HEALTH ADVISORY:

FISH CONSUMPTION GUIDELINES FOR CLEAR LAKE, CACHE CREEK, AND BEAR CREEK (LAKE, YOLO, AND COLUSA COUNTIES)

January 2005

Arnold Schwarzenegger
Governor
State of California

Alan C. Lloyd, Ph.D.
Agency Secretary
California Environmental Protection Agency

Joan E. Denton, Ph.D.
Director
Office of Environmental Health Hazard Assessment

FISH CONSUMPTION GUIDELINES FOR CLEAR LAKE, CACHE CREEK, AND BEAR CREEK (LAKE, YOLO, AND COLUSA COUNTIES)

January 2005

Margy Gassel, Ph.D.
Susan Klasing, Ph.D.
Robert K. Brodberg, Ph.D.
Sue Roberts, M.S.

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

LIST OF CONTRIBUTORS

Reviewers
James Sanborn, Ph.D.

Final Reviewers
Anna M. Fan, Ph.D.
George V. Alexeeff, Ph.D., D.A.B.T.

ACKNOWLEDGEMENTS

We would like to acknowledge staff at the Central Valley Regional Water Quality Control Board, especially Michelle Wood, for coordinating and providing data, and Janis Cooke, Ph.D., for careful review of the data and providing additional technical support. We would also like to acknowledge Shaun M. Ayers, Ph.D., Darell G. Slotton, Ph.D., and Thomas H. Suchanek, Ph.D. for providing data and technical information for studies conducted by researchers at the University of California – Davis.

FOREWORD

This report provides guidelines for consumption of various fish and shellfish species taken from several water bodies in the Clear Lake and Cache Creek watersheds: Clear Lake (Lake County), Cache Creek (Lake County and Yolo County), and Bear Creek (Colusa County). These guidelines were developed as a result of findings of high mercury levels in fish tested from these water bodies and are provided to protect against possible adverse health effects from methylmercury as consumed from mercury-contaminated fish. This report provides background information and a description of the data and criteria used to develop the guidelines.

For further information, contact:

Pesticide and Environmental Toxicology Section
Office of Environmental Health Hazard Assessment
California Environmental Protection Agency
1515 Clay Street, 16th Floor
Oakland, California 94612
Telephone: (510) 622-3170

OR:

Pesticide and Environmental Toxicology Section
Office of Environmental Health Hazard Assessment
California Environmental Protection Agency
1001 I Street, P.O. Box 4010
Sacramento, CA 95812-4010
Telephone: (916) 327-7319

TABLE OF CONTENTS

EXECUTIVE SUMMARY

The Office of Environmental Health Hazard Assessment (OEHHA), formerly part of the Department of Health Services (DHS) but now in the California Environmental Protection Agency, issued a health advisory in 1987 for sport fish from Clear Lake (Lake County) based on mercury contamination in edible fish tissue collected from the lake (Appendix I). Since the advisory was issued, additional data have been collected for Clear Lake fishes as well as for fish from surrounding water bodies, including Cache Creek and Bear Creek. The Central Valley Regional Water Quality Control Board (CVRWQCB) compiled a large dataset comprised of historical and more recently collected fish tissue data principally for Clear Lake but including data from the nearby water bodies. The CVRWQCB used this dataset to develop a Total Daily Maximum Load (TMDL) for mercury for Clear Lake to lower mercury levels in the watershed such that human and wildlife health are protected (Cooke, 2002). This dataset was reviewed by OEHHA, and data suitable for issuing fish consumption advisories were selected and used to update the advisory for Clear Lake and to determine whether there may be potential adverse health effects associated with consuming sport fish from Cache Creek and Bear Creek.

Mercury is a trace metal that can be toxic to humans and other organisms. Mercury occurs naturally in the environment, and is also redistributed in the environment as a result of human activities such as mining and the burning of fossil fuels. Once mercury is released into the environment, it cycles through land, air, and water. In aquatic systems, it undergoes chemical transformation to the organic form, methylmercury, which accumulates in fish and other organisms. More than 95 percent of the mercury found in fish occurs as methylmercury, which is a highly toxic form of the element. Consumption of fish is the major route of exposure to methylmercury in the United States. For more information on mercury, see Appendix II.

The critical target of methylmercury toxicity is the nervous system, particularly in developing organisms such as the fetus and young children. Significant methylmercury toxicity can occur to the fetus during pregnancy even in the absence of symptoms in the mother. In 1985, the United States Environmental Protection Agency (U.S. EPA) set a reference dose (RfD, that is the daily exposure likely to be without significant risks of deleterious effects during a lifetime) for methylmercury of $3x10^{-4}$ milligrams per kilogram of body weight per day (mg/kg-day), based on central nervous system effects (ataxia, or loss of muscular coordination; and paresthesia, a sensation of numbness and tingling) in adults. This RfD was lowered to $1x10^{-4}$ mg/kg-day in 1995 (and confirmed in 2001), based on developmental neurologic abnormalities in infants exposed *in utero*. Because OEHHA finds convincing evidence that the fetus is more sensitive than adults to the neurotoxic effects of mercury, but also recognizes that fish can play an important role in a healthy diet, OEHHA chooses to use both the current and previous U.S. EPA reference doses for two distinct population groups. In this advisory, the current RfD based on effects in infants will be used for women of childbearing age and children aged 17 years and younger. The previous RfD, based on effects in adults, will be used for women beyond their childbearing years and men.

Sufficient data were available to characterize the concentrations of mercury for the following species and locations: largemouth bass, smallmouth bass, channel catfish, white catfish, brown bullhead, carp, black crappie, white crappie, Sacramento blackfish, and hitch in Clear Lake; and bluegill, sucker, Sacramento pikeminnow, and hardhead in Cache Creek. The data for each species from each of these locations were combined to set consumption guidelines as this would allow for health protective advice to be issued even when some sample sizes were limited. This option also allows for more consistent advice to be provided, which facilitates communication. Data for crayfish from Clear Lake were also evaluated and used to develop consumption guidelines for these shellfish.

In Bear Creek, sufficient samples were limited to two species: Sacramento sucker and Sacramento pikeminnow. In this case, mean mercury concentrations in fish from Bear Creek were considerably higher than concentrations for the same species in Cache Creek, and consequently, advice was developed independently for Bear Creek. Results from other studies conducted in the Cache Creek watershed supported this decision.

Mercury concentrations were compared to guidance tissue levels for methylmercury, which are designed so that individuals consuming no more than a preset number of meals should not exceed the RfD for this chemical. Evaluation of data and comparison with guidance tissue levels for methylmercury indicated that fish consumption advisories were appropriate for Clear Lake, Cache Creek, and Bear Creek. Consumers should be informed of the potential hazards from eating fish from these water bodies, particularly those hazards relating to the developing fetus and children. All individuals, especially women of childbearing age and children aged 17 years and younger, are advised to limit their fish consumption to reduce methylmercury ingestion to a level as close to the reference dose as possible. To help sport fish consumers achieve this goal, OEHHA has developed the advisories contained in this report. Meal sizes should be adjusted to body weight as described in the advisory table.

For general advice on how to limit your exposure to chemical contaminants in sport fish (*e.g.*, eating smaller fish of legal size), see the California Sport Fish Consumption Advisories (http://www.oehha.ca.gov/fish.html) or Appendix III. Site-specific advice for other California water bodies can be found online at: http://www.oehha.ca.gov/fish/so_cal/index.html. It should be noted that, unlike the case for many organic contaminants, various cooking and cleaning techniques will not reduce the methylmercury content of fish.

HEALTH ADVISORY

Fish are nutritious and should be part of a healthy, balanced diet. As with many other kinds of food, however, it is prudent to consume fish in moderation, particularly when chemical contaminants such as methylmercury are present in fish at concentrations that pose a concern for public health. OEHHA provides the following consumption advice to the public so that people can continue to eat fish from these locations without putting their health at risk.

FISH AND SHELLFISH CONSUMPTION GUIDELINES FOR CLEAR LAKE AND CACHE CREEK	
Women of childbearing age and children 17 years and younger may eat:	
Once a month	Largemouth bass, smallmouth bass, channel catfish, white catfish, brown bullhead, green sunfish, black crappie, white crappie, Sacramento blackfish, Sacramento pikeminnow, hardhead, or Sacramento sucker ***OR:***
Once a week	Bluegill, hitch, carp, trout, or crayfish
Women beyond childbearing age and men may eat:	
Once a week	Largemouth bass, smallmouth bass, channel catfish, white catfish, brown bullhead, green sunfish, black crappie, white crappie, Sacramento blackfish, Sacramento pikeminnow, hardhead, or Sacramento sucker ***OR:***
3 times a week	Bluegill, hitch, carp, trout, or crayfish
FISH AND SHELLFISH CONSUMPTION GUIDELINES FOR BEAR CREEK	
DO NOT EAT	No one should eat any fish or shellfish from Bear Creek

MANY OTHER WATER BODIES ARE KNOWN OR SUSPECTED TO HAVE ELEVATED MERCURY LEVELS. If guidelines are not already in place for the water body where you fish, women of childbearing age and children 17 and younger may eat up to one sport fish meal per week, and women beyond childbearing age and men may eat up to three sport fish meals per week from any location.

EAT SMALLER FISH OF LEGAL SIZE. Fish accumulate mercury as they grow.

DO NOT COMBINE FISH CONSUMPTION ADVICE. If you eat multiple species or catch fish from more than one area, the recommended guidelines for different species and locations should not be combined. For example, if you eat a meal of fish from the one meal per month category, you should not eat another fish species containing mercury for at least one month.

SERVE SMALLER MEALS TO CHILDREN. Meal size is assumed to be 8 ounces for a 160-pound adult. If you weigh more or less than 160 pounds, add or subtract one ounce to your meal size, respectively, for each 20-pound difference in body weight.

CONSIDER YOUR TOTAL FISH CONSUMPTION**. Fish from many sources (including stores and restaurants) can contain elevated levels of mercury and other contaminants. IF YOU EAT FISH WITH LOWER CONTAMINANT LEVELS (INCLUDING COMMERCIAL FISH) YOU CAN SAFELY EAT MORE FISH. The American Heart Association recommends that healthy adults eat at least two servings of fish per week. Shrimp, king crab, scallops, farmed catfish, wild salmon, oysters, tilapia, flounder, and sole generally contain some of the lowest levels of mercury.**

CLEAR LAKE, CACHE CREEK AND BEAR CREEK SPORT FISH

Note: Images are not to scale

Largemouth Bass *(Micropterus salmoides)*

Duane Raver, USFWS

Smallmouth Bass *(Micropterus dolomieu)*

Duane Raver, USFWS

Channel Catfish (*Ictalurus punctalus)*

Duane Raver, USFWS

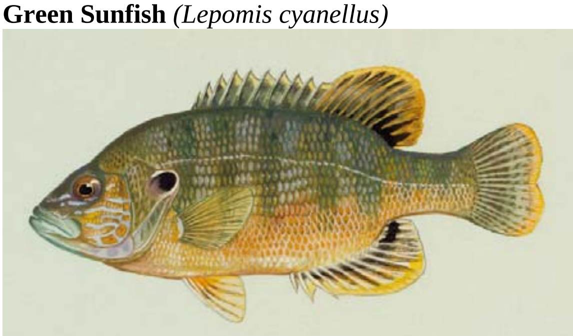
White Catfish *(Amereiurus catus)*

Duane Raver, USFWS

Brown Bullhead *(Ameiurus nebulosus)*

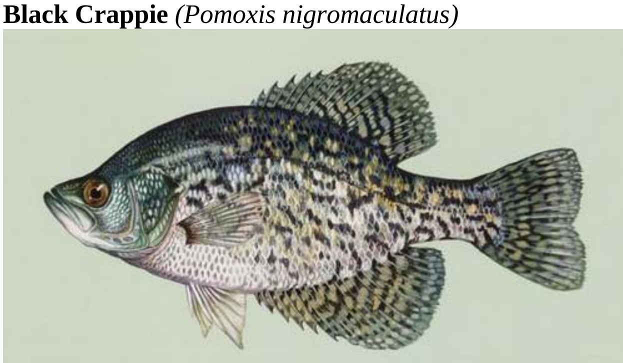
Duane Raver, USFWS

Green Sunfish *(Lepomis cyanellus)*



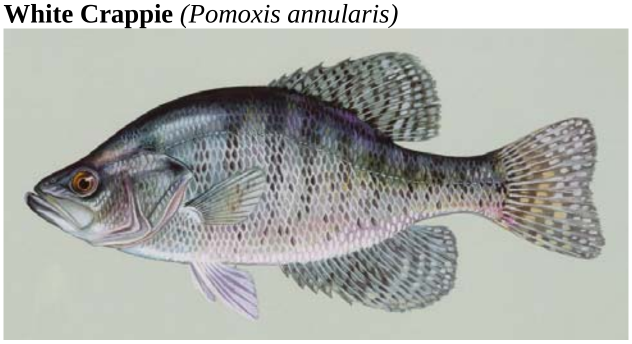
Duane Raver, USFWS

Black Crappie *(Pomoxis nigromaculatus)*



Duane Raver, USFWS

White Crappie *(Pomoxis annularis)*



Duane Raver, USFWS

Sacramento Blackfish (*Orthodon microlepidotus)*

Zak Sutphin, USBR

Sacramento Pikeminnow *(Ptychocheilus grandis)*

Rene' Reyes, USBR

Hardhead *(Mylopharodon conocephalus)*

Rene' Reyes, USBR

Sacramento Sucker *(Catostomus occidentalis)*

Rene' Reyes, USBR

Hitch *(Lavinia exilicauda)*

Rene' Reyes, USBR

Carp *(Cyprinus carpio)*

Duane Raver, USFWS

Bluegill *(Lepomis macrochirus)*

Duane Raver, USFWS

Louisiana or Red swamp crayfish (*Procambarus clarkii*)

Keith A. Crandall

INTRODUCTION

Elevated levels of mercury associated with historic gold mining have been found in fish in a number of lakes and reservoirs in northern California. The Office of Environmental Health Hazard Assessment (OEHHA), formerly part of the Department of Health Services (DHS) but now in the California Environmental Protection Agency, issued a health advisory in 1987 for sport fish from Clear Lake (Lake County) based on mercury contamination in edible fish tissue collected from the lake (Stratton *et al.*, 1987; Appendix I). Additional fish tissues have subsequently been collected and analyzed from Clear Lake and nearby water bodies, including Cache Creek and Bear Creek. The Central Valley Regional Water Quality Control Board (CVRWQCB) compiled a large fish tissue dataset, including historical and more recently collected data principally for Clear Lake but also including some samples from Cache Creek and Bear Creek. The CVRWQCB used these data to develop a Total Daily Maximum Load (TMDL) for mercury for Clear Lake (Cooke, 2002). A TMDL represents a maximum load of a pollutant that can be assimilated by a water body and not result in impairments. The goal of the TMDL is to lower mercury levels in the watershed such that human and wildlife health are protected. OEHHA also evaluated the data compiled by the CVRWQCB and selected out those that were suitable for developing fish consumption advice. Data used to issue advice must meet minimum size and other criteria as described later in this report. OEHHA used the selected data to update the fish consumption advisory for Clear Lake and to determine whether there may be potential adverse health effects associated with consuming sport fish from Cache Creek and Bear Creek.

Mercury is a trace metal that can be toxic to humans and other organisms. Mercury occurs naturally in the environment, and exists in various forms including elemental or metallic mercury, inorganic, and organic mercury (ATSDR, 1999; IARC, 1993). Cinnabar ores, naturally rich in mercury, are common in northern California, and mercury was extensively mined in California in the 1800s and early 1900s. Mercury enters the environment from the breakdown of minerals in rocks and leaching from old mine sites. It is also emitted into air from mining deposits, the burning of fossil fuels, and other industrial sources, as well as from volcanic emissions. Mercury contamination thus occurs as a result of both natural and anthropogenic sources and processes. Once mercury is released into the environment, it cycles through land, air, and water. The deposition of mercury in aquatic ecosystems is a concern for public and environmental health because microorganisms (bacteria and fungi) in the sediments can convert inorganic mercury into organic methylmercury, a particularly toxic form of mercury. Once formed, methylmercury accumulates or "biomagnifies" in the aquatic food chain, reaching the highest levels in fish and other organisms at the top of the food web. Concentrations of methylmercury in fish tissues can therefore be orders of magnitude greater than concentrations in water. Consumption of fish is the principal route of exposure to methylmercury. Whether consumption of fish is harmful depends on the concentrations of methylmercury in the fish and the amount of fish consumed.

OEHHA is the agency responsible for evaluating public health impacts from chemical contamination of sport fish, and issuing 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, and Section 59011, to advise local health authorities; and the California Water Code Section 13177.5, to issue health advisories. Fish advisories developed by OEHHA are published in the California Sport Fishing Regulations of the California Department of Fish and Game (CDFG).

In evaluating the fish tissue data for Clear Lake, Cache Creek, and Bear Creek, it was evident that some fish species in each of these water bodies had sufficient levels of mercury that could be a concern for frequent sport fish consumers. Because fish consumption advice was not currently in place for Cache Creek and Bear Creek, a health advisory was deemed appropriate for these water bodies. Additionally, the advisory for Clear Lake was updated taking all relevant data into account.

BACKGROUND

Clear Lake, Cache Creek, and Bear Creek are located in the California Coast Range in Lake County, Yolo County, and Colusa County, California (Figure 1). Clear Lake is a shallow, eutrophic[1] water body about 18 miles long, with a surface area of approximately 43,000 acres. It is the largest natural lake located entirely within the boundaries of California. Several small communities and resorts are located around Clear Lake. Tourism and sport fishing are important in the area, and five Native American Tribes also use the resources of the lake and its watershed. The Elem Colony of Southeastern Pomo Native Americans (Elem Tribal Colony or Sulphur Bank Rancheria) is located along the eastern shore of the Oaks Arm of Clear Lake, adjacent to the Sulphur Bank Mercury Mine (described further below).

Clear Lake is comprised of three distinct basins: the large northern circular Upper Arm, the elongated southeast-trending Lower Arm, and the relatively small eastern Oaks Arm (Figure 1). The mean depth of the basins ranges from 23 feet in Upper Arm to 36 feet in Oaks Arm (Cooke, 2002). Clear Lake empties at the southern end of Lower Arm into the South Fork of Cache Creek, forming the headwaters of the mainstem of Cache Creek. Cache Creek, approximately 80 miles long, flows southeastward, eventually draining into the Yolo Bypass of the Sacramento River. Cache Creek consists of three sub-basins: the North Fork of Cache Creek, beginning above Indian Valley Reservoir, the South Fork of Cache Creek, beginning at the Clear Lake dam, and Bear Creek, located to the north of Cache Creek (Figure 1). Bear Creek is 39 miles long between its headwaters and Cache Creek; there are no dams on Bear Creek (Cooke *et al.*, 2004).

Rich mineral deposits were created as a result of historic volcanic activity in the region[2]. The first commercial mines were small-scale operations that exploited borax in 1864 and sulphur in 1865 (Suchanek *et al.*, 2002). Mercury mining became a significant industry when the Sulphur Bank Mercury Mine was developed in 1872.

A shallow magma chamber beneath the Geysers-Clear Lake area is the source of geothermal activity throughout the region. The U.S. Geological Survey has mapped numerous hot springs discharging in the area. Geothermal waters are also frequently associated with the formation of ores (Slotton *et al.*, 2004). A large number of these springs vent directly into Clear Lake (Cooke, 2002) and several abandoned mines and active springs and vents drain into Cache Creek from downstream tributaries in Colusa and Lake Counties (Schwarzbach *et al.*, 2001). Sulphur Creek, a tributary to Bear Creek, drains the Wilbur mining district and also contains contributions from geothermal springs enriched with mercury (Schwarzbach *et al.*, 2001).

The Sulphur Bank Mercury Mine (SBMM), currently owned by the Bradley Mining Company and located on the shore of Oaks Arm at Clear Lake, was a highly productive source of mercury

[1] A eutrophic water body is enriched in dissolved nutrients that stimulate the growth of aquatic plant life.

[2] Volcanoes in the area are now considered dormant.

between 1872 and 1957. Several smaller mines, now inactive, were also located in the Clear Lake watershed. Levels of mercury in sediments at Clear Lake increased significantly after 1927, when open pit operations became the dominant method used at SBMM (Cooke, 2002). The U.S. Environmental Protection Agency (U.S. EPA) declared SBMM a federal Superfund site in 1991. Since then, several remediation projects have been completed, including regrading and adding vegetation to the mine waste piles along the shoreline, and constructing a diversion system for surface water runoff. Although the steep, unvegetated slopes of waste rock piles were a significant source of mercury entering Clear Lake, remediation appears to have appreciably reduced erosion of mine material into the lake. However, mercury from SBMM continues to enter Clear Lake through groundwater, surface erosion, and possibly atmospheric deposition (Cooke, 2002).

A TMDL has also been developed by the CVRWQCB for Cache Creek, Bear Creek, and Harley Gulch (Cooke *et al.*, 2004). The goal of this TMDL will be to lower mercury levels in the watershed to protect human and wildlife health. Because Cache Creek is a primary source of mercury to the Sacramento-San Joaquin Delta Estuary, it is assumed in the TMDL that lowering mercury levels in the Cache Creek watershed will aid in protecting human health and wildlife in the Delta (Cooke *et al.*, 2004). The TMDL will encompass the 81-mile reach of Cache Creek between Clear Lake dam and the outflow of Cache Creek settling basin, Bear Creek from its headwaters to its confluence with Cache Creek (39 miles), and the 8-mile stretch of Harley Gulch[1].

Sources of mercury entering Cache Creek include mine tailings and waste rock from historic mercury mines, erosion of mercury-containing soils, geothermal springs, and atmospheric deposition (Cooke *et al.*, 2004). Multiple inactive mercury mines exist in the Cache Creek watershed in addition to the SBMM at Clear Lake, which contributes mercury to the South Fork Cache Creek. Eight mines in the Sulphur Creek mining district drain predominantly into Bear Creek via Sulphur Creek. Harley Gulch receives inputs from the Turkey Run and Abbott mines. The Reed Mine drains into Davis Creek, a tributary to Cache Creek (Cooke *et al.*, 2004).

The majority of mercury loads in the Cache Creek basin, including large contributions from mines, are carried in winter storms. Contributions from Bear Creek are likely to be greater during the early season storms when the reservoirs are in storage mode (Schwarzbach *et al.*, 2001). Mercury loads can therefore be highly variable according to season and weather conditions, and vary by location.

Stratton *et al.* (1987) identified sport fish of interest for Clear Lake as largemouth bass, channel catfish, white catfish, brown bullhead (often called mudcat), crappie (both black and white), hitch (caught principally by the Elem Indian Colony), and Sacramento blackfish (a species fished commercially). The data used in this report included each of these species and also bluegill, carp, and crayfish from Clear Lake.

