, black (large)	M	63	72	337	67-810
Crappie, white[11]	M	10	10	475	150-1300
Crappie, species combined (large)	M	73	82	354	67-1300
Crayfish[12]	M	140	208	149	2-1116
Inland silversides	W	486[13]	NA[14]	80[15]	11-412
Mosquitofish	W	11	11	323	20-1110
Prickly sculpin	W,M	6	6	135	79-184
Sunfish, bluegill (small)	W,M	21[16]	21	95	44-142
Sunfish, bluegill (large)	M	35	39	196	40-470
Sunfish, green	M	3	3	157	103-194
Sunfish, species combined (large)	M	38	42	193	40-470
Threadfin shad	W,M	23[17]	23	67	30-169
Winged floater mussel	soft	22	22	18	7-70

M muscle W whole body NA Information not available

[7] Wet weight was extrapolated from dry weight in some or all of CLERC data for 2000, 2001, 2004
[8] All samples from 1976-1984; no additional data
[9] Some samples were identified as “black crappie,” others only as “crappie”
[10] Includes 13 samples analyzed as muscle tissue and six fish analyzed whole
[11] White crappie were collected in 1984 only
[12] Results for crayfish are for methylmercury and are unweighted
[13] Includes 18 samples analyzed as eviscerated whole bodies
[14] Based on composites reported to have two to five fish, the total number of inland silversides is between 972 and 2430
[15] Mean mercury is unweighted because the exact number of fish per sample is unknown
[16] Includes 17 fish analyzed whole and four samples analyzed as muscle tissue
[17] Includes 19 whole fish and four fillets

PERSISTENT ORGANIC COMPOUNDS

The results for PCBs and pesticides measured in carp, a species that tends to accumulate persistent organic compounds, and largemouth bass are shown in Table 3. The analyses were done on one composite sample containing 20 carp and one composite sample of five largemouth bass, using muscle tissue. All pesticides (dieldrin, chlordane, and DDTs) were below the ATL thresholds for daily consumption (Appendix II). Mean concentrations of PCBs in the carp and bass were low. The recommended numbers of servings per week based on mercury levels are fewer than if advice were based on PCBs. Therefore, mercury is the chemical of concern in fish and shellfish from Clear Lake and all advice is based on mercury.

TABLE 3. PERSISTENT ORGANIC COMPOUNDS

Project Name	Sample Date	Common Name	Percent Lipid	Chlordanes (ppb ww)	DDTs (ppb ww)	Dieldrin (ppb ww)	PCBs (ppb ww)
SWAMP Statewide Lakes Sportfish Contamination Study 2008	9/15/2008 9/16/2008	Carp	7.07	4.71	134	0	13.2
NLFTS National Lakes Fish Tissue Study	10/16/2000	Largemouth bass	2.83	16.2	106	0	9.03

DEVELOPMENT OF ADVICE FOR EATING FISH AND SHELLFISH FROM CLEAR LAKE

GENERAL INFORMATION

To determine the recommended number of servings per week, OEHHA compared the mean mercury concentrations in each fish or shellfish species provided in Table 2 to the ATLs for methylmercury in Appendix II. As mentioned above, all mercury in fish was considered to be in the form of methylmercury. For crayfish, methylmercury itself was measured. There are two sets of ATLs for exposure to methylmercury in fish and shellfish because of age-related toxicity. The ATLs for the sensitive population (women 18 to 45 years and children 1 to 17 years) are lower than for women over 45 years and men. This lower value is meant to protect the brain and nervous system of the young during growth and development. Women ages 18–45 years are included in the sensitive population to protect the fetus because these women are of childbearing age. A complete description of the process of developing the ATLs can be found in Klasing and Brodberg (2008).

OEHHA's advisory process and the ATLs also consider the health benefits from fish consumption. There is much evidence and scientific consensus that eating fish promotes significant health benefits. Reported health benefits include reduced rates of heart disease and stroke, decreased inflammation, and improvements in mental and visual functions (IOM, 2007). The potential beneficial effects are thought to stem largely from specific omega-3 fatty acids found in significant quantities in fish:

- docosahexaenoic acid or "DHA"
- eicosapentaenoic acid or "EPA"

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, 2008). Further discussion on the benefits and risks of fish consumption can be found in Klasing and Brodberg (2008).

OEHHA includes only legal-sized fish in its evaluations. For Clear Lake, largemouth bass is the only species for which CDFW has a minimum size requirement (12 inches, equivalent to 305 millimeters [mm]). For fish species that do not have legal size requirements, OEHHA generally applies "edible" size criteria (Appendix VI) based on fish species size at maturity and professional judgment (Gassel and Brodberg, 2005). OEHHA requires a minimum of nine fish per species to represent that species in a small water body. Larger sample numbers are appropriate for larger water bodies. Sample sizes are also increased when related species are combined, as discussed below.