Because Clear Lake is managed as a reservoir to deliver water to Yolo County for agriculture, excess water flows downstream in summer and as a result, South Fork Cache Creek experiences enhanced summer flows, except during years of drought (Moyle, 2001). These summer flows were further enhanced by the construction of a dam at Indian Valley Reservoir in 1976 on the North Fork of Cache Creek. The diverted water is more plentiful and colder than the original creek water. A consequence of having higher flows in summer than in winter is that carp and other

[1] Harley Gulch is an ephemeral stream that only supports small fish (less than 105 mm; Cooke *et al.*, 2004), and was not included in this advisory.

large fish from Clear Lake can become stranded in large pools in Cache Creek during winter. Thus, the management of water in these water bodies can affect temperature and other characteristics of the water and the movement and location of fishes.

Waters in the Cache Creek watershed are typically warm and alkaline, but as a result of reverse water flows, Cache Creek, like Clear Lake, also supports a fish fauna that is a mixture of native and introduced species (Moyle, 2001). Smallmouth bass are abundant in Cache Creek, and even though they frequently tend to eliminate competing native fishes, native species including Sacramento pikeminnow, hardhead, sucker, and hitch in Cache Creek have managed to coexist with smallmouth bass and are fairly common (Moyle, 2001). Other fish species include carp, catfish, and largemouth bass (Schwartzbach *et al.*, 2001). Moyle (2002) also reported the presence of rainbow and brown trout in Cache Creek and, historically, anadromous species including steelhead trout, but it is unknown whether the anadromous species have persisted since the construction of Clear Lake dam. Fish samples collected for Cache Creek included smallmouth bass, largemouth bass, channel catfish, brown bullhead, white crappie, green sunfish, bluegill, sucker, Sacramento pikeminnow, hardhead, and carp. Crayfish are rarely present in Cache Creek; no samples were available for evaluation.

Samples collected from Bear Creek included sucker, Sacramento pikeminnow, and one green sunfish. Other species that may be present in this warmer stream include sunfishes, catfishes, and other cyprinids (*e.g.*, hitch, California roach, Sacramento blackfish, and hardhead). Bear Creek, which receives drainage from hot springs, is not likely to be as popular for sport fishing (Linn, pers. comm. 2004).

The dataset compiled by the CVRWQCB originated from several different sources (Cooke, 2002), principally CDFG and the Toxic Substance Monitoring Program (TSMP); and the University of California – Davis (UCD). Historical samples of fish from Clear Lake were included in the CVRWQCB dataset from the U.S. Food and Drug Administration (U.S. FDA, 1976) and the California Department of Public Health, Berkeley (CDPH) as well as from CDFG. Other historical data included those used by Stratton *et al.* (1987) to develop the initial advisory for Clear Lake. Detailed documentation of methods of sampling and analysis were not available for all historical data, and some of them were excluded in OEHHA's evaluation due to missing information (*e.g.*, size). The data used by Stratton *et al.* (1987) were summarized by the CVRWQCB in a report titled "Summary of Mercury Data Collection at Clear Lake," copies of which were sent to CDFG and DHS in 1985. Test results on individual fish provided the analytical basis for the fish consumption recommendations developed by DHS (Stratton *et al.*, 1987). These data were collected by CDFG and analyzed by the CDFG Water Pollution Control Laboratory for total mercury concentration by cold vapor atomic absorption spectrophotometry, and the methods of collection and analysis presumably followed the same procedures described here for other samples collected and analyzed by CDFG.

CDFG sampled fish from Clear Lake using gill nets and electrofishing equipment; the CDFG Water Pollution Control Laboratory in Rancho Cordova performed the analyses. In 1977, data obtained from CDFG were from fish caught in a lake-wide fishing tournament at Clear Lake. All other samples collected by CDFG were part of TSMP, an ongoing state program designed to evaluate water quality by measuring the accumulation of chemicals in fish tissues. CDFG collected fish samples for TSMP using electrofishing equipment, nets, and hook and line. Species collected included black crappie, bluegill, brown bullhead, carp, channel catfish, hitch, largemouth bass, smallmouth bass, Sacramento blackfish, white catfish, green sunfish, Sacramento pikeminnow, and sucker. Fish were measured and weighed and made into composites using skin-off muscle fillet. Composite samples were homogenized at the CDFG Water Pollution Control Laboratory and analyzed for total mercury by cold vapor atomic absorption spectrophotometry. Other samples collected by CDFG were collected, prepared, and analyzed in the same manner.

The most recent (1992, 1994, 1995, 1996, and 2000) and largest number of samples came from UCD. Researchers from UCD collected samples of bluegill, brown bullhead, carp, channel catfish, white catfish, green sunfish, hardhead, largemouth bass, smallmouth bass, Sacramento pikeminnow, sucker, and white crappie using electrofishing equipment, nets, or hook and line from multiple locations in Clear Lake, Cache Creek, and Bear Creek. In addition, 27 composite samples of red swamp crayfish, including one to ten individuals per sample, were collected from multiple locations at Clear Lake. These samples were weighed, and tail muscle was extracted and analyzed for total mercury and methylmercury. Mercury and methylmercury were measured as dry weight, and an average percent solids ratio of 16.7 percent was used to calculate wet weight concentrations (Suchanek *et al*., 1997). Fish were measured and weighed; boneless and skinless individual fillets were submitted to UCD for total mercury analyses by cold vapor atomic absorption spectrophotometry.

Although the data compiled by CVRWQCB were not collected specifically with the intention of developing fish consumption advisories, they can be used for that purpose providing certain sampling criteria are met. For example, U.S. EPA recommends a minimum of three replicate composite samples of three fish per composite (nine total fish) in order to begin assessing the magnitude of contamination at a site. U.S. EPA also recommends that at least two fish species be sampled per site. Although composite analysis is generally the most cost-efficient method of estimating the average concentration of chemicals in a fish species, individual sampling provides a better measure of the range and variability of contaminant levels in a fish population (U.S. EPA, 2000a). Using these guidelines, OEHHA believes that a minimum of three replicates of three fish per composite or, preferably, nine individual fish samples of multiple species from each water body should be analyzed for the purpose of assessing the potential risks from consumption of fish from the water body. Species of fish that do not grow large (*e.g.*, sunfish) usually require more than three individuals per composite to provide sufficient tissue for analysis; this additional number of individuals will also make the samples more representative. When feasible, fish samples should be collected from multiple (legal/edible-) sizes when a large size range exists in that species. Following this sampling protocol will allow estimation of the range and variation of contaminant concentrations at a particular site and derivation of a representative mean concentration for use in developing fish consumption advisories. However, more samples will provide a better estimate of the mean contaminant level in various fish species and are especially important for large water bodies. The samples used in this evaluation were collected under different research programs designed for purposes other than issuing fish advisories, but were useful for developing advice and in most cases, met or exceeded the minimum criteria for number of samples.

Only legal and/or edible size fish were included in this evaluation. Crayfish length was not measured in the available study so all crayfish were included in the evaluation. Minimum size requirements are shown in Table 1, and the case summaries in Appendix IV present all data and indicate which of the data were selected and used in this evaluation. Because many of the samples in the dataset compiled by the CVRWQCB included undersized fish, a smaller subset of the data was used for developing the advice for these water bodies. Additionally, because data were compiled from a combination of multiple projects over multiple years, every effort was made to rule out duplicate samples in the dataset. Historical data comprised a relatively smaller portion of the overall dataset; nevertheless, there was no clear evidence of change in mercury concentrations over time, and no reason to believe the levels are decreasing, because this region continues to be a source of mercury contamination (Slotton *et al.*, 2004).

METHYLMERCURY TOXICOLOGY[1]

The toxicity of mercury to humans is greatly dependent on its chemical form (elemental, inorganic, or organic) and route of exposure (oral, dermal, or inhalation). Methylmercury, an organic form, is highly toxic and can pose a variety of human health risks (NAS/NRC, 2000). Of the total amount of mercury found in fish muscle tissue, methylmercury comprises more than 95 percent (ATSDR, 1999; Bloom, 1992). Because analysis of total mercury is less expensive than that for methylmercury, total mercury is usually analyzed for most fish studies.

Fish consumption accounts for almost 100 percent of the average daily methylmercury intake in adults not occupationally exposed to this chemical (ATSDR, 1999). Almost all fish contain detectable levels of methylmercury, which, when ingested, is almost completely absorbed from the gastrointestinal tract (Aberg *et al.*, 1969; Myers *et al.*, 2000). Once absorbed, methylmercury is distributed throughout the body, reaching the largest concentration in kidneys. Its ability to cross the placenta as well as the blood brain barrier allows methylmercury to accumulate in the brain and fetus, which are known to be especially sensitive to the toxic effects of this chemical (ATSDR, 1999). In the body, methylmercury is slowly converted to inorganic mercury and excreted predominantly by the fecal (biliary) pathway. Methylmercury is also excreted in breast milk (ATSDR, 1999). The biological half-life of methylmercury is approximately 44 to 74 days in humans (Aberg, 1969; Smith *et al.*, 1994), meaning that it takes approximately 44 to 74 days for one half of an ingested dose of methylmercury to be eliminated from the body.

Human toxicity of methylmercury has been well studied following several epidemics of human poisoning resulting from consumption of highly contaminated fish (Japan) or seed grain (Iraq, Guatemala, and Pakistan) (Elhassani, 1982-83). The first mass methylmercury poisoning occurred in the 1950s and 1960s in Minamata, Japan, following the consumption of fish contaminated by industrial pollution (Marsh, 1987). The resulting illness was manifested largely by neurological signs and symptoms such as loss of sensation in the hands and feet, loss of gait coordination, slurred speech, sensory deficits including blindness, and mental disturbances (Bakir *et al.*, 1973; Marsh, 1987). This syndrome was subsequently named Minamata Disease. A second outbreak of methylmercury poisoning occurred in Niigata, Japan, in the mid-1960s. In that case, contaminated fish were also the source of illness (Marsh, 1987). In all, more than 2,000 cases of methylmercury poisoning were reported in Japan, including more than 900 deaths (Mishima, 1992).

The largest outbreak of methylmercury poisoning occurred in Iraq in 1971-1972 and resulted from consumption of bread made from seed grain treated with a methylmercury fungicide (Bakir *et al.*, 1973). This epidemic occurred over a relatively short term (several months) compared to the Japanese outbreak. The mean methylmercury concentration of wheat flour samples was found to be 9.1 micrograms per gram (μg/g). Over 6,500 people were hospitalized, with 459 fatalities. Signs and symptoms of methylmercury toxicity were similar to those reported in the Japanese epidemic.

---

[1] The information in this section and the subsequent one was taken largely from Klasing and Brodberg (2003).

Review of data collected during and subsequent to the Japan and Iraq outbreaks identified the critical target of methylmercury as the nervous system and the most sensitive subpopulation as the developing organism (U.S. EPA, 1997). During critical periods of prenatal and postnatal structural and functional development, the fetus and children are especially susceptible to the toxic effects of methylmercury (ATSDR, 1999; IRIS, 1995). When maternal methylmercury consumption is very high, as happened in Japan and Iraq, significant methylmercury toxicity can occur to the fetus during pregnancy, with only very mild or even in the absence of symptoms in the mother. In those cases, symptoms in children were often not recognized until development of cerebral palsy and/or mental retardation many months after birth (Harada, 1978; Marsh *et al.*, 1980; Marsh *et al.*, 1987; Matsumoto *et al.*, 1964; Snyder, 1971).

The International Agency for Research on Cancer (IARC) has listed methylmercury compounds as possible human carcinogens, based on increased incidence of tumors in mice exposed to methylmercury chloride (IARC, 1993). Based on IARC's evaluation, OEHHA has administratively listed methylmercury compounds on the Proposition 65 list of carcinogens. No cancer potency factor (an estimate of the increased cancer risk from lifetime exposure to a chemical) has been developed for methylmercury. The potential for carcinogenic effects from exposure to methylmercury should be noted, but current understanding of the toxicology of methylmercury supports consideration of neurotoxicity as the principal and appropriate endpoint of concern.

DERIVATION OF REFERENCE DOSES FOR METHYLMERCURY

A reference dose (RfD) is an estimate, with uncertainty spanning perhaps an order of magnitude, of a daily oral exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime (IRIS, 1995). Reference doses are expressed in units of milligrams of the chemical of concern per kilogram of body weight per day (mg/kg-day). The estimate includes a safety factor to account for data uncertainty. The underlying assumption of a reference dose is that, unlike carcinogenic effects, there is a threshold dose below which certain toxic effects will not occur. The reference dose for a particular chemical is derived from review of relevant toxicological and epidemiological studies in animals and/or humans. These studies are used to determine a No-Observed-Adverse-Effect-Level (NOAEL; the highest dose at which no adverse effect is seen), a Lowest-Observed-Adverse-Effect-Level (LOAEL; the lowest dose at which any adverse effect is seen), or a benchmark dose level (BMDL; a statistical lower confidence limit of a dose that produces a certain percent change in the risk of an adverse effect) (IRIS, 1995). Based on these values and the application of uncertainty factors to account for incomplete data and sensitive subgroups of the population, a reference dose is then generated. Exposure to a level above the RfD does not mean that adverse effects will occur, only that the possibility of adverse effects occurring has increased (IRIS, 1993).

The first U.S. EPA RfD for methylmercury was developed in 1985 and set at 3×10^{-4} mg/kg-day (U.S. EPA, 1997). This RfD was based, in part, on a World Health Organization report summarizing data obtained from several early epidemiological studies on the Iraqi and Japanese methylmercury poisoning outbreaks (WHO, 1976). WHO found that the earliest symptoms of methylmercury intoxication, paresthesias, were reported in these studies at blood and hair concentrations ranging from 200 to 500 micrograms per liter (µg/L) and 50-125 µg/g in adults, respectively. In cases where ingested mercury dose could be estimated (based, for example, on mercury concentration in contaminated bread and number of loaves consumed daily), an empirical correlation between blood and/or hair mercury concentrations and onset of symptoms was obtained. From these studies, WHO determined that methylmercury exposure equivalent to long-term daily intake of 3-7 μg/kg body weight in adults was associated with an approximately 5 percent prevalence of paresthesias (WHO, 1976). U.S. EPA further cited a study by Clarkson *et al.* (1976) to support the range of mercury concentrations at which paresthesias were first observed in sensitive members of the adult population. This study found that a small percentage of Iraqi adults exposed to methylmercury-treated seed grain developed paresthesias at blood levels ranging from 240 to 480 μg/L. U.S. EPA applied a 10-fold uncertainty factor to the LOAEL (3 μg/kg-day) to reach what was expected to be the NOAEL. Because the LOAEL was observed in sensitive individuals in the population after chronic exposure, additional uncertainty factors were not considered necessary for exposed adults (U.S. EPA, 1997).

Although this RfD was derived on the basis of effects in adults, even at that time researchers were aware that the fetus might be more sensitive to methylmercury (WHO, 1976). It was not until 1995, however, that U.S. EPA had sufficient data from Marsh *et al.* (1987) and Seafood Safety (1991) to develop an oral RfD based on methylmercury exposures during the prenatal stage of development (IRIS, 1995). Marsh *et al.* (1987) collected and summarized data from 81 mother and child pairs where the child had been exposed to methylmercury *in utero* during the Iraqi epidemic. Maximum mercury concentrations in maternal hair during gestation were correlated with clinical signs in the offspring such as cerebral palsy, altered muscle tone and deep tendon reflexes, and delayed developmental milestones that were observed over a period of several years after the poisoning. Clinical effects incidence tables included in the critique of the risk assessment for methylmercury conducted by U.S. FDA (Seafood Safety, 1991) provided dose-response data for a benchmark dose approach to the RfD, rather than the previously used NOAEL/LOAEL method. The BMDL was based on a maternal hair mercury concentration of 11 ppm. From that, an average blood mercury concentration of 44 μg/L was estimated based on a hair: blood concentration ratio of 250:1. Blood mercury concentration was, in turn, used to calculate a daily oral dose of 1.1 μg/kg-day, using an equation that assumed steady-state conditions and first-order kinetics for mercury. An uncertainty factor of 10 was applied to this dose to account for variability in the biological half-life of methylmercury, the lack of a two-generation reproductive study and insufficient data on the effects of exposure duration on developmental neurotoxicity and adult paresthesia. The oral RfD was then calculated to be 1×10^{-4} mg/kg-day, to protect against developmental neurological abnormalities in infants (IRIS, 1995). This fetal RfD was deemed protective of infants and sensitive adults.

The two RfDs for methylmercury were developed using data from high-dose poisoning events. Recently, the National Academy of Sciences was directed to provide scientific guidance to U.S. EPA on the development of a new RfD for methylmercury (NAS/NRC, 2000). Three large prospective epidemiological studies were evaluated in an attempt to provide more precise dose-response estimates for methylmercury at chronic low-dose exposures, such as might be expected to occur in the United States. The three studies were conducted in the Seychelles Islands (Davidson *et al.*, 1995, 1998), the Faroe Islands (Grandjean *et al.*, 1997, 1998, 1999), and New Zealand (Kjellstrom *et al.*, 1986, 1989). The residents of these areas were selected for study because their diets rely heavily on consumption of fish and marine mammals, which provide a continual source of methylmercury exposure (NAS/NRC, 2000).

Although estimated prenatal methylmercury exposures were similar among the three studies, subtle neurobehavioral effects in children were found to be associated with maternal methylmercury dose in the Faroe Islands and New Zealand studies, but not in the Seychelle Islands study. The reasons for this discrepancy were unclear; however, it may have resulted from differences in sources of exposure (marine mammals and/or fish), differences in exposure pattern, differences in neurobehavioral tests administered and age at testing, the effects of confounding variables, or issues of statistical analysis (NRC/NAS, 2000). After review of these studies, the National Academy of Sciences report supported the current U.S. EPA RfD of 1×10^{-4} mg/kg-day for fetuses, but suggested that it should be based on the Faroe Islands study rather than Iraqi data. U.S. EPA has recently published a new RfD document that arrives at the same numerical RfD as the previous fetal RfD, using data from all three recent epidemiological studies while placing emphasis on the Faroe Island data (IRIS, 2001). In order to develop an RfD, U.S. EPA used several scores from the Faroes data, rather than a single measure for the critical endpoint, as is customary (IRIS, 2001). U.S. EPA developed BMDLs utilizing test scores for several different neuropsychological effects and the preferred biomarker for the Faroes data (cord blood). The BMDLs for different neuropsychological effects in the Faroes study ranged from 46 to 79 ppb mercury. U.S. EPA then chose a one-compartment model for conversion of cord blood to ingested maternal dose, which resulted in estimated maternal mercury exposures of 0.857-1.472 μg/kg-day (IRIS, 2001). An uncertainty factor of ten was applied to the oral doses corresponding to the range of BMDLs to account for inter-individual toxicokinetic variability in ingested dose estimation from cord-blood mercury levels and pharmacodynamic variability and uncertainty, leading to an RfD of 1×10^{-4} mg/kg-day (IRIS, 2001). In support of this RfD, U.S. EPA found that benchmark dose analysis of several neuropsychological endpoints from the Faroe Island and New Zealand studies, as well as an integrative analysis of all three epidemiological studies, converged on an RfD of 1×10^{-4} mg/kg-day (IRIS, 2001). U.S. EPA (IRIS, 2001) now considers this RfD to be protective for all populations; however, in their joint federal advisory for mercury in fish, U.S. EPA and FDA only apply this RfD to women who might become pregnant, women who are pregnant, nursing mothers, and young children (U.S. EPA, 2004).

OEHHA finds that there is convincing evidence that the fetus is more sensitive than adults to the neurotoxic and subtle neuropsychological effects of methylmercury. As noted previously, during the Japanese and Iraqi methylmercury poisoning outbreaks, significant neurological toxicity occurred to the fetus even in the absence of symptoms in the mother. In later epidemiological studies at lower exposure levels (*e.g.*, in the Faroe Islands), these differences in maternal and fetal susceptibility to methylmercury toxicity were also observed. Recent evidence has shown that the nervous system continues to develop through adolescence (see, for example, Giedd *et al.*, 1999; Paus *et al.*, 1999; Rice and Barone, 2000). As such, it is likely that exposure to a neurotoxic agent during this time may damage neural structure and function (Adams *et al.*, 2000), which may not become evident for many years (Rice and Barone, 2000). Thus, OEHHA considers the RfD based on subtle neuropsychological effects following fetal exposure to be the best estimate of a protective daily exposure level for pregnant or nursing females and children aged 17 years and younger.

OEHHA also recognizes that fish can play an important role in a healthy diet, particularly when it replaces other higher-fat sources of protein. Numerous human and animal studies have shown that fish oils have beneficial cardiovascular and neurological effects (see, for example, Harris and Isley, 2001; Iso *et al.*, 2001; Mori and Beilin *et al.*, 2001; Daviglus *et al.*, 1997; von Schacky *et al.*, 1999; Valagussa *et al.*, 1999; Moriguchi *et al.*, 2000; Lim and Suzuki, 2000; Cheruka *et al.*, 2002). Nonetheless, the hazards of methylmercury that may be present in fish, particularly to developing fetuses and children, cannot be overlooked. When contaminants are present in a specific medium (*e.g.*, a food) that can be differentially avoided, it is not necessary to treat all populations in the most conservative manner to protect the most sensitive population. Sport fish consumption advisories are such a case. Exposure advice can be tailored to specific risks and benefits for populations with different susceptibilities so that each population is protected without undue burden to the other. Fish consumption advisories utilize the best scientific data available to provide the most relevant advice and protection for all potential consumers.

In an effort to address the risks of methylmercury contamination in different populations as well as the cardiovascular and neurological benefits of fish consumption, two separate RfDs will be used to assess risk for different population groups. OEHHA has formerly used separate methylmercury RfDs for adults and pregnant females to formulate advisories for methylmercury contamination of sport fish (Stratton *et al.*, 1987). Additionally, most states issue separate consumption advice for sensitive (*e.g.*, children) and general population groups. OEHHA chooses to use both the current and previous U.S. EPA references doses for two distinct population groups. In this advisory, the current RfD based on effects in infants will be used for women of childbearing age and children aged 17 years and younger. The previous RfD, based on effects in adults, will be used for women beyond their childbearing years and men.

MERCURY LEVELS IN FISH FROM CLEAR LAKE, CACHE CREEK, AND BEAR CREEK

Mercury concentrations in fish and other biota are dependent, in general, on the mercury level of the environment in which they reside. However, there are many factors that affect the accumulation of mercury in fish tissue. Fish species and age (as inferred from length) are known to be important determinants of tissue mercury concentration (WHO, 1989; 1990). Fish at the highest trophic levels (*i.e.*, predatory fish) generally have the highest levels of mercury. Additionally, because the biological half-life of methylmercury in fish is much longer (approximately 2 years) than in mammals, tissue concentrations increase with increased duration of exposure (Krehl, 1972; Stopford and Goldwater, 1975; Tollefson and Cordle, 1986). Thus, with increasing age (length) within a given species, tissue methylmercury concentrations are expected to increase. In addition to differences in species, size, and water mercury concentration, the accumulation of mercury in fish is also dependent on environmental differences in pH, redox potential, temperature, alkalinity, buffering capacity, suspended sediment load, and geomorphology in individual water bodies (Andren and Nriagu, 1979; Berlin, 1986; WHO, 1989).

For the data presented below, chemical concentrations are reported in wet weight. Arithmetic means, rather than geometric means, were used to represent the central tendency (average) of mercury concentrations for all species in this report. In general, arithmetic means for environmental chemical exposures are more health-protective than geometric means, and are commonly used in human health risk assessments. Complete descriptive statistics for each fish species in this study can be found in Appendices V-VII; individual mercury concentrations and fish lengths from which species means were generated can be found in Appendix IV.

Combining data for water bodies in the same watershed is advantageous because this increases available results for individual species and leads to consistent advice. Combining data is not appropriate, however, when mercury concentrations in fish from different water bodies are so dissimilar that they might result in significantly different advice if considered independently. As a result of these considerations, the data for species in Clear Lake and Cache Creek were combined but Bear Creek was considered separately. The mean mercury concentration, length, and sample size for each species collected and analyzed for Clear Lake and Cache Creek are presented in Table 1 and the Bear Creek data are presented in Table 2. The data are discussed further below.

An adequate number of samples was available for all species sampled at Clear Lake except for bluegill (N=8, one less than the minimum requirement of ≥ 9 fish per species). Generally, fewer samples and species meeting the minimum size criteria were collected from Cache Creek compared to Clear Lake. However, fish from each species are known to reside in both Clear Lake and Cache Creek and fish from Clear Lake may spill over the dam into Cache Creek (Linn, pers. comm. 2004) so that the populations may not be distinct. Due to low sample sizes from Cache Creek, statistical analyses of potential differences between Clear Lake and Cache Creek fishes were limited. Examination of the mean mercury concentrations for each species collected in both Clear Lake and Cache Creek, however, showed similar values. (Additional discussion of statistical comparisons of these water bodies as well as the three Clear Lake basins[1] can be found in Appendix VIII.) Therefore, it was deemed appropriate and health protective to average the concentrations of mercury for each species in Clear Lake and Cache Creek and provide the same advice for both water bodies. Samples collected from Rodman Slough (north of Upper Arm of Clear Lake) were included in the evaluation.

When samples were combined from Clear Lake and Cache Creek, all species except smallmouth bass met or exceeded the minimum number of samples. Data for smallmouth bass consisted of eight individual fish. These data were compared to data for a closely related species, largemouth bass, for which there were 127 samples comprised of 149 fish. The results for smallmouth bass showed a somewhat higher concentration of mercury but because there were only eight samples of smallmouth bass, all of which were collected from one location (Cache Creek at Rumsey), consistent advice for both bass species based on largemouth bass was provided for all of Clear Lake and Cache Creek. For other species that did not have samples from one of the two water bodies, it was considered health protective to base advice on data from the same species in the other water body. For Clear Lake and Cache Creek, mean mercury concentrations in legal/edible size fish of all species with adequate data ranged from 0.16 ppm in hitch to 0.61 ppm in largemouth bass. The mean concentration of methylmercury in crayfish was 0.14 ppm.

Nearly all fish species that occur in Clear Lake and Cache Creek were sampled. However, no samples were obtained for any trout species. Therefore, advice was provided for trout based on national advice from U.S. EPA (2004) and OEHHA's general advice as described further below.

Although adequate data for Bear Creek were limited to two species, Sacramento pikeminnow and Sacramento sucker, assessments of Bear Creek biota by Schwarzbach *et al.* (2001; as described below) and bioaccumulation of mercury in the Cache Creek watershed by Slotton *et al.* (2004) supported the finding that fish from Bear Creek show appreciably greater accumulation of mercury compared to fish from Cache Creek and Clear Lake. The fish tissue data from Bear Creek (Table 2) were collected from upper and middle Bear Creek, and had the highest concentrations of mercury measured in all three water bodies. The mean concentrations measured in pikeminnow and sucker from Bear Creek were 2.2 ppm and 0.6 ppm, and the maximum concentrations in these

---

[1] The discussion in Appendix VIII also considers whether mercury concentrations in fish from Oaks Arm of Clear Lake are different enough from those in the other arms that separate advice is warranted for this area of the lake. Although tissue concentrations were often higher in this arm, the differences were not great enough to significantly change the final advice. See the appendix for a full discussion.

species were 6.4 and 1.7 ppm, respectively. In contrast, in Cache Creek, the mean and maximum mercury concentrations in pikeminnow were 0.6 and 1.4 ppm, and in sucker, 0.3 and 0.5 ppm, respectively. These large differences supported the idea that Bear Creek is considerably different from Cache Creek, and that separate, more restrictive advice should be issued for Bear Creek. Although the highest concentrations were measured in fish from middle Bear Creek, consistent advice was developed for the entire length of Bear Creek because concentrations were exceptionally high, fish may not necessarily remain in one place, and consistent advice for a water body is easier to remember and follow.

In the summer of 1997 and fall of 1998, Schwarzbach *et al.* (2001) collected Sacramento pikeminnows, suckers, and California roach from multiple locations in Cache Creek and Bear Creek and analyzed them for mercury. Fish were analyzed for total mercury as whole body samples. Schwarzbach *et al.* (2001) found that mercury concentrations in their samples were significantly elevated in Bear Creek compared to Cache Creek. For all three species, mercury concentrations varied with length but the authors reported that location, not length, was the most important factor determining mercury concentrations. Schwarzbach *et al.* (2001) concluded that Bear Creek appears to experience the greatest mercury bioaccumulation hazard. These findings are consistent with the results from UCD for Bear Creek[1] and support the idea that mercury contamination in fish in Bear Creek is likely to be greater than in Clear Lake and Cache Creek, and that more conservative advice is warranted.

One sample of green sunfish, a relatively small species that generally accumulates lower levels of mercury, was sampled from Bear Creek by UCD and found to have a mercury concentration of 2.1 ppm. A sample size of one fish is inadequate to represent accumulation of mercury in this fish population; however, it does raise a concern and show the need for additional data. Until more data are available, and given the relatively high concentrations of mercury in the two species sampled as well as the results from other studies in the watershed (Schwarzbach *et al.*, 2001; Slotton *et al.*, 2004), it was deemed health protective to develop conservative advice for Bear Creek even without data for other fish species that may be caught and consumed.

GUIDELINES FOR FISH CONSUMPTION FOR CLEAR LAKE AND CACHE CREEK, AND FOR BEAR CREEK

Guidance tissue levels for chemicals of concern in fish have been developed that relate the number and size of recommended fish meals to methylmercury concentrations found in fish (Table 3). OEHHA has developed guidance tissue levels for mercury or methylmercury (Brodberg and Klasing, 2003) similar to risk-based consumption limits recommended by U.S. EPA (U.S. EPA, 2000b). These guidance values were designed so that individuals consuming no more than a preset number of meals should not exceed the RfD for methylmercury. Meal sizes are based on a standard 8-ounce (227 grams) portion of uncooked fish (approximately 6 ounces after cooking) for adults who weigh approximately 70 kilograms (equivalent to 154 pounds). OEHHA's general advice allows fishers to consume up to twelve meals per month without exceeding the reference dose for a specific contaminant (*e.g.*, mercury) (see Appendix III for additional general advice). Twelve meals per month (*i.e.*, the general advice consumption level) is representative of an upper bound consumption rate for frequent sport fish consumers in California (Gassel, 2001). OEHHA

[1] The mercury concentrations measured by Schwarzbach *et al.* (2001) were not as high compared to samples from UCD, but were measured in whole bodies of fish and showed the same spatial trends.

begins issuing site-specific consumption advice if data indicate that consumption of twelve meals per month is potentially hazardous. This advice begins for sensitive populations when the methylmercury concentration exceeds 0.08 ppm. Tissue guidance levels for women beyond their childbearing years and men are approximately three times higher than for sensitive populations because of the 3-fold higher RfD level used for this population group.

Comparison of mean mercury concentrations in fish and shellfish species from Clear Lake, Cache Creek, and Bear Creek with guidance tissue levels for mercury indicated that issuance of fish consumption advice is appropriate for these water bodies. Advice for all species except trout was derived on the basis of the guidance tissue levels. In order to issue advice for trout in the absence of data, advice was provided based on joint national advice from U.S. EPA and U.S. Food and Drug Administration (FDA), and OEHHA's general advice, as follows. U.S. EPA and FDA (U.S. EPA 2004) issued national advice for women who are pregnant or may become pregnant, nursing mothers, and young children to limit their consumption of fish caught by family and friends in local waters to one meal a week, when no other advice is available. Therefore, this advice was used in this advisory as the basis for advice provided for women of childbearing age and children who eat trout. OEHHA's general advice applies to women beyond childbearing age and men and recommends that this population limit consumption of sport fish to 12 meals per month (equal to three meals a week). This advice was provided for consumption of trout for women beyond childbearing age and men. Consumers should be informed of the potential hazards from eating fish from this area, particularly those hazards relating to the developing fetus and children. All individuals, especially women of childbearing age and children aged 17 years and younger, are advised to limit their fish consumption to reduce methylmercury ingestion to a level as close to the RfD as possible. In addition, fish consumers are encouraged to eat fish species with lower levels of mercury in order to enjoy the benefits from eating fish. Recreational fishers may opt to practice catch-and-release for species that have high levels of mercury.

At Bear Creek, sufficient data were available only for Sacramento pikeminnow and sucker. However, the results showed accumulation of extremely high concentrations of mercury in some fish collected from this water body. In particular, the mean and maximum concentrations in Sacramento pikeminnow were 2.2 ppm and 6.4 ppm mercury, respectively. Recent research suggests that a single maternal exposure to a fish meal containing $\geq$ 2 ppm mercury may pose a risk of neurodevelopmental effects in the fetus (Ginsberg and Toal, 2000). Women of childbearing age and children should not eat these species or other fish from Bear Creek. A single toxic dose threshold for women beyond their childbearing years and adult men has not been established; however, because multiple samples of pikeminnow exceeded the criteria at which no consumption would be recommended for women beyond childbearing age and men (2.8 ppm), it is recommended that the general population avoid consumption of fish from Bear Creek. This health protective recommendation is in keeping with providing advice that guides people away from fish high in mercury to fish low in mercury contamination. In this case, it is better for people to consume fish with lower concentrations of mercury from other water bodies.

Recommendations for Clear Lake, Cache Creek, and Bear Creek

Based on this evaluation, it is recommended that **women of childbearing age and children aged 17 years and younger** limit consumption to no more than one meal a month of one of the following species from **Clear Lake and Cache Creek**: largemouth bass, smallmouth bass, channel catfish, white catfish, brown bullhead, green sunfish, black crappie, white crappie, Sacramento blackfish, Sacramento pikeminnow, hardhead, or sucker. Alternatively, this population may eat up to one meal a week of either crayfish, bluegill, hitch, carp, or other species of fish that might be caught (such as trout).

Women beyond childbearing age and men may eat up to one meal a week of one of the following species from **Clear Lake and Cache Creek**: largemouth bass, small mouth bass, channel catfish, white catfish, brown bullhead, green sunfish, black crappie, white crappie, Sacramento blackfish, Sacramento pikeminnow, hardhead, or sucker. Alternatively, this population can eat a combination of bluegill, hitch, carp, other fish species (such as trout), or crayfish at Clear Lake and Cache Creek up to three times a week.

At **Bear Creek**, no one should consume any fish or shellfish taken from this site.

It is very important to note that if an individual consumes multiple species or fish from more than one site, the recommended guidelines for different species and locations should not be combined. For example, if a person eats a meal of fish from the one meal per month category, he or she should not eat another fish species containing mercury for at least one month. For fish in the meal per week category, an individual can eat one species of fish one week, and the same or a different species from the meal per week category the next week. Fish species in the three meals per week category can be combined in the same week. As an example, an adult male could eat one meal of bluegill and two meals of trout from Clear Lake in the same week.

For general advice on how to limit your exposure to chemical contaminants in sport fish (*e.g.*, eating smaller fish of legal size), see Appendix III. It should be noted that, unlike the case for many fat-soluble organic contaminants (*e.g.*, DDTs and PCBs), various cooking and cleaning techniques will not reduce the methylmercury content of fish. Meal sizes should be adjusted to body weight as described in the advisory table. The complete recommendations (health advisories) for consumption of fish from Clear Lake and Cache Creek, and from Bear Creek are presented below.

HEALTH ADVISORY

Fish are nutritious and should be part of a healthy, balanced diet. As with many other kinds of food, however, it is prudent to consume fish in moderation, particularly when chemical contaminants such as methylmercury are present in fish at concentrations that pose a concern for public health. OEHHA provides the following consumption advice to the public so that people can continue to eat fish from these locations without putting their health at risk.

FISH AND SHELLFISH CONSUMPTION GUIDELINES FOR CLEAR LAKE AND CACHE CREEK	
Women of childbearing age and children 17 years and younger may eat:	
Once a month	Largemouth bass, smallmouth bass, channel catfish, white catfish, brown bullhead, green sunfish, black crappie, white crappie, Sacramento blackfish, Sacramento pikeminnow, hardhead, or Sacramento sucker ***OR:***
Once a week	Bluegill, hitch, carp, trout, or crayfish
Women beyond childbearing age and men may eat:	
Once a week	Largemouth bass, smallmouth bass, channel catfish, white catfish, brown bullhead, green sunfish, black crappie, white crappie, Sacramento blackfish, Sacramento pikeminnow, hardhead, or Sacramento sucker ***OR:***
3 times a week	Bluegill, hitch, carp, trout, or crayfish
FISH AND SHELLFISH CONSUMPTION GUIDELINES FOR BEAR CREEK	
DO NOT EAT	No one should eat any fish or shellfish from Bear Creek

MANY OTHER WATER BODIES ARE KNOWN OR SUSPECTED TO HAVE ELEVATED MERCURY LEVELS. If guidelines are not already in place for the water body where you fish, women of childbearing age and children 17 and younger may eat up to one sport fish meal per week, and women beyond childbearing age and men may eat up to three sport fish meals per week from any location.

EAT SMALLER FISH OF LEGAL SIZE. Fish accumulate mercury as they grow.

DO NOT COMBINE FISH CONSUMPTION ADVICE. If you eat multiple species or catch fish from more than one area, the recommended guidelines for different species and locations should not be combined. For example, if you eat a meal of fish from the one meal per month category, you should not eat another fish species containing mercury for at least one month.

SERVE SMALLER MEALS TO CHILDREN. Meal size is assumed to be 8 ounces for a 160-pound adult. If you weigh more or less than 160 pounds, add or subtract one ounce to your meal size, respectively, for each 20-pound difference in body weight.

CONSIDER YOUR TOTAL FISH CONSUMPTION**. Fish from many sources (including stores and restaurants) can contain elevated levels of mercury and other contaminants. IF YOU EAT FISH WITH LOWER CONTAMINANT LEVELS (INCLUDING COMMERCIAL FISH) YOU CAN SAFELY EAT MORE FISH. The American Heart Association recommends that healthy adults eat at least two servings of fish per week. Shrimp, king crab, scallops, farmed catfish, wild salmon, oysters, tilapia, flounder, and sole generally contain some of the lowest levels of mercury.**

REFERENCES

Aberg, B.; Ekman, L.; Falk, R.; Greitz, U.; Persson, G.; Snihs, J-O. (1969). Metabolism of methyl mercury (^{203}Hg) compounds in man. Arch. Environ. Health. 19:478-485.

Adams, J.; Barone, S., Jr.; LaMantia, A.; Philen, R.; Rice, D.C.; Spear, L.; Susser, E. (2000). Workshop to identify critical windows of exposure for children's health: Neurobehavioral Work Group summary. Environ. Health Perspect. 108 (suppl. 3):535-544.

Andren, A.W.; Nriagu, J.O. (1979). The global cycle of mercury. In: Nriagu, J.O., ed. The biogeochemistry of mercury in the environment. Topics in environmental health, Vol. 3. Amsterdam: Elsevier/North-Holland Biomedical Press. p.1-21.

ATSDR (1999). Agency for Toxic Substances and Disease Registry. Toxicological profile for mercury (update). Prepared by Research Triangle Institute under contract no. 205-93-0606. Public Health Service, U.S. Department of Health and Human Services.

Bakir, F.; Damluji, S.F.; Amin-Zaki, L.; Murtadha, M.; Khalidi, A.; Al-Rawi, N.Y.; Tikriti, S.; Dhahir, H.I.; Clarkson, T.W.; Smith, J.C.; Doherty, R.A. (1973). Methylmercury poisoning in Iraq. Science 181:230-241.

Berlin, M. (1986). Mercury. In: Friberg, L.; Nordberg, G.F.; Vouk, V.B.; eds. Handbook on the toxicology of metals. 2nd ed. Vol. II. Specific metals. New York, Elsevier p. 387-445.

Bloom, N.S. (1992). On the chemical form of mercury in edible fish and marine invertebrate tissue. Can. J. Fish. Aquat. Sci. 49(5):1010-1017.

Brodberg, R.K.; Klasing, S.A. (2003). Evaluation of potential health effects of eating fish from Black Butte Reservoir (Glenn and Tehama Counties): Guidelines for sport fish consumption. Office of Environmental Health Hazard Assessment, California Environmental Protection Agency.

Cooke, J., Foe, C., Stanish, S., Morris, P. (2004). Cache Creek, Bear Creek, and Harley Gulch TMDL for Mercury. Staff Report. February 2004. California Environmental Protection Agency. Regional Water Quality Control Board Central Valley Region. Sacramento, California.

Cooke, J. (2002). Clear Lake TMDL for Mercury. Staff Report. Final Report. February 2002. California Environmental Protection Agency. Regional Water Quality Control Board Central Valley Region. Sacramento, California.

Cheruka, S.R.; Montgomery-Downs, H.E.; Farkas, S.L.; Thoman, E.B.; Lammi-Keefe, C.J. (2002). Higher maternal plasma docosahexaenoic acid during pregnancy is associated with more mature neonatal sleep-state patterning. American Journal of Clinical Nutrition 76:608-613.

Clarkson, T.W.; Amin-Zaki, L.; Al-Tikriti. (1976). An outbreak of methyl mercury poisoning due to consumption of contaminated grain. Fed. Proc. 35:2395-2399.

Davidson, P.W.; Myers, G.J.; Cox, C.; Axtell, C.; Shamlaye, C.; Sloane-Reeves, J.; Cernichiari, E.; Needham, L.; Choi, A.; Wang, Y.; Berlin, M.; Clarkson, T.W. (1998). Effects of prenatal and postnatal methylmercury exposure from fish consumption on neurodevelopment. JAMA 280:701-707.

Davidson, P.W.; Myers, G.J.; Cox, C.; Shamlaye, C.F.; Marsh, D.O.; Tanner, M.A.; Berlin, M.; Sloane-Reeves, J.; Cernichiari, E.; Choisy, O.; Choi, A.; Clarkson, T.W. (1995). Longitudinal neurodevelopmental study of Seychellois children following in utero exposure to methylmercury from maternal fish ingestion: outcomes at 19 and 29 months. Neurotoxicology 16(4):677-688.

Daviglus, M.L.; Stamler, J.; Orencia, A.J.; Dyer, A.R.; Liu, K.; Greenland, P.; Walsh, M.K.; Morris, D.; Shekelle, R.B. (1997). Fish consumption and the 30-year risk of fatal myocardial infarction. N. Engl. J. Med. 336:1046-53.

Elhassani, S.B. (1982-83). The many faces of methylmercury poisoning. J. Toxicol. Clin. Toxicol. 19(8):875-906.

Gassel, M. (2001). Chemicals in Fish: Consumption of Fish and Shellfish in California and the United States. Pesticide and Environmental Toxicology Section. Office of Environmental Health Hazard Assessment. California Environmental Protection Agency. Oakland, CA.

Giedd, J.N.; Blumenthal, J.; Jeffries, N.O.; Castellanos, F.X.; Liu, H.; Zijdenbos, A.; Paus, T.; Evans, A.C.; Rapoport, J.L. (1999). Brain development during childhood and adolescence: A longitudinal MRI study. Nature Neuroscience 2(10):861-863.

Ginsberg, G.L.; Toal, B.E. (2000). Development of a single-meal fish consumption advisory for methyl mercury. Risk Anal. 20:41-47.

Grandjean, P.; Budtz-Jorgensen, E.; White, R.F.; Weihe, P.; Debes, F.; Keiding, N. (1999). Methylmercury exposure biomarkers as indicators of neurotoxicity in children aged 7 years. Am. J. Epidemiol. 150(3):310-305.

Grandjean, P.; Weihe, P.; White, R.F.; Keiding, N.; Budtz-Jorgensen, K.; Murato, K.; Needham, L. (1998). Prenatal exposure to methylmercury in the Faroe Islands and neurobehavioral performance at age seven years. Response to workgroup questions for presentation on 18-20 Nov. 1998. In Scientific Issues Relevant to Assessment of Health Effects from Exposure to Methylmercury. Appendix II-B. Faroe Islands Studies. National Institute for Environmental Health Sciences. Available online at:
http://ntp-server.niehs.nih.gov/Main_Pages/PUBS/MethMercWkshpRpt.html

Grandjean, P.; Weihe, P.; White, R.; Debes, F.; Arai, S.; Yokoyama, K.; Murata, N.; Sorensen, N.; Dahl, R.; Jorgensen, P. (1997). Cognitive deficit in 7-year-old children with prenatal exposure to methylmercury. Neurotoxicol. Teratol. 19:417-428.

Harada, M. (1978). Congenital Minamata Disease: Intrauterine methylmercury poisoning. Teratology. 18:285-288.

Harris, W.S.; Isley, W.L. (2001). Clinical trial evidence for the cardioprotective effects of omega-3 fatty acids. Curr. Atheroscler. Rep. 3(2):174-9.

IARC. (1993). IARC Monographs on the evaluation of carcinogenic risks to humans: Beryllium, cadmium, mercury, and exposures in the glass manufacturing industry. Vol. 58. World Health Organization, International Agency for Research on Cancer.

IRIS. (2001). Integrated Risk Information System. Online at:
http://www.epa.gov/iris/subst/0073.htm. Methylmercury (MeHg) (CASRN 22967-92-6). Database maintained by the Office of Health and Environmental Assessment. U.S. Environmental Protection Agency, Environmental Criteria and Assessment Office, Cincinnati, Ohio.

IRIS. (1995). Integrated Risk Information System. Online at: **http://www.epa.gov/iris/subst/0073.htm**. Methylmercury (MeHg) (CASRN 22967-92-6). Database maintained by the Office of Health and Environmental Assessment. U.S. Environmental Protection Agency, Environmental Criteria and Assessment Office, Cincinnati, Ohio.

IRIS. (1993). Integrated Risk Information System. Online at: **http://www.epa.gov/iris/rfd.htm**. Background Document 1A. Database maintained by the Office of Health and Environmental Assessment. U.S. Environmental Protection Agency, Environmental Criteria and Assessment Office, Cincinnati, Ohio.

Iso, H.; Rexrode, K.M.; Stampfer, M.J.; Manson, J.E.; Colditz, G.A.; Speizer, F.; Hennekens, C.H.; Willett, W.C. (2001). Intake of fish and omega-3 fatty acids and risk of stroke in women. J. Am. Med. Assoc. 285(3):304-12.

Kjellstrom, T.; Kennedy, P.; Wallis, S.; Stewart, A.; Friberg, L.; Lind, B.; Wutherspoon, T.; Mantell, C. (1989). Physical and mental development of children with prenatal exposure to mercury from fish. Stage II: Interviews and psychological tests at age 6. National Swedish Environmental Protection Board Report 3642. Solna, Sweden.