OEHHA recommends in its advisories that people avoid eating the skin in fish and the organs of fish and shellfish, except for small fish species. This advice is based on the tendency for persistent organic compounds to accumulate in the organs and skin. OEHHA recognizes that consumption of whole bodies is likely for the small fish species included in this updated advisory and identified as important to Tribal members (silversides, shad, mosquitofish, and sculpin). These species are relatively small, even as adults, and it would be impractical to fillet the fish. In this case, there is less concern for added exposure to persistent organic compounds because mercury is the chemical of concern. Therefore, OEHHA evaluated them as they were analyzed, mainly as whole bodies.

Sample Evaluation

OEHHA selected samples from Clear Lake (excluding Cache Creek and Bear Creek) and calculated mean mercury levels for each species using the data sources shown in Table 1. OEHHA uses weighting when calculating mean concentrations to account for different numbers of fish per sample. The mean mercury levels and range of lengths reported by each data source are shown in Appendix IV. After combining the available data for each species, OEHHA determined the overall mean mercury concentration per species, shown in Table 2, used to develop the consumption advice.

Fish Species with Updated Advice

Bass, Largemouth

The 2014 is advisory based on 121 samples made of 143 individual largemouth bass (*Micropterus salmoides*) from the 2005 and 2009 OEHHA advisories, 30 individual largemouth bass from CLERC, 42 individual samples from SWAMP, and one composite sample of five bass from NLFTS. OEHHA recommends no consumption of largemouth bass by the sensitive population and one serving a week by women over 45 years and men based on the overall weighted mean mercury, 589 ppb.

Blackfish, Sacramento

The CLERC dataset contributed eight individual Sacramento blackfish (*Orthodon microlepidotus*). OEHHA combined these samples with 22 individual blackfish samples in the OEHHA 2005 and 2009 advisories. The overall weighted mean of 278 ppb mercury corresponds to one serving a week for the sensitive population and two servings a week for women over 45 years and men.

Carp

The 2014 advisory included 15 samples of 30 carp (*Cyprinus carpio*) from the 2005 and 2009 advisories, an additional seven individual carp CLERC provided, and four SWAMP samples of 20 carp. The overall weighted mean mercury, 179 ppb, corresponds to one serving a week for the sensitive population and three servings a week for women over 45 years and men.

Catfish

The 2014 advisory adds 13 individual channel catfish CLERC contributed to the 64 samples of 77 individual channel catfish (*Ictalurus punctatus*) included in the 2005 and 2009 advisories. OEHHA combined channel catfish with 34 samples of 49 white catfish (*Ameiurus catus*). The overall weighted mean mercury level of 416 ppb corresponds to one serving a week for the sensitive population and two servings a week for women over 45 years and men.

Crappie

CLERC provided data for 19 individual black crappie (*Pomoxis nigromaculatus*). OEHHA added these samples to the 44 samples (53 black crappie) from the previous OEHHA advisory for a combined weighted mean mercury of 337 ppb. In the previous advisory, OEHHA combined black crappie and ten white crappie (*Pomoxis annularis*) collected in 1984. There were no new data for white crappie. Moyle (2002) reported that white and black crappie populations collapsed to low levels in Clear Lake in the

1970s and did not recover. Knight (2012) reported that crappie made a dramatic comeback in 2005 and collapsed again in 2007. Because of fluctuating populations of both species, OEHHA combined the historic white crappie samples (475 ppb mean mercury) with all black crappie in this updated advisory. The overall weighted mean mercury level, 354 ppb, corresponds to advice of one serving a week for the sensitive population and two servings a week for women over 45 years and men.

The CLERC dataset also included smaller, juvenile crappie. These samples ranged from 59 to 119 mm SL, below OEHHA's minimum size of 150 mm TL (about six inches) (Appendix IV). The mean mercury level in the 19 smaller crappie, 98 ppb, was considerably lower than in the larger crappie. OEHHA did not include the mercury levels in small crappie in the overall mean concentration for this species. Doing so would lower the average concentration and could result in less health protective advice for people eating adult crappie. OEHHA also decided not to provide separate advice for small crappie to avoid complicating the advisory. The recommended frequency based on higher mercury in adult crappie would be health protective for people eating juvenile crappie.

SUNFISH

The CLERC dataset contributed 31 individual samples of bluegill (*Lepomis macrochirus*) in addition to four samples comprised of eight bluegill from the OEHHA 2005 and 2009 advisories. CLERC also collected three individual green sunfish (*Lepomis cyanellus*). Although three fish are not sufficient for issuing advice, green sunfish are related to bluegill. OEHHA combined the results for the two species. The overall weighted mean mercury level, 193 ppb, corresponds to one serving a week for the sensitive population and three servings a week for women over 45 years and men.

CLERC also collected 21 juvenile bluegill, 32-82 mm SL, less than OEHHA's minimum "edible" size of 100 mm TL (about four inches). The mean mercury level in the smaller bluegill was 95 ppb. For the same reasons discussed above for crappie, OEHHA did not include the juvenile bluegill in calculating the mean mercury concentration.