Kjellstrom, T.; Kennedy, P.; Wallis, S.; Mantell, C. (1986). Physical and mental development of children with prenatal exposure to mercury from fish. Stage I: Preliminary tests at age 4. National Swedish Environmental Protection Board Report 3080. Solna, Sweden.

Klasing, S.; Brodberg, R.K. (2003). Evaluation of Potential Health Effects of Eating Fish from Selected Water Bodies in the Northern Sierra Nevada Foothills (Nevada, Placer, and Yuba Counties): Guidelines For Sport Fish Consumption. Final Report. Pesticide and Environmental Toxicology Section. Office of Environmental Health Hazard Assessment. California Environmental Protection Agency. Sacramento, CA

Krehl, W.A. (1972). Mercury, the slippery metal. Nutr. Today November/December 90-102.

Lim, S.Y.; Suzuki, H. (2000). Intakes of dietary docosahexaenoic acid ethyl ester and egg phosphatidylcholine improve maze-learning ability in young and old mice. J. Nutr. 130(6):1629-32.

Linn, J. (2004). California Department of Fish and Game. Sacramento, California. Personal communication. March 2004.

Marsh, D.O. (1987). Dose-response relationships in humans: Methyl mercury epidemics in Japan and Iraq. In: The Toxicity of Methyl Mercury. Eccles, C.U.; Annau, Z., eds. Baltimore, MD: John Hopkins University Press. p. 45-53.

Marsh, D.O.; Clarkson, T.W.; Cox, C.; Myers, G.J.; Amin-Zaki, L.; Al-Tikriti, S. (1987). Fetal methylmercury poisoning: Relationship between concentration in single strands of maternal hair and child effects. Arch. Neurol. 44:1017-1022.

Marsh, D.O.; Myers, G.J.; Clarkson, T.W.; Amin-Zaki, L.; Tikriti, S.; Majeed, M.A. (1980). Fetal methylmercury poisoning: Clinical and toxicological data on 29 cases. Ann. Neurol. 7:348-353.

Matsumo, H.; Koya, G.; Takeuchi, T. (1964). Fetal Minamata Disease: A neuropathological study of two cases of intrauterine intoxication by a methyl mercury compound. J. Neuropathol. Exp. Neurol. 24:563-574.

Mishima, A. (1992). Bitter Sea: The Human Cost of Minamata Disease. Tokyo: Kosei Publishing Co. 231 p.

Mori, T.A.; Beilin, L.J. (2001). Long-chain omega 3 fatty acids, blood lipids and cardiovascular risk reduction. Curr. Opin. Lipidol. 12(1):11-7.

Moriguchi, T.; Greiner, R.S.; Salem, N. (2000). Behavioral deficits associated with dietary induction of decreased brain docosahexaenoic acid concentration. J. Neurochem. 75(6):2563-73.

Moyle, P.B. (2002). Inland Fishes of California. Revised and Expanded. University of California Press.

Moyle, P.B. (2001). Putah and Cache. IN: A Thinking Mammal's Guide to the Watershed. A.J. Boyer, J. Goggins, D. Leroy, D Robertson, R. Thayer, eds. Structure and design of the Putah and Cache website is copyright 2001 University of California. Available online at: http://bioregion.ucdavis.edu/book/13_Lower_Cache_Creek/13_02_moyle_irrigating.html

Myers, G.J.; Davidson, P.W.; Palumbo, D.; Shamlaye, C.; Cox, C.; Cernichiari, E.; Clarkson, T.W. (2000). Secondary analysis from the Seychelles Child Development Study: The child behavior checklist. Environ. Research. Section A 84:12-19.

NAS/NRC. (2000). Toxicological effects of methylmercury. Report of the National Research Council, Committee on the toxicological effects of methylmercury. Washington DC: National Academy Press.

Paus, T.; Zijdenbos, A.; Worsley, K.; Collins, D.L.; Blumenthal, J.; Giedd, J.N.; Rapoport, J.L.; Evans, A.C. (1999). Structural maturation of neural pathways in children and adolescents: In vivo study. Science 283:1908-1911.

Rice, D.; Barone, S., Jr. (2000). Critical periods of vulnerability for the developing nervous system: Evidence from humans and animal models. Environ. Health Perspect. 108 (suppl. 3):511-33.

Schwarzbach, S., Thompson, L., Adelsbach, T. (2001). Cache Creek Mercury Investigation USFWS Final Report. Sacramento Fish and Wildlife Office. Environnemental Contaminants Division. Sacramento, California. Available online at: http://pacific.fws.gov/ecoservices/envicon/pim/reports/Sacramento/2001SacramentoCache.pdf

Seafood Safety. (1991). Committee on Evaluation of the Safety of Fishery Products, Chapter on Methylmercury: FDA Risk Assessment and Current Regulations, National Academy Press, Washington, DC. p.196-221.

Slotton, D.G., Ayers, S.M., Suchanek, T.H., Weyland, R.D., Liston, A.M. (2004). Mercury Bioaccumulation and Trophic Transfer in the cache Creek Watershed of California, in Relation to Diverse Aqueous Mercury Exposure Conditions. Final Report. Janurary 25, 2004. Task 5B of a CALFED Bay-Delta Program Project, Assessment of Ecological and Human Health Impacts of Mercury in the San Francisco Bay-Delta Watershed.

Smith, J.C.; Allen, P.V.; Turner, M.D.; Most, B.; Fisher, H.L.; Hall, L.L. (1994). The kinetics of intravenously administered methyl mercury in man. Toxicol. Appl. Pharmacol. 128(2):251-256.

Snyder, R.D. (1971). Congenital mercury poisoning. New Engl. J. Med. 218:1014-1016.

Stopford, W.; Goldwater, L.J. (1975). Methylmercury in the environment: A review of current understanding. Environ. Health Perspectives 12:115-118.

Stratton, J.W.; Smith, D.F.; Fan, A.M.; Book, S.A. (1987). Methyl Mercury in Northern Coastal Mountain Lakes: Guidelines for Sport Fish Consumption for Clear Lake (Lake County), Lake Berryessa (Napa County), and Lake Herman (Solano County). Office of Environmental Health Hazard Assessment, California Environmental Protection Agency.

Suchanek, T.H., Richerson, P.J., Nelson, D.C., Eagles-Smith, C.A., Anderson, D.W., Cech, Jr., J.J., Schladow, G., Zierenberg, R., Mount, J.F., McHatton, S.C., Slotton, D.G., Webber, L.B., Bern, A.L., Swisher, B.J. (2002). Evaluating and managing a multiply-stressed ecosystem at Clear Lake, California: A holistic ecosystem approach. IN: Managing for Healthy Ecosystems: Case Studies. CRC/Lewis Press. Pp. 1233-1265. (in press)

Suchanek, T.H., Richerson, P.J., Mullen, L.H., Brister, L.L., Becker, J.C., Maxson, A.E., Slotton, D.G. (1997). Sulphur Bank Mercury Mine Superfund Site, Clear Lake, California. Interim Final Report. A Report Prepared for the U.S. Environmental Protection Agency Region IX Superfund Program. University of California, Davis, California and U.C. Davis Clear Lake Research Center, Kelseyville, California. March 1997.

Tollefson, L.; Cordle, F. (1986). Methyl mercury in fish: A review of residue levels, fish consumption and regulatory action in the United States. Environ. Health Perspectives 68:203-208.

U.S. EPA. (1997). Mercury Study Report to Congress. Volume VII: Characterization of Human Health and Wildlife Risks from Mercury Exposure in the United States. EPA-452/R-97-009. U.S. Environmental Protection Agency, Office of Air Quality Planning & Standards and Office of Research and Development, Washington, DC.

U.S. EPA (2000a). Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories. Vol. 1. Fish Sampling and Analysis. Third Edition. U.S. Environmental Protection Agency, Washington, DC.

U.S. EPA (2000b). Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories. Vol. 2. Risk Assessment and Fish Consumption Limits. Third Edition. U.S. Environmental Protection Agency, Washington, DC.

U.S.EPA. (2004). Joint Federal Advisory for Mercury in Fish. What You Need to Know about Mercury in Fish and Shellfish. Available online at: http://www.epa.gov/waterscience/fishadvice/advice.html

U.S. FDA. (1976). Letter from Ronald G. Fischer, Director, Compliance Branch, San Francisco District, U.S. Food and Drug Administration to Chambers F. Bryson, Chief, Food and Drug Section, Environmental Health Services Program, State Department of Public Health, Sacramento, California. July 12, 1976.

Valagussa, F.; Fronzosi, M.G.; Geraci, E. *et al.* (1999). Dietary supplementation with n-3 fatty acids and vitamin E after myocardial infarction: results of the GISSI-Prevenzione trial. Lancet 354(9177):447-55.

von Schacky, C.; Angerer, P.; Kothny, W.; Theisen, K.; Mudra, H. (1999). The effect of dietary omega-3 fatty acids on coronary atherosclerosis. A randomized, double-blind, placebo-controlled trial. Ann. Intern. Med. 130(7):554-62.

WHO (World Health Organization). (1990). Methylmercury. Environmental Health Criteria 101. Geneva: World Health Organization.

WHO (World Health Organization). (1989). Mercury – Environmental Aspects. Environmental Health Criteria 86. Geneva: World Health Organization.

WHO (World Health Organization). (1976). Environmental Health Criteria. Mercury. Geneva, Switzerland: World Health Organization.

Table 1. Summary Statistics for Fish and Shellfish from Clear Lake and Cache Creek

Species	Mean* Mercury (ppm)	Mean* Length (mm)	Number of Samples (Total Number of Fish)	Minimum Acceptable Size (mm Fork Length)
Black Crappie	0.36	233	44 (53)	145
Bluegill	0.19	147	13 (17)	95
Brown Bullhead	0.26	309	36 (39)	200
Carp	0.16	747	17 (32)	185
Channel Catfish	0.41	565	70 (83)	180
Green Sunfish	0.33	119	6 (26)	100
Hardhead	0.40	273	9 (9)	227
Hitch	0.16	274	21 (21)	140
Largemouth Bass	0.61	383	127 (149)	290
Sacramento Blackfish	0.27	372	22 (22)	185
Sacramento Pikeminnow	0.55	282	19 (19)	227
Sacramento Sucker	0.28	334	48 (53)	100
Smallmouth Bass	0.75	333	8 (8)	290
White Catfish	0.40	291	36 (51)	180
White Crappie	0.49	248	13 (13)	145
Crayfish	0.14[1]	NA[2]	27 (95)	NA

*The mean values shown in this table show the average mercury concentrations and mean size for each fish species sampled from Clear Lake and Cache Creek. Whenever the species were collected from both water bodies, the means reflect the average for both water bodies combined. The combined mean concentrations of mercury served as the basis for consumption guidelines provided for fish from these two water bodies.

[1] Methylmercury (ppm) was measured directly in crayfish.

[2] This information is not available (NA), as length was not reported in the dataset. Weight was measured and individual crayfish in the composites ranged from 5 to 58 grams. All crayfish composites were included in the analysis.

Table 2. Summary Statistics for Fish from Bear Creek

Species	Mean Mercury (ppm)	Mean Fork Length (mm)	Number of Samples (Total Number of Fish)
Sacramento Pikeminnow	2.20	273	15 (15)
Sacramento Sucker	0.62	220	17 (17)

Table 3: Guidance Tissue Levels (ppm Total Mercury or Methylmercury*, wet weight) for Two Population Groups

Guidance Tissue Levels (GTLs) (ppm Total Mercury or Methylmercury*, wet weight) for Two Population Groups		***Meals/month:***			
		12	***4***	***1***	***0***
Population group	***Reference Dose (RfD)***	***Tissue concentration (ppm)***			
Women of childbearing age and children aged 17 years and younger	1×10^{-4} mg/kg/day	≤ 0.08	> 0.08-0.23	> 0.23-0.93	> 0.93
Women beyond childbearing age and men	3×10^{-4} mg/kg/day	≤ 0.23	> 0.23-0.70	> 0.70-2.80	> 2.80

*The values in this table are based on the assumption that 100% of total mercury measured in fish is methylmercury. This may not be true for shellfish, so methylmercury needs to be measured directly in these species for use in this table.

The recommended level for consumption of fish contaminated with a non-carcinogenic chemical such as methylmercury is below or equivalent to the chemical's reference level. People could eat more fish with a lower tissue concentration (before they exceed the reference level) than fish with a higher concentration. The following general equation can be used to calculate the fish tissue concentration (in mg/kg) at which the consumption exposure from a chemical with a non-carcinogenic effect is equal to the reference level for that chemical at any consumption level:

$$\text{Tissue concentration} = \frac{(\text{RfD mg/kg - day})(\text{kg Body Weight})(\text{RSC})}{\text{CR kg/day}}$$

where,

RfD = Chemical specific reference dose or other reference level
BW = Body weight of consumer
RSC = Relative source contribution of fish to total exposure
CR = Consumption rate as the daily amount of fish consumed

For example: $\frac{(1 \times 10^{-4}\ \text{mg/kg-day})(70\ \text{kg body weight})\ (1)}{.030\ \text{kg/day}} = 0.23$ mg/kg tissue

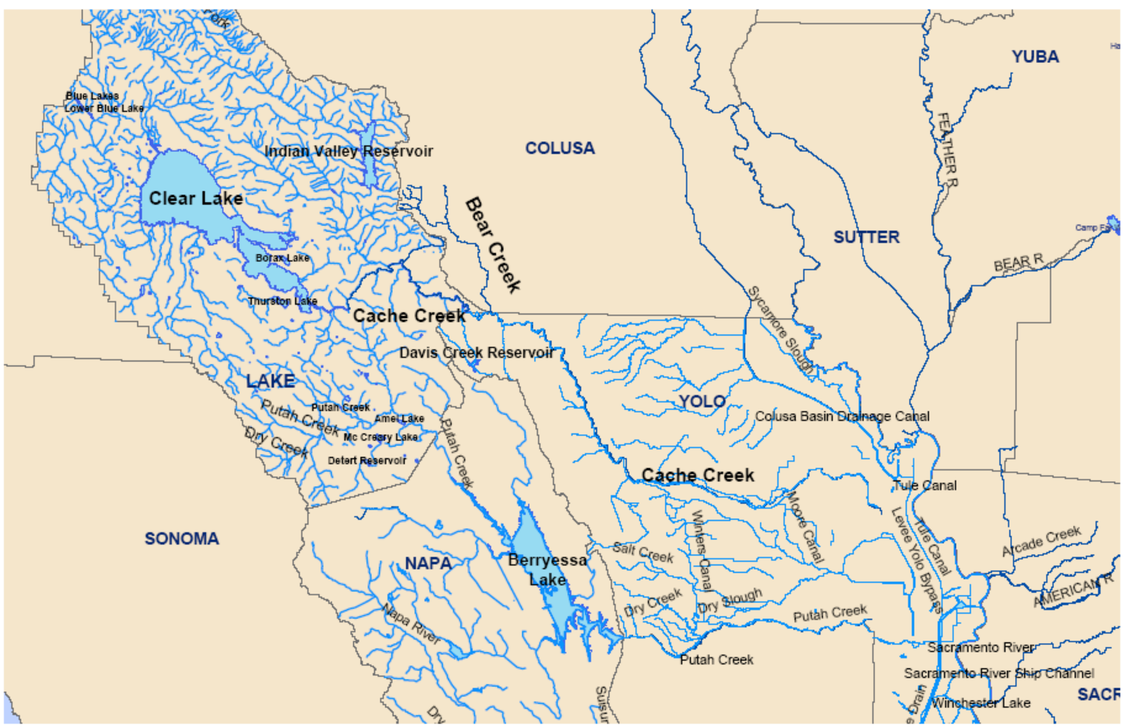
This equation was applied above to determine tissue concentrations of methylmercury (assuming 100% of measured total mercury is methylmercury in fish) in sport fish that would be below or equivalent to the chemical's reference level when eating different amounts of fish. An RfD of $1x10^{-4}$ mg/kg-day was used for women of childbearing age and children aged 17 years and younger. An RfD of $3x10^{-4}$ mg/kg-day was used for women beyond their childbearing years and men. A body weight of 70 kg was used to represent the average weight of an adult. It was assumed that fish represent 100 percent of the source of methylmercury to a fish consumer.

Meal Sizes used in this table: Although people eat different meal sizes, their typical portion size is related to their individual body weight in a fairly consistent manner. The standard portion size eaten by an average adult (body weight 70 kg or 154 pounds) is eight ounces (227 grams) (U.S. EPA, 1994). People tend to remember how many meals of a specific food they eat in a month and this interval is often used in consumption surveys (Gassel, 2001). A standard portion of one fish meal a month is equivalent to $7.5\ x10^{-3}$ kg/day, one meal per week is equivalent to $3.0\ x10^{-2}$ kg/day, and three meals per week is equivalent to $9.0\ x10^{-2}$ kg/day.

Figure 1. Maps of Clear Lake, Cache Creek, and Bear Creek

Cache Creek Watershed: Clear Lake, Cache Creek, and Bear Creek

Cache Creek Watershed: Clear Lake, Cache Creek, and Bear Creek
Including Lower Cache Creek (Yolo County)



Appendix I: 1987 Advisory for Clear Lake

RECOMMENDED FISH CONSUMPTION GUIDELINES FOR SPORT FISH

Because of mercury levels in fish, women who are pregnant or who may soon become pregnant, nursing mothers, and children under age 6 should not eat fish from the lakes listed below. Adults should eat no more than the amount indicated below. Children 6-15 years of age should eat no more than one-half the amount indicated.

Clear Lake (Lake County)

Largemouth bass over 15 inches: 1 pound per month

or largemouth bass under 15 inches: 2 pounds per month

or channel catfish over 24 inches: 1 pound per month

or channel catfish under 24 inches: 3 pounds per month

or crappie over 12 inches: 1 pound per month

or crappie under 12 inches: 3 pounds per month

or all white catfish: 3 pounds per month

or all brown bullhead: 6 pounds per month

or all Sacramento blackfish: 6 pounds per month

or all hitch: 10 pounds per month

Appendix II: Methylmercury in Sport Fish: Information for Fish Consumers

Methylmercury is a form of mercury that is found in most freshwater and saltwater fish. In some lakes, rivers, and coastal waters in California, methylmercury has been found in some types of fish at concentrations that may be harmful to human health. The Office of Environmental Health Hazard Assessment (OEHHA) has issued health advisories to fishers and their families giving recommendations on how much of the affected fish in these areas can be safely eaten. In these advisories, women of childbearing age and children are encouraged to be especially careful about following the advice because of the greater sensitivity of fetuses and children to methylmercury.

Fish are nutritious and should be a part of a healthy, balanced diet. As with many other kinds of food, however, it is prudent to consume fish in moderation. OEHHA provides advice to the public so that people can continue to eat fish without putting their health at risk.

WHERE DOES METHYLMERCURY IN FISH COME FROM?

Methylmercury in fish comes from mercury in the aquatic environment. Mercury, a metal, is widely found in nature in rock and soil, and is washed into surface waters during storms. Mercury evaporates from rock, soil, and water into the air, and then falls back to the earth in rain, often far from where it started. Human activities redistribute mercury and can increase its concentration in the aquatic environment. The coastal mountains in northern California are naturally rich in mercury in the form of cinnabar ore, which was processed to produce quicksilver, a liquid form of inorganic mercury. This mercury was taken to the Sierra Nevada, Klamath mountains, and other regions, where it was used in gold mining. Historic mining operations and the remaining tailings from abandoned mercury and gold mines have contributed to the release of large amounts of mercury into California's surface waters. Mercury can also be released into the environment from industrial sources, including the burning of fossil fuels and solid wastes, and disposal of mercury-containing products.

Once mercury gets into water, much of it settles to the bottom where bacteria in the mud or sand convert it to the organic form of methylmercury. Fish absorb methylmercury when they eat smaller aquatic organisms. Larger and older fish absorb more methylmercury as they eat other fish. In this way, the amount of methylmercury builds up as it passes through the food chain. Fish eliminate methylmercury slowly, and so it builds up in fish in much greater concentrations than in the surrounding water. Methylmercury generally reaches the highest levels in predatory fish at the top of the aquatic food chain.

HOW MIGHT I BE EXPOSED TO METHYLMERCURY?

Eating fish is the main way that people are exposed to methylmercury. Each person's exposure depends on the amount of methylmercury in the fish that they eat and how much and how often they eat fish.

Women can pass methylmercury to their babies during pregnancy, and this includes methylmercury that has built up in the mother's body even before pregnancy. For this reason, women of childbearing age are encouraged to be especially careful to follow consumption advice, even if they are not pregnant. In addition, nursing mothers can pass methylmercury to their child through breast milk.

You may be exposed to inorganic forms of mercury through dental amalgams (fillings) or accidental spills, such as from a broken thermometer. For most people, these sources of exposure to mercury are minor and of less concern than exposure to methylmercury in fish.

AT WHAT LOCATIONS IN CALIFORNIA HAVE ELEVATED LEVELS OF MERCURY BEEN FOUND IN FISH?

Methylmercury is found in most fish, but some fish and some locations have higher amounts than others. Methylmercury is one of the chemicals in fish that most often creates a health concern. Consumption advisories due to high levels of methylmercury in fish have been issued in about 40 states. In California, methylmercury advisories have been issued for San Francisco Bay and the Delta; Tomales Bay in Marin County; and at the following inland lakes: Lake Nacimiento in San Luis Obispo County; Lake Pillsbury and Clear Lake in Lake County; Lake Berryessa in Napa County; Guadalupe Reservoir and associated reservoirs in Santa Clara County; Lake Herman in Solano County; San Pablo Reservoir in Contra Costa County; Black Butte Reservoir in Glenn and Tehama Counties; Trinity Lake in Trinity County; and certain lakes and river stretches in the Sierra Nevada foothills in Nevada, Placer, and Yuba counties. Other locations may be added in the future as more fish and additional water bodies are tested.

HOW DOES METHYLMERCURY AFFECT HEALTH?

Much of what we know about methylmercury toxicity in humans stems from several mass poisoning events that occurred in Japan during the 1950s and 1960s, and Iraq during the 1970s. In Japan, a chemical factory discharged vast quantities of mercury into several bays near fishing villages. Many people who consumed large amounts of fish from these bays became seriously ill or died over a period of several years. In Iraq, thousands of people were poisoned by eating contaminated bread that was mistakenly made from seed grain treated with methylmercury.

From studying these cases, researchers have determined that the main target of methylmercury toxicity is the central nervous system. At the highest exposure levels experienced in these poisonings, methylmercury toxicity symptoms included such nervous system effects as loss of coordination, blurred vision or blindness, and hearing and speech impairment. Scientists also discovered that the developing nervous systems of fetuses are particularly sensitive to the toxic effects of methylmercury. In the Japanese outbreak, for example, some fetuses developed methylmercury toxicity during pregnancy even when their mothers did not. Symptoms reported in the Japan and Iraq epidemics resulted from methylmercury levels that were much higher than what fish consumers in the U.S. would experience.

Individual cases of adverse health effects from heavy consumption of commercial fish containing moderate to high levels of methylmercury have been reported only rarely. Nervous system symptoms reported in these instances included headaches, fatigue, blurred vision, tremor, and/or some loss of concentration, coordination, or memory. However, because there was no clear link between the severity of symptoms and the amount of mercury to which the person was exposed, it is not possible to say with certainly that these effects were a consequence of methylmercury exposure and not the result of other health problems. The most subtle symptoms in adults known to be clearly associated with methylmercury toxicity are numbness or tingling in the hands and feet or around the mouth.

In recent studies of high fish-eating populations in different parts of the world, researchers have been able to detect more subtle effects of methylmercury toxicity in children whose mothers frequently ate seafood containing low to moderate mercury concentrations during their pregnancy. Several studies found slight decreases in learning ability, language skills, attention and/or memory in some of these children. These effects were not obvious without using very specialized and sensitive tests. Children may have increased susceptibility to the effects of methylmercury through adolescence, as the nervous system continues to develop during this time.

Methylmercury builds up in the body if exposure continues to occur over time. Exposure to relatively high doses of methylmercury for a long period of time may also cause problems in other organs such as the kidneys and heart.

CAN MERCURY POISONING OCCUR FROM EATING SPORT FISH IN CALIFORNIA?

No case of mercury poisoning has been reported from eating California sport fish. The levels of mercury in California fish are much lower than those that occurred during the Japanese outbreak. Therefore, overt poisoning resulting from sport fish consumption in California would not be expected. At the levels of mercury found in California fish, symptoms associated with methylmercury are unlikely unless someone eats much more than what is recommended or is particularly sensitive. The fish consumption guidelines are designed to protect against subtle effects that would be difficult to detect but could still occur following unrestricted consumption of California sport fish. This is especially true in the case of fetuses and children.

IS THERE A WAY TO REDUCE METHYLMERCURY IN FISH TO MAKE THEM SAFER TO EAT?

There is no specific method of cleaning or cooking fish that will significantly reduce the amount of methylmercury in the fish. However, fish should be cleaned and gutted before cooking because some mercury may be present in the liver and other organs of the fish. These organs should not be eaten.

In the case of methylmercury, fish size is important because large fish that prey upon smaller fish can accumulate more of the chemical in their bodies. It is better to eat the smaller fish within the same species, provided that they are legal size.

IS THERE A MEDICAL TEST TO DETERMINE EXPOSURE TO METHYLMERCURY?

Mercury in blood and hair can be measured to assess methylmercury exposure. However, this is not routinely done. Special techniques in sample collection, preparation, and analysis are required for these tests to be accurate. Although tests using hair are less invasive, they are also less accurate. It is important to consult with a physician before undertaking medical testing because these tests alone cannot determine the cause of personal symptoms.

HOW CAN I REDUCE THE AMOUNT OF METHYLMERCURY IN MY BODY?

Methylmercury is eliminated from the body over time provided that the amount of mercury taken in is reduced. Therefore, following the OEHHA consumption advice and eating less of the fish that have higher levels of mercury can reduce your exposure and help to decrease the levels of methylmercury already in your body if you have not followed these recommendations in the past.

WHAT IF I EAT FISH FROM OTHER SOURCES SUCH AS RESTAURANTS, STORES, OR OTHER WATER BODIES THAT MAY NOT HAVE AN ADVISORY?

Most commercial fish have relatively low amounts of methylmercury and can be eaten safely in moderate amounts. However, several types of fish such as large, predatory, long-lived fish have high levels of methylmercury, and could cause overly high exposure to methylmercury if eaten often. The U.S. Food and Drug Administration (FDA) is responsible for the safety of commercial seafood. FDA advises that women who are pregnant or could become pregnant, nursing mothers, and young children not eat shark, swordfish, king mackerel, or tilefish.

FDA also advises that women of childbearing age and pregnant women may eat an average of 12 ounces of fish purchased in stores and restaurants each week. However, if 12 ounces of cooked fish from a store or restaurant are eaten in a given week, then fish caught by family or friends should not be eaten the same week. This is important to keep the total level of methylmercury contributed by all fish at a low level in the body. The FDA advice can be found at http://www.cfsan.fda.gov/~dms/admehg.html.

The United States Environmental Protection Agency (U.S. EPA) has issued the following advice for women and children who eat fish that are caught in freshwater bodies anywhere in the U.S. This advice should be followed for water bodies where OEHHA has not already issued more restrictive guidelines.

"If you are pregnant or could become pregnant, are nursing a baby, or if you are feeding a young child, limit consumption of freshwater fish caught by family and friends to one meal per week. For adults, one meal is six ounces of cooked fish or eight ounces uncooked fish; for a young child, one meal is two ounces cooked fish or three ounces uncooked fish."

For more information on the nationwide advice, check the U.S. EPA Web Site at http://www.epa.gov/ost/fishadvice/advice.html.

In addition, OEHHA offers the following general advice that can be followed to reduce exposure to methylmercury in fish. Chemical levels can vary from place to place. Therefore, your overall exposure to chemicals is likely to be lower if you fish at a variety of places, rather than at one location that might have high contamination levels. Furthermore, some fish species have higher chemical levels than others in the same location. If possible, eat smaller amounts of several different types of fish rather than a large amount of one type that may be high in contaminants. Smaller fish of a species will usually have lower chemical levels than larger fish in the same location because some of the chemicals may become more concentrated in larger, older fish. It is advisable to eat smaller fish (of legal size) more often than larger fish. Cleaning and cooking fish in a manner that removes fat and organs is an effective way to reduce other contaminants that may be present in fish.

WHERE CAN I GET MORE INFORMATION?

The health advisories for sport fish are printed in the California Sport Fishing Regulations booklet, which is available wherever fishing licenses are sold. OEHHA also offers a booklet containing the advisories, and additional materials such as this fact sheet on related topics. Additional information and documents related to fish advisories are available on the OEHHA Web Site at http://www.oehha.ca.gov/fish.html. County departments of environmental health may have more information on specific fishing areas.

Appendix III. General Advice for Sport Fish Consumption

You can reduce your exposure to chemical contaminants in sport fish by following the recommendations below. Follow as many of them as you can to increase your health protection. This general advice is not meant to take the place of advisories for specific areas, but should be followed in addition to them. Sport fish in most water bodies in the state have not been evaluated for their safety for human consumption. This is why we strongly recommend following the general advice given below.

Fishing Practices

Chemical levels can vary from place to place. Your overall exposure to chemicals is likely to be lower if you eat fish from a variety of places rather than from one usual spot that might have high contamination levels.

Be aware that OEHHA may issue new advisories or revise existing ones. Consult the Department of Fish and Game regulations booklet or check with OEHHA on a regular basis to see if there are any changes that could affect you.

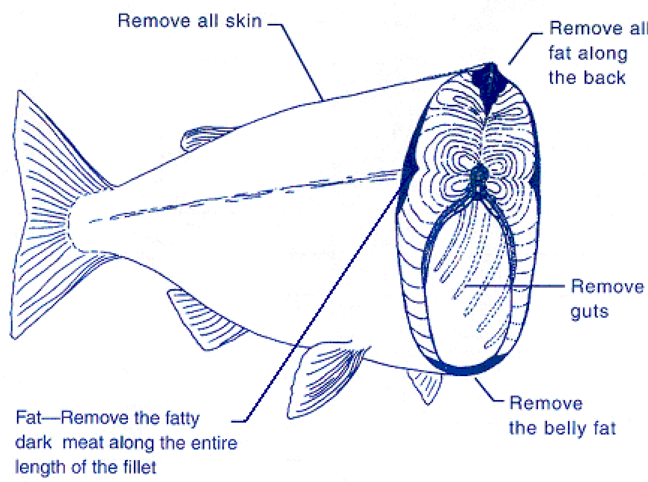
Consumption Guidelines

Fish Species: Some fish species have higher chemical levels than others in the same location. If possible, eat smaller amounts of several different types of fish rather than a large amount of one type that may be high in contaminants.

Fish Size: Smaller fish of a species will usually have lower chemical levels than larger fish in the same location because some of the chemicals may accumulate as the fish grows. It is advisable to eat smaller fish (of legal size).

Fish Preparation and Consumption

- Eat only the fillet portions. Do not eat the guts and liver because chemicals usually concentrate in those parts. Also, avoid frequent consumption of any reproductive parts such as eggs or roe.
- Many chemicals are stored in the fat. To reduce the levels of these chemicals, skin the fish when possible and trim any visible fat.
- Use a cooking method such as baking, broiling, grilling, or steaming that allows the juices to drain away from the fish. The juices will contain chemicals in the fat and should be thrown away. Preparing and cooking fish in this way can remove 30 to 50 percent of the chemicals stored in fat. If you make stews or chowders, use fillet parts.
- Raw fish may be infested by parasites. Cook fish thoroughly to destroy the parasites.



Advice For Pregnant Women, Women of Childbearing Age, and Children

Children and fetuses are more sensitive to the toxic effects of methylmercury, the form of mercury of health concern in fish. For this reason, OEHHA's advisories that are based on mercury provide special advice for women of childbearing age and children. Women should follow this advice throughout their childbearing years.

The U.S. Food and Drug Administration (FDA) is responsible for commercial seafood safety. FDA has issued the following advice about the risks of mercury in fish to pregnant women and women of childbearing age who may become pregnant. FDA advises these women not to eat shark, swordfish, king mackerel, or tilefish. FDA also advises that it is prudent for nursing mothers and young children not to eat these fish as well.

The U.S. Environmental Protection Agency has also issued national advice to protect women who are pregnant or may become pregnant, nursing mothers, and young children against consuming excessive mercury in fish. They recommend that these individuals eat no more than one meal per week of non-commercial freshwater fish caught by family and friends.

National advice for women and children on mercury in fish is available from the U.S. Environmental Protection Agency at *www.epa.gov/waterscience/fishadvice/advice.html* and the U.S. Food and Drug Administration at *www.cfsan.fda.gov/~dms/admehg.html*

Appendix IV: Case Summaries for Fish and Shellfish Samples from Clear Lake, Cache Creek, and Bear Creek

Species	Site Name	Project ID	Sample Year	#	Mercury ppm wet wt.	Fork Length[1] mm	Select
Black Crappie	Clear Lake/Oaks Arm	CDFG	1984	1	.660	174	1
Black Crappie	Clear Lake/Oaks Arm	CDFG	1984	1	.620	180	1
Black Crappie	Clear Lake/Oaks Arm	CDFG	1984	1	.550	182	1
Black Crappie	Clear Lake/Oaks Arm	CDFG	1984	1	.330	184	1
Black Crappie	Clear Lake/Oaks Arm	CDFG	1984	1	.170	187	1
Black Crappie	Clear Lake/Oaks Arm	CDFG	1984	1	.430	188	1
Black Crappie	Clear Lake/Oaks Arm	CDFG	1984	1	.290	190	1
Black Crappie	Clear Lake/Oaks Arm	CDFG	1984	1	.280	191	1
Black Crappie	Clear Lake/Oaks Arm	CDFG	1984	1	.370	194	1
Black Crappie	Clear Lake/Oaks Arm	CDFG	1984	1	.460	194	1
Black Crappie	Clear Lake/Oaks Arm	CDFG	1976	4	.240	195	1
Black Crappie	Clear Lake/Oaks Arm	CDFG	1984	1	.220	197	1
Black Crappie	Clear Lake/Oaks Arm	CDFG	1984	1	.410	198	1
Black Crappie	Clear Lake/Oaks Arm	CDFG	1984	1	.330	200	1
Black Crappie	Clear Lake/Oaks Arm	CDFG	1984	1	.350	202	1
Black Crappie	Clear Lake/Oaks Arm	CDFG	1984	1	.360	208	1
Black Crappie	Clear Lake/Oaks Arm	CDFG	1976	1	.070	220	1
Black Crappie	Clear Lake/Oaks Arm	CDFG	1976	2	.280	224	1
Black Crappie	Clear Lake/Oaks Arm	CDFG	1976	3	.160	224	1
Black Crappie	Clear Lake/Oaks Arm	CDFG	1984	1	.570	284	1
Black Crappie	Clear Lake/Rodman Slough	TSM	1983	1	.230	205	1
Black Crappie	Clear Lake/Rodman Slough	TSM	1983	1	.160	209	1
Black Crappie	Clear Lake/Rodman Slough	TSM	1983	1	.280	242	1
Black Crappie	Clear Lake/Upper Arm	CDFG	1984	1	.360	192	1
Black Crappie	Clear Lake/Upper Arm	CDFG	1984	1	.270	193	1
Black Crappie	Clear Lake/Upper Arm	CDFG	1976	4	.180	210	1
Black Crappie	Clear Lake/Upper Arm	CDFG	1984	1	.340	248	1
Black Crappie	Clear Lake/Upper Arm	CDFG	1984	1	.320	270	1
Black Crappie	Clear Lake/Upper Arm	CDFG	1984	1	.460	270	1
Black Crappie	Clear Lake/Upper Arm	CDFG	1984	1	.340	273	1
Black Crappie	Clear Lake/Upper Arm	CDFG	1984	1	.300	275	1
Black Crappie	Clear Lake/Upper Arm	CDFG	1984	1	.490	280	1
Black Crappie	Clear Lake/Upper Arm	CDFG	1984	1	.460	283	1
Black Crappie	Clear Lake/Upper Arm	CDFG	1984	1	.570	284	1
Black Crappie	Clear Lake/Upper Arm	CDFG	1984	1	.400	286	1
Black Crappie	Clear Lake/Upper Arm	CDFG	1984	1	.400	290	1
Black Crappie	Clear Lake/Upper Arm	CDFG	1984	1	.690	292	1
Black Crappie	Clear Lake/Upper Arm	CDFG	1984	1	.290	292	1
Black Crappie	Clear Lake/Upper Arm	CDFG	1984	1	.810	298	1
Black Crappie	Clear Lake/Upper Arm	CDFG	1984	1	.490	299	1
Black Crappie	Clear Lake/Upper Arm	CDFG	1984	1	.660	302	1
Black Crappie	Clear Lake/Upper Arm	CDFG	1984	1	.300	304	1
Black Crappie	Clear Lake/Upper Arm	CDFG	1984	1	.430	308	1
Black Crappie	Clear Lake/Upper Arm	CDFG	1984	1	.590	345	1
Bluegill	Cache Creek/btw Road 102 & I-5	UCDavis2	1995	1	.290	157	1
Bluegill	Cache Creek/btw Road 102 & I-5	UCDavis2	1995	1	.280	169	1
Bluegill	Cache Creek/Clear Lake Outflow	UCDavis5	2000	1	.055	118	1
Bluegill	Cache Creek/Clear Lake Outflow	UCDavis5	2000	1	.060	120	1
Bluegill	Cache Creek/Clear Lake Outflow	UCDavis5	2000	1	.075	149	1
Bluegill	Cache Creek/Clear Lake Outflow	UCDavis5	2000	1	.070	152	1

[1] Lengths reported in italics were estimated based on weight

Species	Site Name	Project ID	Sample Year	#	Mercury ppm wet wt.	Fork Length[1] mm	Select
Bluegill	Cache Creek/Clear Lake Outflow	UCDavis5	2000	1	.095	156	1
Bluegill	Cache Creek/Clear Lake Outflow	UCDavis5	2000	1	.095	158	1
Bluegill	Cache Creek/Solano Concrete	UCDavis5	2000	1	.350	109	1
Bluegill	Clear Lake/Oaks Arm	CDFG	1976	2	.040	124	1
Bluegill	Clear Lake/Oaks Arm	CDFG	1976	3	.470	159	1
Bluegill	Clear Lake/Oaks Arm	CDFG	1976	1	.190	184	1
Bluegill	Clear Lake/Upper Arm	CDFG	1976	2	.060	150	1
Brown Bullhead	Cache Creek/btw Road 102 & I-5	UCDavis2	1995	1	.220	260	1
Brown Bullhead	Cache Creek/btw Road 102 & I-5	UCDavis2	1995	1	.280	293	1
Brown Bullhead	Cache Creek/btw Road 102 & I-5	UCDavis2	1995	1	.310	310	1
Brown Bullhead	Cache Creek/btw Road 102 & I-5	UCDavis2	1995	1	.270	316	1
Brown Bullhead	Clear Lake/Oaks Arm	CDFG	1976	1	.120	220	1
Brown Bullhead	Clear Lake/Oaks Arm	CDFG	1976	2	.200	229	1
Brown Bullhead	Clear Lake/Oaks Arm	CDFG	1984	1	.130	241	1
Brown Bullhead	Clear Lake/Oaks Arm	CDFG	1984	1	.190	271	1
Brown Bullhead	Clear Lake/Oaks Arm	CDFG	1984	1	.340	284	1
Brown Bullhead	Clear Lake/Oaks Arm	CDFG	1976	2	.250	293	1
Brown Bullhead	Clear Lake/Oaks Arm	CDFG	1984	1	.260	303	1
Brown Bullhead	Clear Lake/Oaks Arm	CDFG	1984	1	.220	308	1
Brown Bullhead	Clear Lake/Oaks Arm	CDFG	1984	1	.240	309	1
Brown Bullhead	Clear Lake/Oaks Arm	CDFG	1984	1	.240	310	1
Brown Bullhead	Clear Lake/Oaks Arm	CDFG	1984	1	.310	312	1
Brown Bullhead	Clear Lake/Oaks Arm	CDFG	1984	1	.260	313	1
Brown Bullhead	Clear Lake/Oaks Arm	CDFG	1976	1	.580	320	1
Brown Bullhead	Clear Lake/Oaks Arm	CDFG	1984	1	.260	322	1
Brown Bullhead	Clear Lake/Oaks Arm	CDFG	1984	1	.140	323	1
Brown Bullhead	Clear Lake/Oaks Arm	CDFG	1984	1	.240	328	1
Brown Bullhead	Clear Lake/Oaks Arm	CDFG	1984	1	.240	330	1
Brown Bullhead	Clear Lake/Oaks Arm	CDFG	1984	1	.270	334	1
Brown Bullhead	Clear Lake/Oaks Arm	CDFG	1984	1	.420	337	1
Brown Bullhead	Clear Lake/Oaks Arm	CDFG	1976	1	.200	340	1
Brown Bullhead	Clear Lake/Oaks Arm	CDFG	1984	1	.300	344	1
Brown Bullhead	Clear Lake/Oaks Arm	CDFG	1984	1	.320	347	1
Brown Bullhead	Clear Lake/Oaks Arm	CDFG	1984	1	.380	347	1
Brown Bullhead	Clear Lake/Oaks Arm	CDFG	1984	1	.200	351	1
Brown Bullhead	Clear Lake/Oaks Arm	CDFG	1984	1	.540	358	1
Brown Bullhead	Clear Lake/Rodman Slough	TSM	1983	1	.180	309	1
Brown Bullhead	Clear Lake/Rodman Slough	TSM	1983	1	.150	315	1
Brown Bullhead	Clear Lake/Rodman Slough	TSM	1983	1	.370	320	1
Brown Bullhead	Clear Lake/Rodman Slough	TSM	1983	1	.120	325	1
Brown Bullhead	Clear Lake/Rodman Slough	TSM	1983	1	.240	336	1
Brown Bullhead	Clear Lake/Rodman Slough	TSM	1983	1	.280	343	1
Brown Bullhead	Clear Lake/Upper Arm	CDFG	1976	2	.220	320	1
Carp	Cache Creek	TSM	1978	4	.	450	0
Carp	Cache Creek/btw Road 102 & I-5	UCDavis2	1995	1	.280	202	1
Carp	Cache Creek/btw Road 102 & I-5	UCDavis2	1995	1	.270	210	1
Carp	Clear Lake	USFDA	1976	1	.440	.	0
Carp	Clear Lake	USFDA	1976	1	.540	.	0
Carp	Clear Lake	USFDA	1976	1	.600	.	0
Carp	Clear Lake/Lower Arm	UCDavis-CLERC	1992	3	.220	*682*	1
Carp	Clear Lake/Lower Arm	UCDavis-CLERC	1992	4	.100	*762*	1
Carp	Clear Lake/Lower Arm	UCDavis-CLERC	1992	3	.050	*953*	1
Carp	Clear Lake/Lower Arm	UCDavis-CLERC	1992	1	.050	*1346*	1
Carp	Clear Lake/Oaks Arm	CDFG	1976	1	.070	*358*	1
Carp	Clear Lake/Oaks Arm	CDFG	1976	1	.200	422	1
Carp	Clear Lake/Oaks Arm	CDFG	1976	1	.130	435	1
Carp	Clear Lake/Oaks Arm	UCDavis-CLERC	1992	1	.050	*431*	1

Species	Site Name	Project ID	Sample Year	#	Mercury ppm wet wt.	Fork Length[1] mm	Select
Carp	Clear Lake/Oaks Arm	UCDavis-CLERC	1992	1	.050	*457*	1
Carp	Clear Lake/Oaks Arm	UCDavis-CLERC	1992	4	.100	*739*	1
Carp	Clear Lake/Oaks Arm	UCDavis-CLERC	1992	1	.130	*853*	1
Carp	Clear Lake/Oaks Arm	UCDavis-CLERC	1992	4	.210	*893*	1
Carp	Clear Lake/Oaks Arm	UCDavis-CLERC	1992	3	.400	*1046*	1
Carp	Clear Lake/Upper Arm	UCDavis-CLERC	1992	1	.130	*762*	1
Carp	Clear Lake/Upper Arm	UCDavis-CLERC	1992	1	.100	*801*	1
Channel Catfish	Cache Creek/btw Road 102 & I-5	UCDavis2	1995	1	.570	332	1
Channel Catfish	Cache Creek/btw Road 102 & I-5	UCDavis2	1995	1	.280	351	1
Channel Catfish	Cache Creek/btw Road 102 & I-5	UCDavis2	1995	1	.460	353	1
Channel Catfish	Cache Creek/btw Road 102 & I-5	UCDavis2	1995	1	.330	470	1
Channel Catfish	Cache Creek/Rumsey	UCDavis5	2000	1	.225	381	1
Channel Catfish	Cache Creek/Solano Concrete	UCDavis5	2000	1	.225	326	1
Channel Catfish	Clear Lake	UCDavis-CLERC	2000	1	.210	385	1
Channel Catfish	Clear Lake	UCDavis-CLERC	2000	1	.250	395	1
Channel Catfish	Clear Lake	UCDavis-CLERC	2000	1	.540	430	1
Channel Catfish	Clear Lake	UCDavis-CLERC	2000	1	.460	505	1
Channel Catfish	Clear Lake	UCDavis-CLERC	2000	1	.160	535	1
Channel Catfish	Clear Lake	UCDavis-CLERC	2000	1	.620	565	1
Channel Catfish	Clear Lake	UCDavis-CLERC	2000	1	.150	570	1
Channel Catfish	Clear Lake	UCDavis-CLERC	2000	1	.130	605	1
Channel Catfish	Clear Lake	UCDavis-CLERC	2000	1	.200	610	1
Channel Catfish	Clear Lake	UCDavis-CLERC	2000	1	.280	665	1
Channel Catfish	Clear Lake	UCDavis-CLERC	2000	1	.830	670	1
Channel Catfish	Clear Lake	UCDavis-CLERC	2000	1	.760	705	1
Channel Catfish	Clear Lake	UCDavis-CLERC	2000	1	.550	720	1
Channel Catfish	Clear Lake	UCDavis-CLERC	2000	1	.440	720	1
Channel Catfish	Clear Lake	UCDavis-CLERC	2000	1	.550	730	1
Channel Catfish	Clear Lake	UCDavis-CLERC	2000	1	.500	740	1
Channel Catfish	Clear Lake	UCDavis-CLERC	2000	1	.210	750	1
Channel Catfish	Clear Lake	UCDavis-CLERC	2000	1	.470	755	1
Channel Catfish	Clear Lake	UCDavis-CLERC	2000	1	.610	760	1
Channel Catfish	Clear Lake	UCDavis-CLERC	2000	1	.240	790	1
Channel Catfish	Clear Lake	UCDavis-CLERC	2000	1	.370	805	1
Channel Catfish	Clear Lake	UCDavis-CLERC	2000	1	.530	815	1
Channel Catfish	Clear Lake	UCDavis-CLERC	2000	1	.310	855	1
Channel Catfish	Clear Lake/Lower Arm	UCDavis-CLERC	1992	1	.150	317	1
Channel Catfish	Clear Lake/Lower Arm	UCDavis-CLERC	1992	3	.220	544	1
Channel Catfish	Clear Lake/Lower Arm	UCDavis-CLERC	1992	3	.240	619	1
Channel Catfish	Clear Lake/Lower Arm	UCDavis-CLERC	1992	3	.210	704	1
Channel Catfish	Clear Lake/Oaks Arm	CDFG	1984	1	.080	126	0
Channel Catfish	Clear Lake/Oaks Arm	CDFG	1984	1	.250	196	1
Channel Catfish	Clear Lake/Oaks Arm	CDFG	1984	1	.190	233	1
Channel Catfish	Clear Lake/Oaks Arm	CDFG	1984	1	.190	273	1
Channel Catfish	Clear Lake/Oaks Arm	CDFG	1984	1	.300	385	1
Channel Catfish	Clear Lake/Oaks Arm	CDFG	1984	1	.170	408	1
Channel Catfish	Clear Lake/Oaks Arm	CDFG	1984	1	.190	451	1
Channel Catfish	Clear Lake/Oaks Arm	CDFG	1984	1	.290	494	1
Channel Catfish	Clear Lake/Oaks Arm	CDFG	1984	1	.380	512	1
Channel Catfish	Clear Lake/Oaks Arm	CDFG	1984	1	.510	518	1
Channel Catfish	Clear Lake/Oaks Arm	CDFG	1984	1	.460	545	1
Channel Catfish	Clear Lake/Oaks Arm	CDFG	1984	1	.930	635	1
Channel Catfish	Clear Lake/Oaks Arm	CDFG	1984	1	.280	730	1
Channel Catfish	Clear Lake/Oaks Arm	CDFG	1984	1	1.200	740	1
Channel Catfish	Clear Lake/Oaks Arm	UCDavis-CLERC	1992	3	.100	346	1
Channel Catfish	Clear Lake/Oaks Arm	UCDavis-CLERC	1992	1	.100	445	1
Channel Catfish	Clear Lake/Oaks Arm	UCDavis-CLERC	1992	3	.140	455	1