FISH SPECIES ADDED IN 2014

OEHHA used CLERC data to add the following fish species to the Clear Lake advisory.

BULLHEAD

In the 2009 advisory, brown bullhead (*Ameiurus nebulosa*) was combined with channel catfish and white catfish because they are related species (in the same family, Ictaluridae. Black bullhead (*A. melas*) was not part of the 2009 advisory (or previous ones). The CLERC dataset had results for seven individual brown bullhead collected in 2000-2001 and six individual black bullhead collected by CDFW in 1983. In this updated advisory, OEHHA is giving advice for bullhead as well as catfish. The weighted

mean mercury for brown bullhead, including the CLERC data and 32 samples of 35 brown bullhead from the previous advisory dataset, was 266 ppb. Combined with the mean mercury in black bullhead (223 ppb), the overall weighted mean for bullhead is 261 ppb. The overall mean mercury concentration corresponds to one serving a week for the sensitive population and two servings a week for women over 45 years and men.

Inland Silversides

The Big Valley Rancheria Band of Pomo Indians identified inland silversides (*Menidia beryllina*) as a fish species of interest. Extensive sampling between 1986 and 2004 at Clear Lake by CLERC included a total of 486 composite samples of two to five fish analyzed for whole-body total mercury concentrations (Suchanek et al., 2008b). Because the number of individual fish in each composite sample was not specified, the mean mercury concentration for inland silversides was not weighted. The overall mean mercury level, 80 ppb, corresponds to two servings a week for the sensitive population and daily consumption for women over 45 years and men.

Mosquitofish

The Big Valley Rancheria Band of Pomo Indians also identified mosquitofish (*Gambusia affinis*) as a Tribal food of interest. CLERC analyzed 11 samples of mosquitofish collected in 1995 through 1997, presumably as whole bodies. Sizes were not provided in the dataset, but maximum lengths are about 35 mm TL for males and 65 mm TL for females (about 1½ and 2½ inches, respectively) (Moyle, 2002). Mosquitofish feed principally on mosquito larvae and pupae, and also on algae, zooplankton[19], terrestrial insects, and aquatic invertebrates (Moyle, 2002). The mean concentration in this small, short-lived species, 323 ppb, corresponds to one serving a week for the sensitive population and two servings a week for women over 45 years and men.

Prickly Sculpin

There were only six CLERC samples of prickly sculpin (*Cottus asper*), one of the fish species identified as important to the Big Valley Rancheria Band of Pomo Indians. Five

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[19] Microscopic floating or weakly swimming small animals or immature stages of larger aquatic animals

samples were analyzed as whole bodies and one sample as muscle tissue in 2000 or 2001. Despite a small sample size, the size of fish collected (45-76 mm SL) represents mature prickly sculpin in Clear Lake. The mean mercury concentration (135 ppb) corresponds to two servings a week for the sensitive population and four servings a week for women over 45 years and men.

THREADFIN SHAD

Threadfin shad (*Dorosoma petenense*) is a member of the herring family and feeds on plankton (Moyle, 2002). They typically live two years and reach 100 mm TL (Moyle, 2002). The Big Valley Rancheria Band of Pomo Indians identified threadfin shad as a species of interest. CLERC collected 19 samples from Clear Lake in 1988, 1999, and 2004 and analyzed them as whole bodies. Four additional CLERC samples collected in 1988 were analyzed as muscle tissue. The overall weighted mean mercury level (including whole body and muscle tissue samples) was 67 ppb. The mean mercury level corresponds to three servings a week for the sensitive population and seven servings a week for women over 45 years and men.

SHELLFISH

The 2014 advisory includes guidance for eating clams, crayfish, and mussels. Previous advice was issued only for crayfish.

ASIAN CLAMS

CLERC collected 64 samples of the Asian clam (*Corbicula fluminea*), a non-native invasive species, at measured distances from SBMM. Methylmercury concentrations were not measured but are likely to be considerably lower because clams have a low trophic level[20] and tend to have very low methylmercury to total mercury ratios (Lasorsa and Allen-Gil, 1995). Asian clams are short-lived filter feeders, consuming large quantities of phytoplankton[21] (Sousa et al., 2008). Total mercury concentrations were much higher close to the mine site (Table 4); however, in a study of clams collected at increasing distances from another mercury mine in California and analyzed for total mercury and methylmercury, methylmercury ranged from 14 to 60 percent of total mercury (see Gassel et al., 2004; Appendix VII). The percentage of methylmercury was lowest (14 percent) near the mine site where total mercury was the highest. Similarly, in clams collected from the Delta, the percentage of methylmercury was lowest when total mercury was highest (8 percent at a total mercury concentration of 142 ppb compared

[20] Trophic level is the feeding position of an organism in a food chain or food web. A food chain is a sequence of one organism feeding on another. The lowest trophic level (1) includes plants that produce their own food or energy, and the highest level (5) is for top predators.
[21] Microscopic aquatic plants

to 84 percent when total mercury was 10 ppb) (Appendix VII). The levels of methylmercury were therefore consistently low (20-60 ppb) even as total mercury increased. This relationship is commonly observed, as discussed further below. Thus, a low percentage of methylmercury in clams collected near the SBMM is expected. The mean mercury concentration in clams, 26 ppb, corresponds to seven servings a week. For the sensitive population, less frequent consumption of clams if harvested near the SBMM is would be a sensible choice.

TABLE 4. TOTAL MEAN MERCURY CONCENTRATIONS IN CLAMS BY DISTANCE FROM MINE

Distance (km)	Size* Range (mm)	Mean Mercury (ppb)
0.1	>25 - 35	478
4.2	<15 - >25	25
7.8	<15 - >25	17
9.8	<15 - 35	18
13.2	15 - 39	18
15	<15 - >25	19
16.9	<15 - >25	16
21.7	20 - 36	18
22.5	20 - >25	14

km kilometers
* Clams are measured as the greatest diameter of the shell
< less than > greater than

WINGED FLOATER MUSSELS

CLERC collected 22 samples of the winged floater mussel *(Anodonta nuttalliana*), a freshwater mussel native to the western U.S. (Nedeau et al., 2009; Suchanek et al., 2008b). Mussel collections were made at distances ranging from 0.1 kilometer (km) to 24 km from SBMM. Although samples taken closest to the mine were higher in total mercury than the other samples, total mercury levels overall were low (Table 5).

TABLE 5. TOTAL MEAN MERCURY CONCENTRATIONS IN MUSSELS BY DISTANCE FROM MINE

Distance (km)	Mean Shell Length (mm)	Mean Mercury (ppb)
0.1	73	60
4.2	68	18
13.2	73	11
16.9	79	14
21.7	91	16
22	84	10
24	54	15

Studies of aquatic animals including fish and invertebrates have shown that lower trophic level organisms tend to have very low methylmercury to total mercury ratios. Lasorsa and Allen-Gil (1995) examined total mercury and methylmercury in a variety of

organisms spanning several trophic levels. They found methylmercury to be close to 100 percent of total mercury only in carnivorous (predatory) fish. In mussels, anemones, urchins, and lobsters, the percentage of methylmercury was lower when total mercury was higher. Similarly, methylmercury represented 17 to 59 percent of total mercury in mussels in the Krka River estuary, Croatia (Mikac et al., 1996). The higher the total mercury concentration, the lower the percentage of methylmercury.

Methylmercury was not measured in Clear Lake mussels. The mean total mercury level, 18 ppb, corresponds to seven servings a week for both populations. Based on the research discussed above, the proportion of methylmercury in these samples is likely to be low.

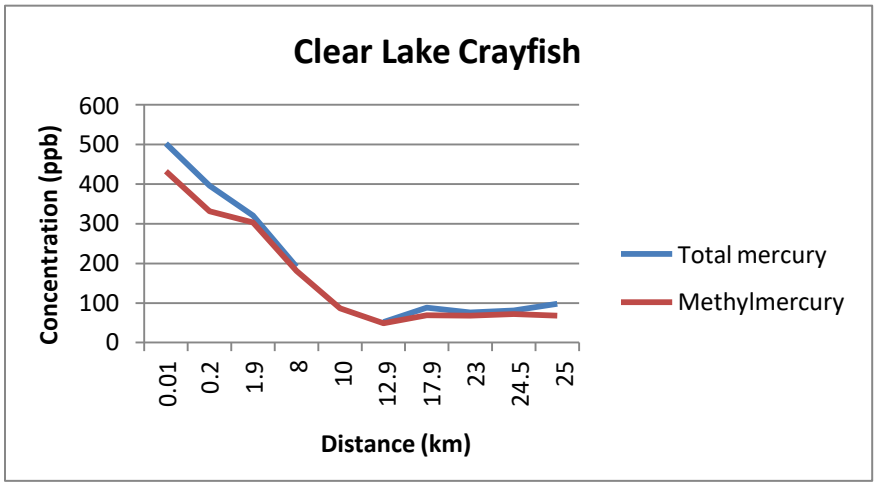
CRAYFISH

Recently received data from CLERC included 113 Louisiana crayfish (*Procambarus clarkii*). The previous advice for crayfish was based on data for 27 samples of 95 crayfish. They were collected from various locations around Clear Lake, at distances from 0.01 km to 25 km from the SBMM. Similar to mussels and clams, total mercury concentrations were highest near the mine site and decreased with distance from the mine. Crayfish samples were also analyzed for methylmercury. Mean methylmercury concentrations showed a similar trend in decreasing concentrations with distance from the SBMM (Table 6 and Figure 3).