Species	Site Name	Project ID	Sample Year	#	Mercury ppm wet wt.	Fork Length[1] mm	Select
Channel Catfish	Clear Lake/Oaks Arm	UCDavis-CLERC	1992	1	.100	522	1
Channel Catfish	Clear Lake/Oaks Arm	UCDavis-CLERC	1992	3	.230	592	1
Channel Catfish	Clear Lake/Oaks Arm	UCDavis-CLERC	1992	1	.380	609	1
Channel Catfish	Clear Lake/Oaks Arm	UCDavis-CLERC	1992	1	.460	776	1
Channel Catfish	Clear Lake/Oaks Arm	UCDavis-CLERC	1992	2	.330	942	1
Channel Catfish	Clear Lake/Oaks Arm	UCDavis-CLERC	1992	1	.700	1214	1
Channel Catfish	Clear Lake/Rattlesnake Isle	TSM	1983	1	.800	547	1
Channel Catfish	Clear Lake/Rattlesnake Isle	TSM	1983	1	1.400	619	1
Channel Catfish	Clear Lake/Rattlesnake Isle	TSM	1983	1	1.400	645	1
Channel Catfish	Clear Lake/Rattlesnake Isle	TSM	1983	1	1.500	745	1
Channel Catfish	Clear Lake/Upper Arm	CDFG	1984	1	.200	350	1
Channel Catfish	Clear Lake/Upper Arm	CDFG	1984	1	.380	408	1
Channel Catfish	Clear Lake/Upper Arm	CDFG	1984	1	.240	431	1
Channel Catfish	Clear Lake/Upper Arm	CDFG	1984	1	.420	438	1
Channel Catfish	Clear Lake/Upper Arm	CDFG	1984	1	.380	462	1
Channel Catfish	Clear Lake/Upper Arm	CDFG	1984	1	.680	485	1
Channel Catfish	Clear Lake/Upper Arm	CDFG	1984	1	.430	508	1
Channel Catfish	Clear Lake/Upper Arm	CDFG	1984	1	.450	519	1
Channel Catfish	Clear Lake/Upper Arm	CDFG	1984	1	1.300	655	1
Channel Catfish	Clear Lake/Upper Arm	CDFG	1984	1	.900	740	1
Channel Catfish	Clear Lake/Upper Arm	UCDavis-CLERC	1992	1	.380	386	1
Green Sunfish	Bear Creek/Mid	UCDavis5	2000	1	2.190	142	1
Green Sunfish	Cache Creek	TSM	1981	12	.330	110	1
Green Sunfish	Cache Creek	TSM	1980	10	.340	126	1
Green Sunfish	Cache Creek/Solano Concrete	UCDavis5	2000	1	.270	119	1
Green Sunfish	Cache Creek/Solano Concrete	UCDavis5	2000	1	.395	126	1
Green Sunfish	Cache Creek/Solano Concrete	UCDavis5	2000	1	.210	130	1
Green Sunfish	Cache Creek/Solano Concrete	UCDavis5	2000	1	.210	137	1
Hardhead	Cache Creek/Rumsey	UCDavis5	2000	1	.395	251	1
Hardhead	Cache Creek/Rumsey	UCDavis5	2000	1	.440	253	1
Hardhead	Cache Creek/Rumsey	UCDavis5	2000	1	.275	258	1
Hardhead	Cache Creek/Rumsey	UCDavis5	2000	1	.410	261	1
Hardhead	Cache Creek/Rumsey	UCDavis5	2000	1	.295	266	1
Hardhead	Cache Creek/Rumsey	UCDavis5	2000	1	.365	278	1
Hardhead	Cache Creek/Rumsey	UCDavis5	2000	1	.395	279	1
Hardhead	Cache Creek/Rumsey	UCDavis5	2000	1	.360	285	1
Hardhead	Cache Creek/Rumsey	UCDavis5	2000	1	.705	325	1
Hitch	Clear Lake	USFDA	1976	1	.540	.	0
Hitch	Clear Lake	USFDA	1976	1	.560	.	0
Hitch	Clear Lake/Oaks Arm	CDFG	1984	1	.150	252	1
Hitch	Clear Lake/Upper Arm	CDFG	1984	1	.210	247	1
Hitch	Clear Lake/Upper Arm	CDFG	1984	1	.090	263	1
Hitch	Clear Lake/Upper Arm	CDFG	1984	1	.190	264	1
Hitch	Clear Lake/Upper Arm	CDFG	1984	1	.240	265	1
Hitch	Clear Lake/Upper Arm	CDFG	1984	1	.110	265	1
Hitch	Clear Lake/Upper Arm	CDFG	1984	1	.120	265	1
Hitch	Clear Lake/Upper Arm	CDFG	1984	1	.160	272	1
Hitch	Clear Lake/Upper Arm	CDFG	1984	1	.160	272	1
Hitch	Clear Lake/Upper Arm	CDFG	1984	1	.090	274	1
Hitch	Clear Lake/Upper Arm	CDFG	1984	1	.280	274	1
Hitch	Clear Lake/Upper Arm	CDFG	1984	1	.240	275	1
Hitch	Clear Lake/Upper Arm	CDFG	1984	1	.130	277	1
Hitch	Clear Lake/Upper Arm	CDFG	1984	1	.070	280	1
Hitch	Clear Lake/Upper Arm	CDFG	1984	1	.090	281	1
Hitch	Clear Lake/Upper Arm	CDFG	1984	1	.120	284	1
Hitch	Clear Lake/Upper Arm	CDFG	1984	1	.180	286	1
Hitch	Clear Lake/Upper Arm	CDFG	1984	1	.120	287	1

Species	Site Name	Project ID	Sample Year	#	Mercury ppm wet wt.	Fork Length[1] mm	Select
Hitch	Clear Lake/Upper Arm	CDFG	1984	1	.100	290	1
Hitch	Clear Lake/Upper Arm	CDFG	1984	1	.210	292	1
Hitch	Clear Lake/Upper Arm	CDFG	1984	1	.230	299	1
Largemouth Bass	Cache Creek	TSM	1978	3	.610	268	0
Largemouth Bass	Cache Creek/Clear Lake Outflow	UCDavis5	2000	1	.090	135	0
Largemouth Bass	Cache Creek/Clear Lake Outflow	UCDavis5	2000	1	.080	146	0
Largemouth Bass	Cache Creek/Clear Lake Outflow	UCDavis5	2000	1	.095	162	0
Largemouth Bass	Cache Creek/Clear Lake Outflow	UCDavis5	2000	1	.090	163	0
Largemouth Bass	Cache Creek/Clear Lake Outflow	UCDavis5	2000	1	.070	168	0
Largemouth Bass	Cache Creek/Clear Lake Outflow	UCDavis5	2000	1	.160	184	0
Largemouth Bass	Cache Creek/Clear Lake Outflow	UCDavis5	2000	1	.110	205	0
Largemouth Bass	Cache Creek/Clear Lake Outflow	UCDavis5	2000	1	.140	272	0
Largemouth Bass	Cache Creek/Clear Lake Outflow	UCDavis5	2000	1	.270	330	1
Largemouth Bass	Cache Creek/Clear Lake Outflow	UCDavis5	2000	1	.295	352	1
Largemouth Bass	Cache Creek/Clear Lake Outflow	UCDavis5	2000	1	.295	375	1
Largemouth Bass	Cache Creek/Clear Lake Outflow	UCDavis5	2000	1	.450	400	1
Largemouth Bass	Cache Creek/Clear Lake Outflow	UCDavis5	2000	1	.665	444	1
Largemouth Bass	Cache Creek/Clear Lake Outflow	UCDavis5	2000	1	.625	499	1
Largemouth Bass	Clear Lake	CDFG	1977	1	.510	.	0
Largemouth Bass	Clear Lake	CDFG	1977	1	.550	302	1
Largemouth Bass	Clear Lake	CDFG	1977	1	.320	304	1
Largemouth Bass	Clear Lake	CDFG	1977	1	.170	310	1
Largemouth Bass	Clear Lake	CDFG	1977	1	.400	312	1
Largemouth Bass	Clear Lake	CDFG	1977	1	.290	315	1
Largemouth Bass	Clear Lake	CDFG	1977	1	.260	319	1
Largemouth Bass	Clear Lake	CDFG	1977	1	1.030	330	1
Largemouth Bass	Clear Lake	CDFG	1977	1	.180	337	1
Largemouth Bass	Clear Lake	CDFG	1977	1	1.910	341	1
Largemouth Bass	Clear Lake	CDFG	1977	1	.410	342	1
Largemouth Bass	Clear Lake	CDFG	1977	1	.270	353	1
Largemouth Bass	Clear Lake	CDFG	1977	1	.890	355	1
Largemouth Bass	Clear Lake	CDFG	1977	1	.350	357	1
Largemouth Bass	Clear Lake	CDFG	1977	1	.490	357	1
Largemouth Bass	Clear Lake	CDFG	1977	1	.540	362	1
Largemouth Bass	Clear Lake	CDFG	1977	1	.540	399	1
Largemouth Bass	Clear Lake	CDFG	1977	1	1.010	400	1
Largemouth Bass	Clear Lake	CDFG	1977	1	.680	411	1
Largemouth Bass	Clear Lake	CDFG	1977	1	.530	422	1
Largemouth Bass	Clear Lake	CDFG	1977	1	.580	441	1
Largemouth Bass	Clear Lake	CDFG	1977	1	.740	467	1
Largemouth Bass	Clear Lake	CDFG	1977	1	1.520	468	1
Largemouth Bass	Clear Lake	CDFG	1977	1	1.370	489	1
Largemouth Bass	Clear Lake	CDFG	1977	1	.950	490	1
Largemouth Bass	Clear Lake	CDHS	1970	10	.400	.	0
Largemouth Bass	Clear Lake/Lower Arm	CDFG	1983	1	.130	289	0
Largemouth Bass	Clear Lake/Lower Arm	CDFG	1983	1	.120	294	1
Largemouth Bass	Clear Lake/Lower Arm	CDFG	1983	1	.500	322	1
Largemouth Bass	Clear Lake/Lower Arm	CDFG	1983	1	.190	325	1
Largemouth Bass	Clear Lake/Lower Arm	CDFG	1983	1	.340	331	1
Largemouth Bass	Clear Lake/Lower Arm	CDFG	1983	1	.340	349	1
Largemouth Bass	Clear Lake/Lower Arm	CDFG	1983	1	.220	351	1
Largemouth Bass	Clear Lake/Lower Arm	CDFG	1983	1	.490	353	1
Largemouth Bass	Clear Lake/Lower Arm	CDFG	1983	1	.220	353	1
Largemouth Bass	Clear Lake/Lower Arm	CDFG	1983	1	.300	354	1
Largemouth Bass	Clear Lake/Lower Arm	CDFG	1983	1	.460	355	1
Largemouth Bass	Clear Lake/Lower Arm	CDFG	1983	1	.280	357	1
Largemouth Bass	Clear Lake/Lower Arm	CDFG	1983	1	.350	372	1

Species	Site Name	Project ID	Sample Year	#	Mercury ppm wet wt.	Fork Length[1] mm	Select
Largemouth Bass	Clear Lake/Lower Arm	CDFG	1983	1	.290	372	1
Largemouth Bass	Clear Lake/Lower Arm	CDFG	1983	1	.250	378	1
Largemouth Bass	Clear Lake/Lower Arm	CDFG	1983	1	.440	382	1
Largemouth Bass	Clear Lake/Lower Arm	CDFG	1983	1	.530	403	1
Largemouth Bass	Clear Lake/Lower Arm	CDFG	1983	1	.560	406	1
Largemouth Bass	Clear Lake/Lower Arm	CDFG	1983	1	.360	410	1
Largemouth Bass	Clear Lake/Lower Arm	CDFG	1983	1	.330	427	1
Largemouth Bass	Clear Lake/Lower Arm	CDFG	1983	1	.350	430	1
Largemouth Bass	Clear Lake/Lower Arm	CDFG	1983	1	.440	430	1
Largemouth Bass	Clear Lake/Lower Arm	CDFG	1983	1	.710	432	1
Largemouth Bass	Clear Lake/Lower Arm	CDFG	1983	1	.350	437	1
Largemouth Bass	Clear Lake/Lower Arm	CDFG	1983	1	.530	469	1
Largemouth Bass	Clear Lake/Lower Arm	TSM	1983	1	.370	275	0
Largemouth Bass	Clear Lake/Lower Arm	UCDavis-CLERC	1992	1	.130	*259*	0
Largemouth Bass	Clear Lake/Lower Arm	UCDavis-CLERC	1992	2	.100	*320*	1
Largemouth Bass	Clear Lake/Lower Arm	UCDavis-CLERC	1992	2	.390	*450*	1
Largemouth Bass	Clear Lake/Lower Arm	UCDavis-CLERC	1992	2	.580	*500*	1
Largemouth Bass	Clear Lake/Lower Lake	TSM	1980	6	.530	264	0
Largemouth Bass	Clear Lake/Lower Lake	TSM	1983	1	.370	275	0
Largemouth Bass	Clear Lake/Lower Lake	TSM	1983	1	.510	293	1
Largemouth Bass	Clear Lake/Lower Lake	TSM	1983	1	.390	310	1
Largemouth Bass	Clear Lake/Lower Lake	TSM	1983	1	.420	317	1
Largemouth Bass	Clear Lake/Lower Lake	TSM	1983	1	.810	424	1
Largemouth Bass	Clear Lake/Lower Lake	TSM	1983	1	.920	426	1
Largemouth Bass	Clear Lake/Oaks Arm	CDFG	1976	2	.130	144	0
Largemouth Bass	Clear Lake/Oaks Arm	CDFG	1976	1	.790	292	1
Largemouth Bass	Clear Lake/Oaks Arm	CDFG	1987	1	.410	333	1
Largemouth Bass	Clear Lake/Oaks Arm	CDFG	1983	1	.750	343	1
Largemouth Bass	Clear Lake/Oaks Arm	CDFG	1983	1	.570	348	1
Largemouth Bass	Clear Lake/Oaks Arm	CDFG	1983	1	.660	349	1
Largemouth Bass	Clear Lake/Oaks Arm	CDFG	1983	1	.720	352	1
Largemouth Bass	Clear Lake/Oaks Arm	CDFG	1983	1	.520	352	1
Largemouth Bass	Clear Lake/Oaks Arm	CDFG	1976	1	.870	355	1
Largemouth Bass	Clear Lake/Oaks Arm	CDFG	1983	1	.790	369	1
Largemouth Bass	Clear Lake/Oaks Arm	CDFG	1983	1	.780	371	1
Largemouth Bass	Clear Lake/Oaks Arm	CDFG	1983	1	1.520	371	1
Largemouth Bass	Clear Lake/Oaks Arm	CDFG	1983	1	.760	385	1
Largemouth Bass	Clear Lake/Oaks Arm	CDFG	1983	1	.790	394	1
Largemouth Bass	Clear Lake/Oaks Arm	CDFG	1983	1	.740	407	1
Largemouth Bass	Clear Lake/Oaks Arm	CDFG	1983	1	1.840	412	1
Largemouth Bass	Clear Lake/Oaks Arm	CDFG	1983	1	1.050	428	1
Largemouth Bass	Clear Lake/Oaks Arm	CDFG	1983	1	1.690	430	1
Largemouth Bass	Clear Lake/Oaks Arm	CDFG	1983	1	.870	430	1
Largemouth Bass	Clear Lake/Oaks Arm	CDFG	1983	1	.730	431	1
Largemouth Bass	Clear Lake/Oaks Arm	CDFG	1983	1	.780	432	1
Largemouth Bass	Clear Lake/Oaks Arm	CDFG	1983	1	1.250	454	1
Largemouth Bass	Clear Lake/Oaks Arm	CDFG	1983	1	1.750	515	1
Largemouth Bass	Clear Lake/Oaks Arm	UCDavis-CLERC	1992	2	.290	*251*	0
Largemouth Bass	Clear Lake/Oaks Arm	UCDavis-CLERC	1992	1	.630	*290*	1
Largemouth Bass	Clear Lake/Oaks Arm	UCDavis-CLERC	1992	2	.770	*321*	1
Largemouth Bass	Clear Lake/Oaks Arm	UCDavis-CLERC	1992	3	.500	*339*	1
Largemouth Bass	Clear Lake/Oaks Arm	UCDavis-CLERC	1992	4	.800	*355*	1
Largemouth Bass	Clear Lake/Oaks Arm	UCDavis-CLERC	1992	1	.440	*394*	1
Largemouth Bass	Clear Lake/Oaks Arm	UCDavis-CLERC	1992	3	.730	*395*	1
Largemouth Bass	Clear Lake/Oaks Arm	UCDavis-CLERC	1992	2	.910	*523*	1
Largemouth Bass	Clear Lake/Oaks Arm	UCDavis-CLERC	1992	1	.660	*613*	1
Largemouth Bass	Clear Lake/Rattlesnake Isle	TSM	1983	1	.180	169	0

Species	Site Name	Project ID	Sample Year	#	Mercury ppm wet wt.	Fork Length[1] mm	Select
Largemouth Bass	Clear Lake/Rattlesnake Isle	TSM	1983	1	.220	172	0
Largemouth Bass	Clear Lake/Rattlesnake Isle	TSM	1983	1	.330	175	0
Largemouth Bass	Clear Lake/Rattlesnake Isle	TSM	1983	1	.500	179	0
Largemouth Bass	Clear Lake/Rattlesnake Isle	TSM	1983	1	.360	180	0
Largemouth Bass	Clear Lake/Rattlesnake Isle	TSM	1983	1	.470	184	0
Largemouth Bass	Clear Lake/Rattlesnake Isle	TSM	1983	1	.250	187	0
Largemouth Bass	Clear Lake/Rattlesnake Isle	TSM	1983	1	.620	198	0
Largemouth Bass	Clear Lake/Rattlesnake Isle	TSM	1983	1	.370	199	0
Largemouth Bass	Clear Lake/Rattlesnake Isle	TSM	1983	1	.410	200	0
Largemouth Bass	Clear Lake/Rattlesnake Isle	TSM	1983	1	.450	211	0
Largemouth Bass	Clear Lake/Rattlesnake Isle	TSM	1983	1	.240	218	0
Largemouth Bass	Clear Lake/Rattlesnake Isle	TSM	1983	1	.570	221	0
Largemouth Bass	Clear Lake/Rattlesnake Isle	TSM	1983	1	.420	225	0
Largemouth Bass	Clear Lake/Rattlesnake Isle	TSM	1983	1	.440	232	0
Largemouth Bass	Clear Lake/Rattlesnake Isle	TSM	1983	1	.670	235	0
Largemouth Bass	Clear Lake/Rattlesnake Isle	TSM	1983	1	.580	238	0
Largemouth Bass	Clear Lake/Rattlesnake Isle	TSM	1983	1	.600	240	0
Largemouth Bass	Clear Lake/Rattlesnake Isle	TSM	1983	1	.720	242	0
Largemouth Bass	Clear Lake/Rattlesnake Isle	TSM	1983	1	.590	242	0
Largemouth Bass	Clear Lake/Rattlesnake Isle	TSM	1982	1	.310	246	0
Largemouth Bass	Clear Lake/Rattlesnake Isle	TSM	1982	1	.340	252	0
Largemouth Bass	Clear Lake/Rattlesnake Isle	TSM	1983	1	.830	262	0
Largemouth Bass	Clear Lake/Rattlesnake Isle	TSM	1982	1	.660	264	0
Largemouth Bass	Clear Lake/Rattlesnake Isle	TSM	1982	1	.290	264	0
Largemouth Bass	Clear Lake/Rattlesnake Isle	TSM	1982	1	.480	272	0
Largemouth Bass	Clear Lake/Rattlesnake Isle	TSM	1982	1	.330	272	0
Largemouth Bass	Clear Lake/Rattlesnake Isle	TSM	1982	1	.340	276	0
Largemouth Bass	Clear Lake/Rattlesnake Isle	TSM	1983	1	.580	284	0
Largemouth Bass	Clear Lake/Rattlesnake Isle	TSM	1983	1	.760	287	0
Largemouth Bass	Clear Lake/Rattlesnake Isle	TSM	1981	6	.920	289	0
Largemouth Bass	Clear Lake/Rattlesnake Isle	TSM	1983	1	.650	290	1
Largemouth Bass	Clear Lake/Rattlesnake Isle	TSM	1980	5	.730	293	1
Largemouth Bass	Clear Lake/Rattlesnake Isle	TSM	1983	1	.430	296	1
Largemouth Bass	Clear Lake/Rattlesnake Isle	TSM	1983	1	.590	321	1
Largemouth Bass	Clear Lake/Rodman Slough	TSM	1983	1	.130	162	0
Largemouth Bass	Clear Lake/Rodman Slough	TSM	1983	1	.120	180	0
Largemouth Bass	Clear Lake/Rodman Slough	TSM	1983	1	.320	194	0
Largemouth Bass	Clear Lake/Rodman Slough	TSM	1983	1	.160	204	0
Largemouth Bass	Clear Lake/Rodman Slough	TSM	1983	1	.200	218	0
Largemouth Bass	Clear Lake/Rodman Slough	TSM	1983	1	.230	219	0
Largemouth Bass	Clear Lake/Rodman Slough	TSM	1983	1	.200	225	0
Largemouth Bass	Clear Lake/Rodman Slough	TSM	1983	1	.280	229	0
Largemouth Bass	Clear Lake/Rodman Slough	TSM	1983	1	.340	234	0
Largemouth Bass	Clear Lake/Rodman Slough	TSM	1983	1	.460	251	0
Largemouth Bass	Clear Lake/Rodman Slough	TSM	1983	7	.300	256	0
Largemouth Bass	Clear Lake/Rodman Slough	TSM	1983	1	.380	275	0
Largemouth Bass	Clear Lake/Rodman Slough	TSM	1983	1	.200	276	0
Largemouth Bass	Clear Lake/Rodman Slough	TSM	1983	1	.280	279	0
Largemouth Bass	Clear Lake/Rodman Slough	TSM	1983	1	.360	283	0
Largemouth Bass	Clear Lake/Rodman Slough	TSM	1983	1	.310	286	0
Largemouth Bass	Clear Lake/Rodman Slough	TSM	1983	1	.510	292	1
Largemouth Bass	Clear Lake/Rodman Slough	TSM	1983	1	.320	297	1
Largemouth Bass	Clear Lake/Rodman Slough	TSM	1983	1	.380	298	1
Largemouth Bass	Clear Lake/Upper Arm	CDFG	1976	2	.540	290	1
Largemouth Bass	Clear Lake/Upper Arm	CDFG	1976	1	.350	300	1
Largemouth Bass	Clear Lake/Upper Arm	CDFG	1976	1	.320	302	1
Largemouth Bass	Clear Lake/Upper Arm	CDFG	1983	1	.320	327	1

Species	Site Name	Project ID	Sample Year	#	Mercury ppm wet wt.	Fork Length[1] mm	Select
Largemouth Bass	Clear Lake/Upper Arm	CDFG	1983	1	.430	331	1
Largemouth Bass	Clear Lake/Upper Arm	CDFG	1983	1	.400	332	1
Largemouth Bass	Clear Lake/Upper Arm	CDFG	1983	1	.450	336	1
Largemouth Bass	Clear Lake/Upper Arm	CDFG	1983	1	.300	339	1
Largemouth Bass	Clear Lake/Upper Arm	CDFG	1983	1	.340	348	1
Largemouth Bass	Clear Lake/Upper Arm	CDFG	1983	1	.450	354	1
Largemouth Bass	Clear Lake/Upper Arm	CDFG	1983	1	.520	362	1
Largemouth Bass	Clear Lake/Upper Arm	CDFG	1983	1	.760	364	1
Largemouth Bass	Clear Lake/Upper Arm	CDFG	1983	1	.420	365	1
Largemouth Bass	Clear Lake/Upper Arm	CDFG	1976	1	.360	368	1
Largemouth Bass	Clear Lake/Upper Arm	CDFG	1983	1	.450	368	1
Largemouth Bass	Clear Lake/Upper Arm	CDFG	1983	1	.730	370	1
Largemouth Bass	Clear Lake/Upper Arm	CDFG	1983	1	.650	375	1
Largemouth Bass	Clear Lake/Upper Arm	CDFG	1983	1	.480	385	1
Largemouth Bass	Clear Lake/Upper Arm	CDFG	1983	1	.580	397	1
Largemouth Bass	Clear Lake/Upper Arm	CDFG	1983	1	.690	398	1
Largemouth Bass	Clear Lake/Upper Arm	CDFG	1983	1	.510	399	1
Largemouth Bass	Clear Lake/Upper Arm	CDFG	1983	1	.480	400	1
Largemouth Bass	Clear Lake/Upper Arm	CDFG	1983	1	.480	402	1
Largemouth Bass	Clear Lake/Upper Arm	CDFG	1983	1	1.030	482	1
Largemouth Bass	Clear Lake/Upper Arm	TSM	1983	1	.280	229	0
Largemouth Bass	Clear Lake/Upper Arm	TSM	1983	1	.280	279	0
Largemouth Bass	Clear Lake/Upper Arm	UCDavis-CLERC	1992	3	.270	*269*	0
Largemouth Bass	Clear Lake/Upper Arm	UCDavis-CLERC	1992	1	.370	*324*	1
Largemouth Bass	Clear Lake/Upper Arm	UCDavis-CLERC	1992	5	.750	*466*	1
Largemouth Bass	Clear Lake/Upper Arm	UCDavis-CLERC	1992	1	.770	*585*	1
Largemouth Bass	Clear Lake/Upper Arm	UCDavis-CLERC	1992	2	1.050	*829*	1
Sacramento Blackfish	Clear Lake/Lower Arm	UCDavis-CLERC	1992	1	.450	.	0
Sacramento Blackfish	Clear Lake/Oaks Arm	CDFG	1976	1	.380	345	1
Sacramento Blackfish	Clear Lake/Oaks Arm	CDFG	1976	1	.300	359	1
Sacramento Blackfish	Clear Lake/Oaks Arm	UCDavis-CLERC	1992	1	.460	.	0
Sacramento Blackfish	Clear Lake/Upper Arm	CDFG	1984	1	.240	335	1
Sacramento Blackfish	Clear Lake/Upper Arm	CDFG	1984	1	.260	340	1
Sacramento Blackfish	Clear Lake/Upper Arm	CDFG	1984	1	.080	347	1
Sacramento Blackfish	Clear Lake/Upper Arm	CDFG	1984	1	.260	355	1
Sacramento Blackfish	Clear Lake/Upper Arm	CDFG	1984	1	.270	362	1
Sacramento Blackfish	Clear Lake/Upper Arm	CDFG	1984	1	.290	368	1
Sacramento Blackfish	Clear Lake/Upper Arm	CDFG	1984	1	.450	369	1
Sacramento Blackfish	Clear Lake/Upper Arm	CDFG	1984	1	.290	370	1
Sacramento Blackfish	Clear Lake/Upper Arm	CDFG	1984	1	.180	371	1
Sacramento Blackfish	Clear Lake/Upper Arm	CDFG	1984	1	.170	371	1
Sacramento Blackfish	Clear Lake/Upper Arm	CDFG	1984	1	.180	372	1
Sacramento Blackfish	Clear Lake/Upper Arm	CDFG	1984	1	.180	377	1
Sacramento Blackfish	Clear Lake/Upper Arm	CDFG	1984	1	.390	383	1
Sacramento Blackfish	Clear Lake/Upper Arm	CDFG	1984	1	.190	384	1
Sacramento Blackfish	Clear Lake/Upper Arm	CDFG	1984	1	.270	389	1
Sacramento Blackfish	Clear Lake/Upper Arm	CDFG	1984	1	.300	393	1
Sacramento Blackfish	Clear Lake/Upper Arm	CDFG	1984	1	.200	398	1
Sacramento Blackfish	Clear Lake/Upper Arm	CDFG	1984	1	.320	398	1
Sacramento Blackfish	Clear Lake/Upper Arm	CDFG	1984	1	.350	399	1
Sacramento Blackfish	Clear Lake/Upper Arm	CDFG	1984	1	.380	400	1
Sacramento Pikeminnow	Bear Creek/Mid	UCDavis5	2000	1	1.670	168	0
Sacramento Pikeminnow	Bear Creek/Mid	UCDavis5	2000	1	2.460	182	0
Sacramento Pikeminnow	Bear Creek/Mid	UCDavis5	2000	1	2.470	188	0
Sacramento Pikeminnow	Bear Creek/Mid	UCDavis5	2000	1	1.980	195	0
Sacramento Pikeminnow	Bear Creek/Mid	UCDavis5	2000	1	3.135	217	0
Sacramento Pikeminnow	Bear Creek/Mid	UCDavis5	2000	1	2.735	219	0

Species	Site Name	Project ID	Sample Year	#	Mercury ppm wet wt.	Fork Length[1] mm	Select
Sacramento Pikeminnow	Bear Creek/Mid	UCDavis5	2000	1	3.550	223	0
Sacramento Pikeminnow	Bear Creek/Mid	UCDavis5	2000	1	2.790	224	0
Sacramento Pikeminnow	Bear Creek/Mid	UCDavis5	2000	1	3.090	234	1
Sacramento Pikeminnow	Bear Creek/Mid	UCDavis5	2000	1	2.580	239	1
Sacramento Pikeminnow	Bear Creek/Mid	UCDavis5	2000	1	2.985	247	1
Sacramento Pikeminnow	Bear Creek/Mid	UCDavis5	2000	1	3.805	280	1
Sacramento Pikeminnow	Bear Creek/Mid	UCDavis5	2000	1	3.480	315	1
Sacramento Pikeminnow	Bear Creek/Mid	UCDavis5	2000	1	4.055	329	1
Sacramento Pikeminnow	Bear Creek/Mid	UCDavis5	2000	1	6.430	381	1
Sacramento Pikeminnow	Bear Creek/Upper	UCDavis5	2000	1	.490	202	0
Sacramento Pikeminnow	Bear Creek/Upper	UCDavis5	2000	1	.730	212	0
Sacramento Pikeminnow	Bear Creek/Upper	UCDavis5	2000	1	.450	212	0
Sacramento Pikeminnow	Bear Creek/Upper	UCDavis5	2000	1	.350	225	0
Sacramento Pikeminnow	Bear Creek/Upper	UCDavis5	2000	1	.475	227	1
Sacramento Pikeminnow	Bear Creek/Upper	UCDavis5	2000	1	.555	241	1
Sacramento Pikeminnow	Bear Creek/Upper	UCDavis5	2000	1	.785	242	1
Sacramento Pikeminnow	Bear Creek/Upper	UCDavis5	2000	1	.770	260	1
Sacramento Pikeminnow	Bear Creek/Upper	UCDavis5	2000	1	.775	263	1
Sacramento Pikeminnow	Bear Creek/Upper	UCDavis5	2000	1	1.035	271	1
Sacramento Pikeminnow	Bear Creek/Upper	UCDavis5	2000	1	1.150	280	1
Sacramento Pikeminnow	Bear Creek/Upper	UCDavis5	2000	1	1.045	284	1
Sacramento Pikeminnow	Cache Creek	TSM	1988	8	.330	235	0
Sacramento Pikeminnow	Cache Creek/N.F.	UCDavis5	2000	1	.150	188	0
Sacramento Pikeminnow	Cache Creek/N.F.	UCDavis5	2000	1	.185	196	0
Sacramento Pikeminnow	Cache Creek/N.F.	UCDavis5	2000	1	.110	202	0
Sacramento Pikeminnow	Cache Creek/N.F.	UCDavis5	2000	1	.125	214	0
Sacramento Pikeminnow	Cache Creek/N.F.	UCDavis5	2000	1	.235	226	0
Sacramento Pikeminnow	Cache Creek/N.F.	UCDavis5	2000	1	.250	232	1
Sacramento Pikeminnow	Cache Creek/N.F.	UCDavis5	2000	1	.115	236	1
Sacramento Pikeminnow	Cache Creek/N.F.	UCDavis5	2000	1	.260	240	1
Sacramento Pikeminnow	Cache Creek/N.F.	UCDavis5	2000	1	.180	245	1
Sacramento Pikeminnow	Cache Creek/N.F.	UCDavis5	2000	1	.230	248	1
Sacramento Pikeminnow	Cache Creek/Rumsey	UCDavis5	2000	1	.180	166	0
Sacramento Pikeminnow	Cache Creek/Rumsey	UCDavis5	2000	1	.445	189	0
Sacramento Pikeminnow	Cache Creek/Rumsey	UCDavis5	2000	1	.290	220	0
Sacramento Pikeminnow	Cache Creek/Rumsey	UCDavis5	2000	1	1.390	241	1
Sacramento Pikeminnow	Cache Creek/Rumsey	UCDavis5	2000	1	.445	288	1
Sacramento Pikeminnow	Cache Creek/Rumsey	UCDavis5	2000	1	.655	314	1
Sacramento Pikeminnow	Cache Creek/Rumsey	UCDavis5	2000	1	.575	315	1
Sacramento Pikeminnow	Cache Creek/Rumsey	UCDavis5	2000	1	.430	324	1
Sacramento Pikeminnow	Cache Creek/Rumsey	UCDavis5	2000	1	.450	336	1
Sacramento Pikeminnow	Cache Creek/Rumsey	UCDavis5	2000	1	.740	355	1
Sacramento Pikeminnow	Cache Creek/Rumsey	UCDavis5	2000	1	1.325	459	1
Sacramento Pikeminnow	Cache Creek/Solano Concrete	UCDavis5	2000	1	.300	193	0
Sacramento Pikeminnow	Cache Creek/Solano Concrete	UCDavis5	2000	1	.405	209	0
Sacramento Pikeminnow	Cache Creek/Solano Concrete	UCDavis5	2000	1	.265	218	0
Sacramento Pikeminnow	Cache Creek/Solano Concrete	UCDavis5	2000	1	.435	221	0
Sacramento Pikeminnow	Cache Creek/Solano Concrete	UCDavis5	2000	1	.465	231	1
Sacramento Pikeminnow	Cache Creek/Solano Concrete	UCDavis5	2000	1	.335	235	1
Sacramento Pikeminnow	Cache Creek/Solano Concrete	UCDavis5	2000	1	1.060	249	1
Sacramento Pikeminnow	Cache Creek/Solano Concrete	UCDavis5	2000	1	.575	262	1
Sacramento Pikeminnow	Cache Creek/Solano Concrete	UCDavis5	2000	1	.405	264	1
Sacramento Pikeminnow	Cache Creek/Solano Concrete	UCDavis5	2000	1	.535	281	1
Sacramento Sucker	Bear Creek/Mid	UCDavis5	2000	1	.860	152	1
Sacramento Sucker	Bear Creek/Mid	UCDavis5	2000	1	1.325	214	1
Sacramento Sucker	Bear Creek/Mid	UCDavis5	2000	1	1.390	228	1
Sacramento Sucker	Bear Creek/Mid	UCDavis5	2000	1	1.330	237	1

Species	Site Name	Project ID	Sample Year	#	Mercury ppm wet wt.	Fork Length[1] mm	Select
Sacramento Sucker	Bear Creek/Mid	UCDavis5	2000	1	1.300	245	1
Sacramento Sucker	Bear Creek/Mid	UCDavis5	2000	1	1.650	278	1
Sacramento Sucker	Bear Creek/Upper	UCDavis5	2000	1	.270	144	1
Sacramento Sucker	Bear Creek/Upper	UCDavis5	2000	1	.120	155	1
Sacramento Sucker	Bear Creek/Upper	UCDavis5	2000	1	.090	158	1
Sacramento Sucker	Bear Creek/Upper	UCDavis5	2000	1	.145	164	1
Sacramento Sucker	Bear Creek/Upper	UCDavis5	2000	1	.305	226	1
Sacramento Sucker	Bear Creek/Upper	UCDavis5	2000	1	.265	236	1
Sacramento Sucker	Bear Creek/Upper	UCDavis5	2000	1	.425	239	1
Sacramento Sucker	Bear Creek/Upper	UCDavis5	2000	1	.300	252	1
Sacramento Sucker	Bear Creek/Upper	UCDavis5	2000	1	.340	252	1
Sacramento Sucker	Bear Creek/Upper	UCDavis5	2000	1	.205	273	1
Sacramento Sucker	Bear Creek/Upper	UCDavis5	2000	1	.185	285	1
Sacramento Sucker	Cache Creek	TSM	1981	6	.470	345	1
Sacramento Sucker	Cache Creek/btw Road 102 & I-5	UCDavis2	1995	1	.290	393	1
Sacramento Sucker	Cache Creek/btw Yolo & Settling Basin	UCDavis5	2000	1	.210	271	1
Sacramento Sucker	Cache Creek/btw Yolo & Settling Basin	UCDavis5	2000	1	.185	273	1
Sacramento Sucker	Cache Creek/btw Yolo & Settling Basin	UCDavis5	2000	1	.500	329	1
Sacramento Sucker	Cache Creek/btw Yolo & Settling Basin	UCDavis5	2000	1	.460	330	1
Sacramento Sucker	Cache Creek/btw Yolo & Settling Basin	UCDavis5	2000	1	.370	348	1
Sacramento Sucker	Cache Creek/btw Yolo & Settling Basin	UCDavis5	2000	1	.535	357	1
Sacramento Sucker	Cache Creek/Clear Lake Outflow	UCDavis5	2000	1	.090	222	1
Sacramento Sucker	Cache Creek/Clear Lake Outflow	UCDavis5	2000	1	.095	256	1
Sacramento Sucker	Cache Creek/Clear Lake Outflow	UCDavis5	2000	1	.110	257	1
Sacramento Sucker	Cache Creek/Clear Lake Outflow	UCDavis5	2000	1	.105	285	1
Sacramento Sucker	Cache Creek/Clear Lake Outflow	UCDavis5	2000	1	.105	290	1
Sacramento Sucker	Cache Creek/Clear Lake Outflow	UCDavis5	2000	1	.190	386	1
Sacramento Sucker	Cache Creek/Clear Lake Outflow	UCDavis5	2000	1	.360	404	1
Sacramento Sucker	Cache Creek/Clear Lake Outflow	UCDavis5	2000	1	.350	414	1
Sacramento Sucker	Cache Creek/Clear Lake Outflow	UCDavis5	2000	1	.320	418	1
Sacramento Sucker	Cache Creek/Clear Lake Outflow	UCDavis5	2000	1	.275	429	1
Sacramento Sucker	Cache Creek/N.F.	UCDavis5	2000	1	.120	264	1
Sacramento Sucker	Cache Creek/N.F.	UCDavis5	2000	1	.055	290	1
Sacramento Sucker	Cache Creek/N.F.	UCDavis5	2000	1	.065	291	1
Sacramento Sucker	Cache Creek/N.F.	UCDavis5	2000	1	.190	367	1
Sacramento Sucker	Cache Creek/N.F.	UCDavis5	2000	1	.190	368	1
Sacramento Sucker	Cache Creek/N.F.	UCDavis5	2000	1	.290	370	1
Sacramento Sucker	Cache Creek/N.F.	UCDavis5	2000	1	.305	376	1
Sacramento Sucker	Cache Creek/N.F.	UCDavis5	2000	1	.345	385	1
Sacramento Sucker	Cache Creek/N.F.	UCDavis5	2000	1	.470	412	1
Sacramento Sucker	Cache Creek/N.F.	UCDavis5	2000	1	.370	437	1
Sacramento Sucker	Cache Creek/Rumsey	UCDavis5	2000	1	.215	264	1
Sacramento Sucker	Cache Creek/Rumsey	UCDavis5	2000	1	.155	298	1
Sacramento Sucker	Cache Creek/Rumsey	UCDavis5	2000	1	.145	309	1
Sacramento Sucker	Cache Creek/Rumsey	UCDavis5	2000	1	.135	317	1
Sacramento Sucker	Cache Creek/Rumsey	UCDavis5	2001	1	.150	331	1
Sacramento Sucker	Cache Creek/Rumsey	UCDavis5	2000	1	.390	336	1
Sacramento Sucker	Cache Creek/Rumsey	UCDavis5	2000	1	.245	342	1
Sacramento Sucker	Cache Creek/Rumsey	UCDavis5	2001	1	.400	345	1
Sacramento Sucker	Cache Creek/Rumsey	UCDavis5	2000	1	.270	375	1
Sacramento Sucker	Cache Creek/Rumsey	UCDavis5	2000	1	.525	435	1

Species	Site Name	Project ID	Sample Year	#	Mercury ppm wet wt.	Fork Length[1] mm	Select
Sacramento Sucker	Cache Creek/Solano Concrete	UCDavis5	2000	1	.120	202	1
Sacramento Sucker	Cache Creek/Solano Concrete	UCDavis5	2000	1	.145	211	1
Sacramento Sucker	Cache Creek/Solano Concrete	UCDavis5	2000	1	.160	256	1
Sacramento Sucker	Cache Creek/Solano Concrete	UCDavis5	2000	1	.195	257	1
Sacramento Sucker	Cache Creek/Solano Concrete	UCDavis5	2000	1	.150	267	1
Sacramento Sucker	Cache Creek/Solano Concrete	UCDavis5	2000	1	.245	338	1
Sacramento Sucker	Cache Creek/Solano Concrete	UCDavis5	2000	1	.275	340	1
Sacramento Sucker	Cache Creek/Solano Concrete	UCDavis5	2000	1	.310	381	1
Sacramento Sucker	Cache Creek/Solano Concrete	UCDavis5	2000	1	.295	401	1
Sacramento Sucker	Cache Creek/Solano Concrete	UCDavis5	2000	1	.350	406	1
Smallmouth Bass	Cache Creek	TSM	1988	12	.150	130	0
Smallmouth Bass	Cache Creek	TSM	1982	12	.170	137	0
Smallmouth Bass	Cache Creek	TSM	1979	2	.680	243	0
Smallmouth Bass	Cache Creek/btw Yolo & Settling Basin	UCDavis5	2000	1	.430	211	0
Smallmouth Bass	Cache Creek/btw Yolo & Settling Basin	UCDavis5	2000	1	.350	227	0
Smallmouth Bass	Cache Creek/d/s Davis Creek	TSM	1989	13	.040	107	0
Smallmouth Bass	Cache Creek/N.F.	UCDavis5	2000	1	.335	295	1
Smallmouth Bass	Cache Creek/Rumsey	UCDavis5	2000	1	.090	142	0
Smallmouth Bass	Cache Creek/Rumsey	UCDavis5	2000	1	.220	158	0
Smallmouth Bass	Cache Creek/Rumsey	UCDavis5	2000	1	.180	158	0
Smallmouth Bass	Cache Creek/Rumsey	UCDavis5	2000	1	.255	180	0
Smallmouth Bass	Cache Creek/Rumsey	UCDavis5	2000	1	.260	180	0
Smallmouth Bass	Cache Creek/Rumsey	UCDavis5	2000	1	.290	229	0
Smallmouth Bass	Cache Creek/Rumsey	UCDavis5	2000	1	.340	239	0
Smallmouth Bass	Cache Creek/Rumsey	UCDavis5	2000	1	.325	250	0
Smallmouth Bass	Cache Creek/Rumsey	UCDavis5	2000	1	.370	251	0
Smallmouth Bass	Cache Creek/Rumsey	UCDavis5	2000	1	.490	278	0
Smallmouth Bass	Cache Creek/Rumsey	UCDavis5	2000	1	.535	281	0
Smallmouth Bass	Cache Creek/Rumsey	UCDavis5	2000	1	.900	281	0
Smallmouth Bass	Cache Creek/Rumsey	UCDavis5	2000	1	.335	283	0
Smallmouth Bass	Cache Creek/Rumsey	UCDavis5	2000	1	.465	292	1
Smallmouth Bass	Cache Creek/Rumsey	UCDavis5	2000	1	.735	307	1
Smallmouth Bass	Cache Creek/Rumsey	UCDavis5	2000	1	.555	311	1
Smallmouth Bass	Cache Creek/Rumsey	UCDavis5	2000	1	.780	332	1
Smallmouth Bass	Cache Creek/Rumsey	UCDavis5	2000	1	.720	344	1
Smallmouth Bass	Cache Creek/Rumsey	UCDavis5	2000	1	.860	378	1
Smallmouth Bass	Cache Creek/Rumsey	UCDavis5	2000	1	1.515	403	1
Smallmouth Bass	Cache Creek/Solano Concrete	UCDavis5	2000	1	.365	151	0
Smallmouth Bass	Cache Creek/Solano Concrete	UCDavis5	2000	1	.455	156	0
Smallmouth Bass	Cache Creek/Solano Concrete	UCDavis5	2000	1	.240	160	0
Smallmouth Bass	Cache Creek/Solano Concrete	UCDavis5	2000	1	.375	163	0
Smallmouth Bass	Cache Creek/Solano Concrete	UCDavis5	2000	1	.375	168	0
Smallmouth Bass	Cache Creek/Solano Concrete	UCDavis5	2000	1	.430	194	0
Smallmouth Bass	Cache Creek/Solano Concrete	UCDavis5	2000	1	.490	246	0
Smallmouth Bass	Cache Creek/Solano Concrete	UCDavis5	2000	1	.550	251	0
Smallmouth Bass	Cache Creek/Solano Concrete	UCDavis5	2000	1	.485	259	0
Smallmouth Bass	Cache Creek/Solano Concrete	UCDavis5	2000	1	.405	271	0
White Catfish	Cache Creek/Clear Lake Outflow	UCDavis5	2000	1	.100	187	1
White Catfish	Cache Creek/Rumsey	UCDavis5	2000	1	.295	172	0
White Catfish	Cache Creek/Rumsey	UCDavis5	2000	1	.180	186	1
White Catfish	Clear Lake	CDHS	1970	10	.260	.	0
White Catfish	Clear Lake/Lower Arm	UCDavis-CLERC	1992	1	.100	.	0
White Catfish	Clear Lake/Lower Lake	TSM	1983	1	.260	287	1
White Catfish	Clear Lake/Lower Lake	TSM	1980	6	.290	305	1
White Catfish	Clear Lake/Oaks Arm	CDFG	1976	1	.240	209	1