TABLE 6. MEAN TOTAL MERCURY AND METHYLMERCURY CONCENTRATIONS IN CRAYFISH BY DISTANCE FROM MINE

Distance (km)	Total Number of Crayfish in Samples (Total Mercury)	Mean Total Mercury (ppb)	Total Number of Crayfish in Samples (Methylmercury)	Mean Methylmercury (ppb)
0.01	13	502	13	432
0.2	27	396	27	331
1.9	10	321	10	303
8	12	192	12	181
10	0	No data	58	87
12.9	1	52	1	49
17.9	39	88	39	69
23	1	76	1	68
24.5	37	81	37	72
25	10	98	10	68

FIGURE 3. MEAN TOTAL MERCURY AND METHYLMERCURY CONCENTRATIONS BY DISTANCE FROM SBMM



Unlike clams and mussels, crayfish are opportunistically omnivorous[22] and have been shown to accumulate higher proportions of methylmercury, similar to predatory fish, because they consume dead fish (Slotton, personal communication; Figure 3).

Methylmercury concentrations from the samples used in the previous advisory were combined with the additional results from CLERC. The mean methylmercury concentrations in Clear Lake crayfish represented between 69 and 94 percent of the mean total mercury levels. The overall (weighted) mean methylmercury concentration, 149 ppb, corresponds to two servings a week for the sensitive population and four servings a week for women over 45 years and men. The mean methylmercury concentration at the sampling location nearest the mine site (432 ppb) corresponds to one serving a week for the sensitive population and two servings a week for women over 45 years and men.

VARIABILITY IN CRAYFISH BY LOCATION

The wide range in concentrations in Table 6 reflects differences in potential methylmercury exposure for people eating crayfish from different areas of Clear Lake. The concentrations in each area correspond to different advice based on collection location. OEHHA calculated weighted mean concentrations for crayfish from each of the three arms of Clear Lake and the Narrows (Figure 1).

Advice for each location would range from one to three servings a week for the sensitive population and from two to seven servings a week for women over 45 years and men.

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[22] Feeding on foods of plant and animal origin, as available.

Different advice by location would make the advisory difficult to communicate. To better represent an average for all of Clear Lake, OEHHA calculated an unweighted mean methylmercury concentration, 166 ppb. Using the unweighted concentration gives equal importance to the range of mercury levels from each location and yields a higher mean concentration. The unweighted mean methylmercury level is more health protective and corresponds to one serving a week for the sensitive population and three servings a week for women over 45 years and men.

SUMMARY OF ADVICE

In the updated advice for Clear Lake, recommendations for some species were adjusted to simplify the advice to three categories for ease of communicating the advice to the public. Specifically, for women 18-45 years and children, the advice for inland silversides was increased from two servings a week to three servings a week, which is the advice for threadfin shad. The mercury levels were similarly low in both species. The advice for prickly sculpin was reduced from two servings to one serving a week. For women over 45 years and men, fish and shellfish in the two, three, and four serving categories were combined, and all were given a three-serving per week recommendation. Table 7 summarizes the recommended maximum numbers of servings for fish and shellfish from Clear Lake.

TABLE 7. RECOMMENDED NUMBER OF SERVINGS PER WEEK

Common Name	Recommended Servings per Week	
	Women 18-45 Years and Children 1-17 Years	Women over 45 Years and Men
Largemouth bass	0	1
Catfish (channel catfish or white catfish)	1	3
Crappie (black crappie or white crappie)	1	3
Mosquitofish	1	3
Sacramento blackfish	1	3
Bullhead (brown bullhead or black bullhead)	1	3
Bluegill or green sunfish	1	3
Prickly sculpin	1	3
Crayfish	1	3
Carp	1	3
Inland silversides	3	7
Threadfin shad	3	7
Asian clams	7	7
Winged floater mussels	7	7

Advice for each species is not meant to be combined in a given week. For example, if a woman between the ages of 18 and 45 eats a serving of catfish, or one of the other species in the one-serving category, OEHHA recommends she wait until the next week to eat fish. However, fish that are recommended three or more servings a week can be combined as long as the total number of servings in that week does not exceed three.

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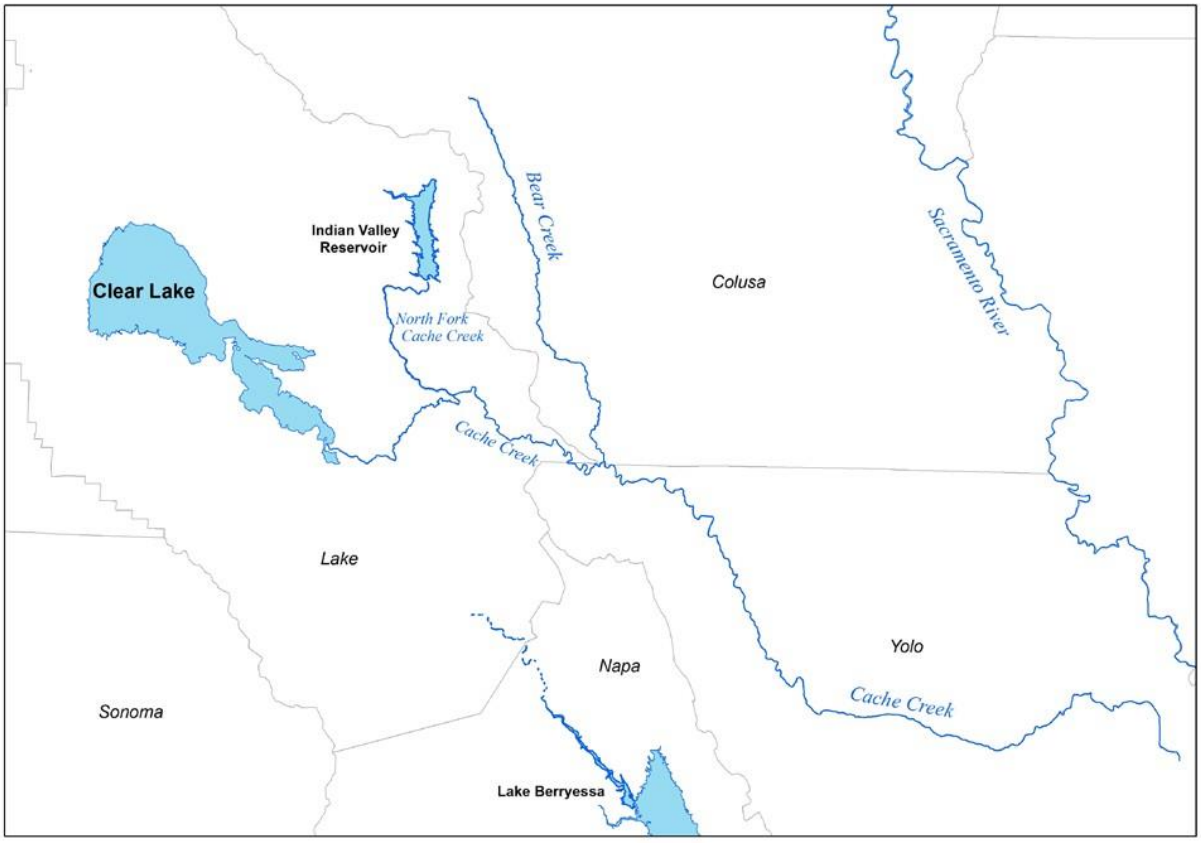
APPENDIX I. MAP OF CLEAR LAKE, CACHE CREEK, AND BEAR CREEK



APPENDIX II. 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 dose[23] 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 U.S. 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 three servings per week. Exposure to chemicals in fish from Clear Lake would be at or below the average daily reference dose or the cancer risk probability of one in ten thousand if the guidelines for eating fish from Clear Lake are followed.

Advisory Tissue Levels (ATLs)
Based on Cancer or Non-Cancer Risk Using an 8-Ounce Serving Size

Chemical	**Consumption Frequency Categories[a] and ATLs[b] (in ppb)**			
	Three Servings per Week	Two Servings per Week	One 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	>16-21	>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.

[23] 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

APPENDIX III. TRADITIONAL TRIBAL AQUATIC RESOURCES

The information presented below was received from Tribal representatives of the Big Valley Rancheria Band of Pomo Indians. After receiving the accounts of traditional Tribal foods, historic and current, OEHHA attempted to locate and obtain additional data on mercury concentrations in Tribal species of interest. Upon receiving data for some of the species and some similar types of organisms, OEHHA began the process of updating the advisory for Clear Lake accordingly.

e-mail correspondence received on 10/4/2011

One thing we have observed is that a large number of fish species, mussels, clams (and even some aquatic birds) that form significant ingredient in the protein supply to the tribal members were somehow left out in the fish advisory maybe inadvertently, not considered fish (in the strict definition of fish) or for other reasons not clear to us. The list of aquatic organisms we have assembled (harvests from the lake may not directly target fish but could be a combination of fish, clams, mussels and some other aquatic organisms including birds and plants) are as follows

1. Golden clam (*Corbicula fluminea)*
2. Pink Heelpsplitter- *Potamilus alatus* (Mussel)
3. Tule perch (*Hysterocarpus traskii traskii)*
4. Prickly sculpin (*Cottus asper*)
5. California roach (*Lavinia symmetricus*)
6. Clear lake split-tail (*Pogonichthys ciscoides*)
7. Threadfin shad (*Dorosoma petenense*)
8. Inland silverside (*Menidia beryllina*)
9. Mosquito fish (*Gambusia affinis*)
10. Mudhens (Ducks)

Are there any efforts at the moment to update the fish advisory to consider some of these fish and other aquatic organisms of interest to the tribe. Thanks and have a nice day. John

John W. Gichuki
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Big Valley Rancheria Band of Pomo Indians
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This information is from some Elders at Big Valley Rancheria and was compiled on March 4, 2004. The information has since been discussed with younger Tribal members who confirm the historical and current consumption.

Overview of Traditional Lake Foods

Main staple eaten year round – fish

Fish (Sha) 10 lbs per family/2-3 lbs per day
- Blackfish (extinct)
- Hitch (extinct) not to be confused with Chai
- Ah-ah-sha (extinct) yellow cat
- Sha-pal (extinct) like steelhead
- Dee-tah (extinct) like crappe
- Sun Perch (extinct)
- Bluegill
- Trout
- Bass
- Catfish

Whole fish was eaten either baked or dried traditionally. Still consumed, although currently at smaller amounts.

Tules – unable to get amount eaten. Still consumed.
- Stalks eaten April – May
- Roots eaten June – July

Mudhens (American coots)
- Eaten twice a week, 1 per person when available
- Still consumed by a few Tribal members

Eggs (Xkoh) crane, duck, mudhen, grebe, etc.
- As much as one could gather, as often as possible
- Still consumed by a few Tribal members

Clams (August, September, October)
- 3-4 lbs per family per day (when desired)
- At the present time, children collect as many clams through the summer to be cooked at home every day – boiled to open, floured and deep fried

Cattails
- New shoots eaten during the spring

Ducks (September – November)
- When desired
- Still consumed by a few Tribal members

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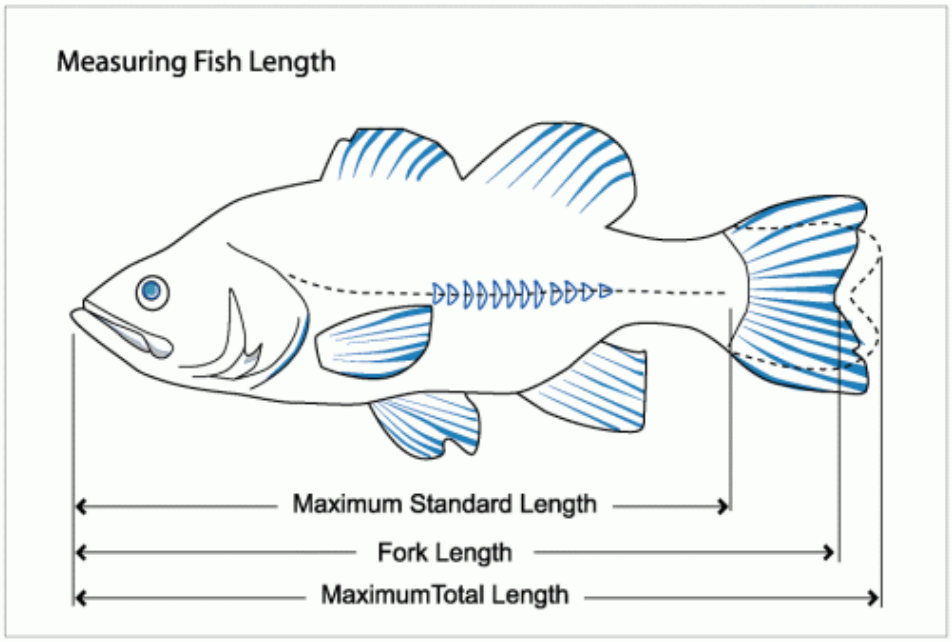
APPENDIX IV. MEAN MERCURY AND LENGTHS IN CLEAR LAKE FISH AND SHELLFISH BY DATA SOURCE

Common Name	Mean Mercury (ppb wet weight)			Range of Lengths (mm)		
	OEHHA 2009	CLERC	SWAMP	Standard Length[24]	Fork Length[25]	Total Length
Asian clam	none	26	none	< 15 -36	NA	15-36[26]
Black crappie	355	286	none	190-336	174-345	NA
Crappie (small)	none	98	none	59-119	NA	NA
Bluegill	225	188	none	85-191	124-184	NA
Bluegill (small)	none	95	none	32-82	NA	NA
Brown bullhead	259	303	none	287-329	220-358	NA
Black bullhead	none	223	none	NA	309-343	NA
Carp	152	319	169	264-650	358-1346	312-767[27] 536-680[28]
Channel catfish	410	459	none	170-775	233-1214	NA
Crayfish	140	171	none	NA	NA	NA
Green sunfish	none	157	none	92-160	NA	NA
Inland silversides	none	80	none	15-95	NA	NA
Largemouth bass	621	710	394/ 585[29]	268-570	290-829	308-656[30] 322-502[31]
Mosquitofish	none	323	none	NA	NA	NA
Prickly sculpin	none	135	none	45-76	NA	NA
Sacramento blackfish	270	299	none	355-385	335-400	NA
Threadfin shad	none	67	none	70-114	NA	NA
White catfish	415	none	none	NA	209-383	NA
White crappie	475	none	none	NA	229-304	NA
Winged floater mussel	none	18	none	NA	NA	48-110[32]

None no samples
< Less than
NA Not available because not measured or not reported

[24] Reported by CLERC
[25] Reported by CDFW
[26] Shell width
[27] Estimated from standard length with CF (conversion factor) of 1.18 (SL x 1.18 = TL)
[28] Reported by SWAMP
[29] Reported by CEDEN for NLFTS
[30] Estimated from standard length with CF (conversion factor) of 1.15 (SL x 1.15 = TL)
[31] Reported by SWAMP; minimum/maximum TL not available from NLFTS
[32] Shell length

APPENDIX V. FISH LENGTH MEASUREMENTS



From http://www.environment.gov.au/

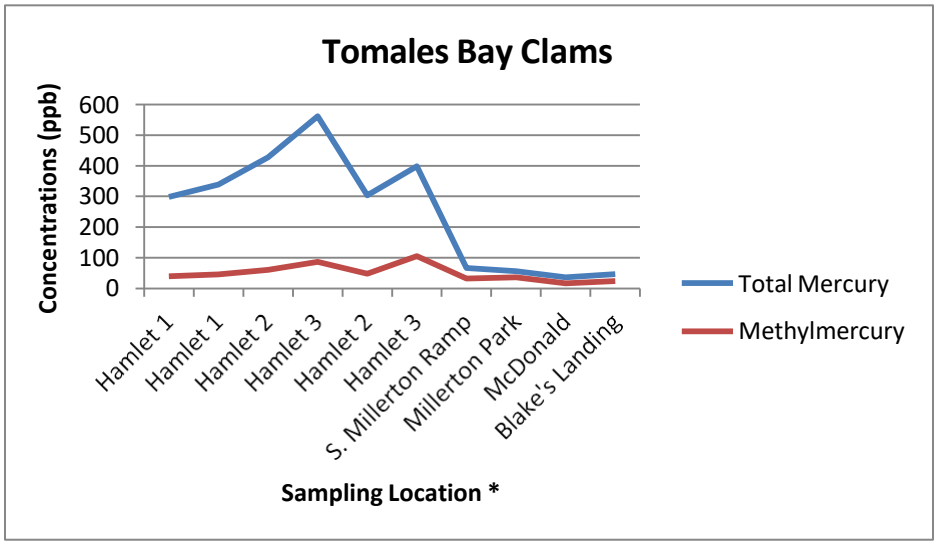
APPENDIX VI. MINIMUM LENGTHS* FOR SPORT (RECREATIONALLY CAUGHT) FISH SPECIES

Common Name	Minimum Length (mm TL)	Approximate Equivalent Size in Inches
Bluegill	100	4
Bullhead	200	8
Carp	200	8
Catfish	200	8
Crappie	150	6
Green sunfish	100	4
Sacramento blackfish	200	8

TL Total Length

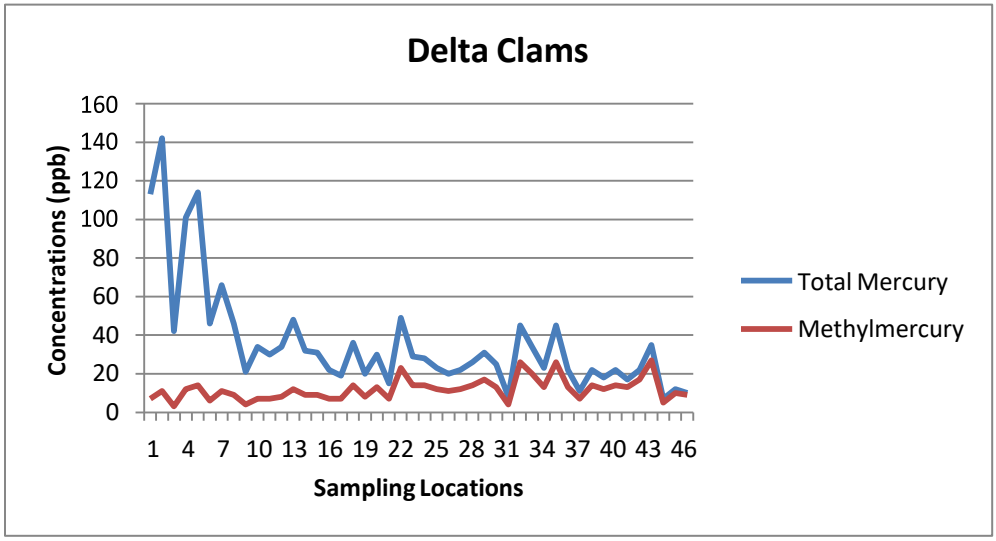
* These lengths were determined by OEHHA based on age at maturity and professional judgment for species without legal size limits.

APPENDIX VII. METHYLMERCURY AS A PERCENTAGE OF TOTAL MERCURY IN CLAMS



* Hamlet was the sampling location closest to the Walker Creek mercury mine site. Despite high total mercury concentrations nearest the mine site, methylmercury concentrations were consistently low.

Data from the San Francisco Bay Regional Water Quality Control Board and Moss Landing Marine Laboratory.



Total mercury concentrations were relatively low in the Delta. Generally, the lowest percentage of methylmercury occurred in the samples with the highest total mercury concentration and vice versa.

Data from Darell Slotton and Tom Suchanek.