Species	Site Name	Project ID	Sample Year	#	Mercury ppm wet wt.	Fork Length[1] mm	Select
White Catfish	Clear Lake/Oaks Arm	CDFG	1984	1	.430	230	1
White Catfish	Clear Lake/Oaks Arm	CDFG	1984	1	.420	243	1
White Catfish	Clear Lake/Oaks Arm	CDFG	1984	1	.620	248	1
White Catfish	Clear Lake/Oaks Arm	CDFG	1984	1	.560	248	1
White Catfish	Clear Lake/Oaks Arm	CDFG	1984	1	.560	265	1
White Catfish	Clear Lake/Oaks Arm	CDFG	1984	1	.600	271	1
White Catfish	Clear Lake/Oaks Arm	CDFG	1976	3	.240	278	1
White Catfish	Clear Lake/Oaks Arm	CDFG	1976	3	.240	280	1
White Catfish	Clear Lake/Oaks Arm	CDFG	1984	1	.400	283	1
White Catfish	Clear Lake/Oaks Arm	CDFG	1984	1	.360	292	1
White Catfish	Clear Lake/Oaks Arm	CDFG	1976	1	.520	305	1
White Catfish	Clear Lake/Oaks Arm	CDFG	1984	1	.520	317	1
White Catfish	Clear Lake/Oaks Arm	CDFG	1984	1	.470	327	1
White Catfish	Clear Lake/Oaks Arm	CDFG	1984	1	.350	328	1
White Catfish	Clear Lake/Oaks Arm	CDFG	1984	1	.610	340	1
White Catfish	Clear Lake/Oaks Arm	CDFG	1984	1	.370	371	1
White Catfish	Clear Lake/Oaks Arm	CDFG	1984	1	.460	383	1
White Catfish	Clear Lake/Rattlesnake Isle	TSM	1983	1	.630	280	1
White Catfish	Clear Lake/Rattlesnake Isle	TSM	1983	1	.600	281	1
White Catfish	Clear Lake/Rattlesnake Isle	TSM	1983	1	.860	296	1
White Catfish	Clear Lake/Rattlesnake Isle	TSM	1983	1	.640	309	1
White Catfish	Clear Lake/Rattlesnake Isle	TSM	1983	1	.750	321	1
White Catfish	Clear Lake/Rattlesnake Isle	TSM	1983	1	.850	325	1
White Catfish	Clear Lake/Rattlesnake Isle	TSM	1983	1	.780	337	1
White Catfish	Clear Lake/Rodman Slough	TSM	1980	6	.210	302	1
White Catfish	Clear Lake/Rodman Slough	TSM	1983	1	.580	359	1
White Catfish	Clear Lake/Upper Arm	CDFG	1976	1	.210	230	1
White Catfish	Clear Lake/Upper Arm	CDFG	1976	2	.330	270	1
White Catfish	Clear Lake/Upper Arm	CDFG	1984	1	.370	291	1
White Catfish	Clear Lake/Upper Arm	CDFG	1984	1	.670	316	1
White Catfish	Clear Lake/Upper Arm	CDFG	1984	1	.540	332	1
White Crappie	Cache Creek/btw Road 102 & I-5	UCDavis2	1995	1	.480	207	1
White Crappie	Cache Creek/btw Road 102 & I-5	UCDavis2	1995	1	.510	238	1
White Crappie	Cache Creek/btw Road 102 & I-5	UCDavis2	1995	1	.650	272	1
White Crappie	Clear Lake/Oaks Arm	CDFG	1984	1	.390	229	1
White Crappie	Clear Lake/Oaks Arm	CDFG	1984	1	.150	238	1
White Crappie	Clear Lake/Oaks Arm	CDFG	1984	1	.360	238	1
White Crappie	Clear Lake/Oaks Arm	CDFG	1984	1	.440	240	1
White Crappie	Clear Lake/Oaks Arm	CDFG	1984	1	.920	240	1
White Crappie	Clear Lake/Oaks Arm	CDFG	1984	1	.320	245	1
White Crappie	Clear Lake/Oaks Arm	CDFG	1984	1	.270	249	1
White Crappie	Clear Lake/Oaks Arm	CDFG	1984	1	.180	252	1
White Crappie	Clear Lake/Oaks Arm	CDFG	1984	1	1.300	304	1
White Crappie	Clear Lake/Upper Arm	CDFG	1984	1	.420	278	1

	Site Name		Sample Year	#	MeHg (ppm ww)	Average Wgt (g)
Crayfish	Clear Lake/Anderson Marsh	UCDavis	1994	7	.04	20.50
Crayfish	Clear Lake/Anderson Marsh	UCDavis	1995	7	.04	10.20
Crayfish	Clear Lake/Anderson Marsh	UCDavis	1995	3	.07	19.54
Crayfish	Clear Lake/Anderson Marsh	UCDavis	1995	1	.04	46.47
Crayfish	Clear Lake/Anderson Marsh	UCDavis	1995	3	.07	25.98
Crayfish	Clear Lake/Anderson Marsh	UCDavis	1996	3	.12	17.31
Crayfish	Clear Lake/Anderson Marsh	UCDavis	1996	1	.11	22.34
Crayfish	Clear Lake/Anderson Marsh	UCDavis	1996	2	.10	30.78
Crayfish	Clear Lake/Narrows	UCDavis	1995	5	.17	25.79
Crayfish	Clear Lake/Narrows	UCDavis	1995	1	.17	44.27
Crayfish	Clear Lake/Narrows	UCDavis	1995	2	.19	57.51
Crayfish	Clear Lake/Oaks Arm	UCDavis	1994	5	.25	16.40
Crayfish	Clear Lake/Oaks Arm	UCDavis	1995	4	.42	15.60
Crayfish	Clear Lake/Oaks Arm	UCDavis	1995	4	.35	25.98
Crayfish	Clear Lake/Oaks Arm	UCDavis	1996	2	.29	17.28
Crayfish	Clear Lake/Oaks Arm	UCDavis	1996	2	.29	29.22
Crayfish	Clear Lake/Oaks Arm	UCDavis	1996	1	.26	47.05
Crayfish	Clear Lake/Oaks Arm/SBMM	UCDavis	1996	3	.32	32.03
Crayfish	Clear Lake/Oaks Arm/SBMM	UCDavis	1996	3	.25	11.86
Crayfish	Clear Lake/Rodman Reclamation Ponds	UCDavis	1995	10	.09	5.38
Crayfish	Clear Lake/Rodman Slough	UCDavis	1994	7	.06	25.30
Crayfish	Clear Lake/Rodman Slough	UCDavis	1995	6	.07	4.70
Crayfish	Clear Lake/Rodman Slough	UCDavis	1995	3	.08	26.79
Crayfish	Clear Lake/Rodman Slough	UCDavis	1995	3	.07	14.66
Crayfish	Clear Lake/Rodman Slough	UCDavis	1995	1	.04	30.67
Crayfish	Clear Lake/Rodman Slough	UCDavis	1996	1	.09	18.40
Crayfish	Clear Lake/Rodman Slough	UCDavis	1996	5	.07	29.69

Appendix V. Descriptive[1] Statistics for Mercury or Methylmercury Concentrations (ppm, wet weight) and Size from Clear Lake

	Mercury ppm						Fork Length mm						Sample Size							
Species	*Mean*	*Median*	*SD*	*Min*	*Max*	*CI*[2]	*Mean*	*Median*	*SD*	*Min*	*Max*	*CI*[2]	*1*	*2*	*3*	*4*	*5*	*6*	*Total # samples*	*Total # Fish*
Black Crappie	.36	.33	.16	.07	.81	.31-.40	233	210	45	174	345	221-246	40	1	1	2	0	0	44	53
Bluegill	.23	.13	.21	.04	.47	.05-.40	151	155	20	124	184	135-168	1	2	1	0	0	0	4	8
Brown Bullhead	.26	.24	.10	.12	.58	.22-.29	311	320	35	220	358	299-323	29	3	0	0	0	0	32	35
Carp	.19	.13	.15	.05	.60	.13-.24	783	762	217	358	1346	702-864	12	0	3	3	0	0	18	33
Channel Catfish	.41	.30	.32	.10	1.50	.34-.49	585	581	172	233	1214	546-625	56	1	6	0	0	0	63	76
Hitch	.16	.15	.06	.07	.28	.13-.18	274	274	13	247	299	269-280	21	0	0	0	0	0	21	21
Largemouth Bass	.62	.54	.33	.10	1.91	.57-.68	382	362	83	290	829	369-396	109	7	2	1	2	0	121	143
Sacramento Blackfish	.27	.27	.09	.08	.45	.23-.31	372	371	20	335	400	363-381	22	0	0	0	0	0	22	22
White Catfish	.41	.36	.19	.21	.86	.36-.47	296	302	34	209	383	286-305	29	1	2	0	0	2	34	49
White Crappie	.47	.38	.36	.15	1.30	.22-.73	251	243	23	229	304	235-268	10	0	0	0	0	0	10	10

	Methylmercury ppm						Average Weight (g)						Sample Size									
Species	*Mean*	*Median*	*SD*	*Min*	*Max*	*CI*[2]	*Mean*	*Median*	*SD*	*Min*	*Max*	*CI*[2]	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*10*	*Total # samples*	*Total # Fish*
Crayfish	.14	.09	.11	.04	.42	.12-.16	20	21	11	5	58	18-23	6	4	7	2	3	1	3	1	27	95

[1] Data weighted by number of individuals per sample

[2] 95 percent Confidence Interval

Appendix VI. Descriptive[1] Statistics for Mercury Concentration (ppm, wet weight) and Length (mm) from Cache Creek

	Mercury ppm						*Length mm*						**Sample Size**					
Species	***Mean***	***Median***	***SD***	***Min***	***Max***	***CI***[2]	***Mean***	***Median***	***SD***	***Min***	***Max***	***CI***[2]	***1***	***6***	***10***	***12***	***Total # samples***	***Total # Fish***
Bluegill	.15	.10	.12	.06	.35	.06-.24	143	152	21	109	169	127-160	9	0	0	0	9	9
Brown Bullhead	.27	.28	.04	.22	.31	.21-.33	295	302	25	260	316	255-335	4	0	0	0	4	4
Carp	.28	.28	.01	.27	.28	.21-.34	206	206	6	202	210	155-257	2	0	0	0	2	2
Channel Catfish	.35	.31	.14	.23	.57	.20-.49	369	352	53	326	470	313-425	6	0	0	0	6	6
Green Sunfish	.32	.33	.04	.21	.40	.31-.34	119	123	9	110	137	115-122	4	0	1	1	6	26
Hardhead	.40	.40	.12	.28	.71	.31-.50	273	266	23	251	325	255-291	9	0	0	0	9	9
Largemouth Bass	.43	.37	.18	.27	.67	.25-.62	400	388	62	330	499	334-466	6	0	0	0	6	6
Sacramento Pikeminnow	.55	.45	.36	.12	1.40	.38-.72	282	262	58	231	459	253-310	19	0	0	0	19	19
Smallmouth Bass	.75	.73	.36	.34	1.52	.45-1.04	333	322	40	292	403	299-366	8	0	0	0	8	8
Sacramento Sucker	.28	.28	.14	.06	.54	.24-.31	334	345	60	202	437	318-350	47	1	0	0	48	53
White Catfish	.14	.14	.06	.10	.18	.00- .65	187	187	1	186	187	180-193	2	0	0	0	2	2
White Crappie	.55	.51	.09	.48	.65	.32-.77	239	238	33	207	272	158-320	3	0	0	0	3	3

[1] Data weighted by number of individuals per sample

[2] 95 percent Confidence Interval

Appendix VII. Descriptive[1] Statistics for Mercury Concentration (ppm, wet weight) and Length (mm) from Bear Creek

	Mercury ppm						*Length mm*						
Species	***Mean***	***Median***	***SD***	***Min***	***Max***	***CI***[2]	***Mean***	***Median***	***SD***	***Min***	***Max***	***CI***[2]	***# Samples (n=1 each)***
Green Sunfish	2.19	2.19	[3]	2.19	2.19	[3]	142	142	3	142	142	[3]	1
Sacramento Pikeminnow	2.20	1.15	1.75	.48	6.43	1.23-3.17	273	263	42	227	381	250-296	15
Sacramento Sucker	.62	.31	.55	.09	1.65	.33-.90	220	236	47	144	285	196-244	17

[1] Data weighted by number of individuals per sample

[2] 95 percent Confidence Interval

[3] Standard deviation and confidence intervals omitted because there was only one sample

Appendix VIII. Statistical Comparisons of Data from Different Locations: Clear Lake versus Cache Creek (Part I) and Oaks Arm versus Other Basins in Clear Lake (Part II)

Statistical analyses performed by Sue Roberts, M.S.

Part I. Clear Lake and Cache Creek

To test whether the data supported treating Clear Lake and Cache Creek separately when evaluating the data and developing consumption guidelines, we used a linear regression approach to conduct an analysis of covariance. We log-transformed mercury and selected length and length-square as the covariate, since a curve analysis indicated a quadratic model as the best fit for these data. Log-transforming length did not improve the model.

The small number of samples from Cache Creek for fish species collected in both Clear Lake and Cache Creek made it difficult to conduct reliable comparisons. Largemouth bass was the only species for which more than a few samples were obtained at Cache Creek (N = 15 at Cache Creek, and N = 180 at Clear Lake). In this species, length accounted for 35 percent of the variance in mercury concentrations ($R^2 = 0.35$; $p < 0.001$). After controlling for length, site predicted an additional four percent of unique variance ($R^2 = 0.04$; $p < 0.001$). These results indicate that length is an important factor in predicting mercury concentrations, and the influence of site, although statistically significant, is likely quite small. In addition, the interaction between length and site was significant ($p < 0.05$) indicating that the relationship between mercury concentration and each of these water bodies differs by fish length and, furthermore, the relationship between fish length and mercury concentration differs between the two locations. Consequently, a single regression equation cannot be used to characterize mercury concentrations for bass of the same length in both water bodies.

The scatterplot of the data shown in Appendix VIII of the draft report (and Figure 1 in this appendix) shows that in the mid size range, mercury concentrations for largemouth bass from the two locations overlap. These sizes are of primary interest for advisories because they include fish of legal size and greater. However, the scatterplot also illustrates the small number of samples for Cache Creek. More samples would be needed from Cache Creek to clarify the respective concentrations in each water body. However, to examine the potential effect of small site differences in largemouth bass using the available data, we compared mean mercury concentrations for this species in Clear Lake and Cache Creek using both the observed means and hypothetical values calculated from independent regression equations for fish of equivalent size from each water body. We estimated the mean concentration of mercury in 329-mm largemouth bass (a medium-sized bass of legal length) for both water bodies. We chose bass of this size because largemouth bass of all sizes were used in the regression equations to estimate mercury concentration and this was the average length for all largemouth bass from both water bodies. The predicted mercury concentrations for a 329-mm largemouth bass were 0.483 ppm from Clear Lake and 0.399 ppm from Cache Creek. The measured mean concentrations for bass were 0.62 ppm in Clear Lake and 0.43 ppm in Cache Creek. Neither the predicted or measured mercury concentrations at Clear Lake would warrant different consumption advice.

The analysis of one species, largemouth bass, showed that differences between the water bodies would not result in different consumption advice. The data, overall, were insufficient to explore potential differences between the water bodies in greater detail or with greater certainty. We therefore chose to consider the data for both Clear Lake and Cache Creek together, as this would allow for health protective advice to be issued even when some sample sizes were limited. Providing the same advice for Clear Lake and Cache Creek is also consistent with our goal to keep our recommendations as simple as possible so they will be easier for people to understand and follow.

Part II. Oaks Arm versus other basins in Clear Lake

To test whether the data supported treating the Oaks Arm separately from the other Clear Lake basins, we used a linear regression approach to conduct an analysis of covariance to compare mercury concentrations in fish from different basins in Clear Lake. We log-transformed mercury and selected length and length-square as the covariate, since a curve analysis indicated a quadratic model as the best fit for these data. The results of the regression analyses differed by species, as described below. Scatterplots of the data for each species are shown in Figures 2-5. We only analyzed species for which there were nine or more samples from Oaks Arm and nine or more samples from the other arms combined.

In channel catfish, length explained about 29 percent of the variance in mercury concentrations ($p < 0.001$). Site did not explain any additional variance. A test for interaction was non-significant. Therefore, after accounting for length, channel catfish from Oaks Arm were not likely to have higher mercury concentrations than those from other Clear Lake sites.

In black crappie, length was significant ($p < 0.001$) and explained about 33 percent of the variance, but site was non-significant. The test for interaction was significant ($p < 0.001$) indicating that the relationship between size and mercury concentration differed by location. Black crappie from Oaks Arm and other basins, however, were not more likely to have different mercury concentrations.

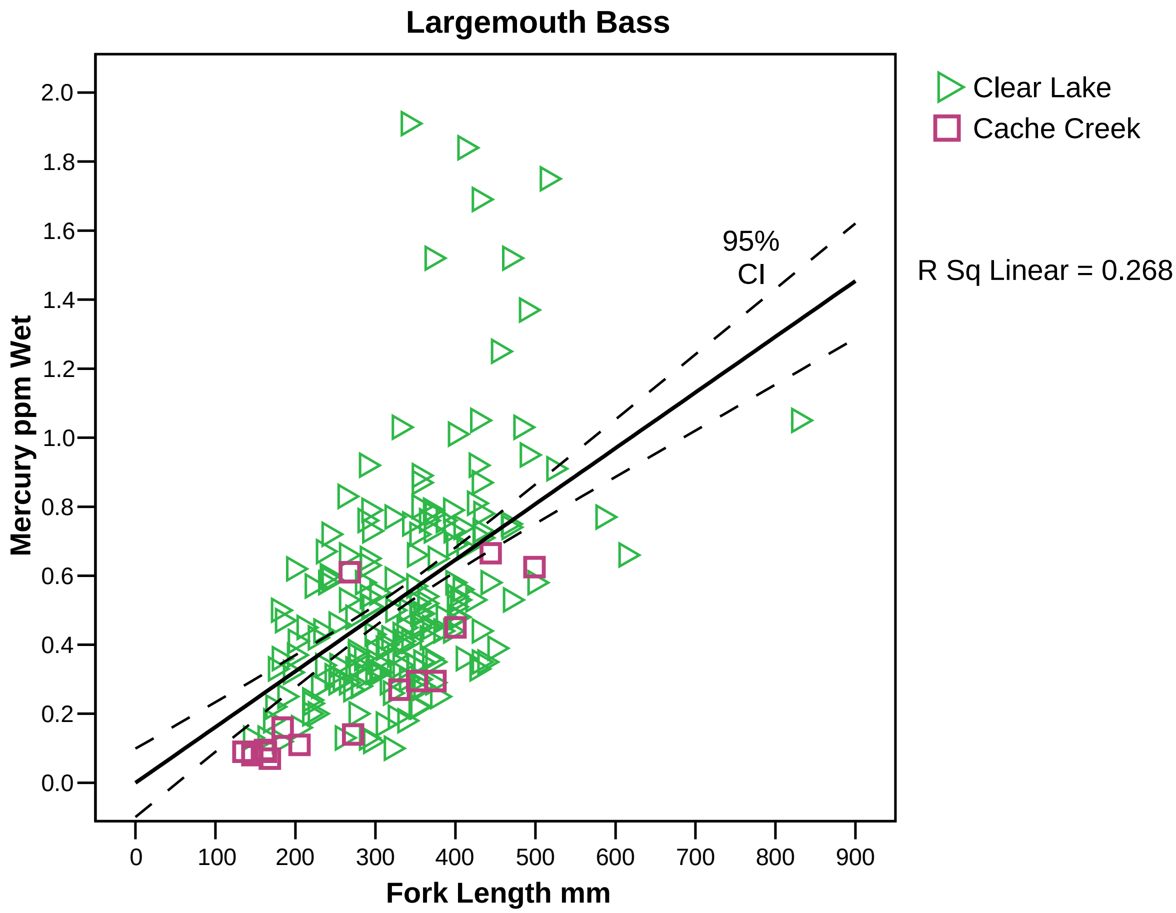
For largemouth bass, length and site were each significant factors. Length explained about 28 percent of the variance ($p < 0.001$) and site explained an additional 26 percent of unique variance ($p < 0.001$). However, the interaction between length and site was also significant ($p < 0.05$). Therefore, the relationships between site, length, and mercury concentration are complex and not easily defined with these data. Again, a single model cannot be used to predict mercury concentrations because of the interaction between these factors. To examine the potential effect of these site differences in largemouth bass, we compared mean mercury concentrations for this species in Oaks Arm and the other Clear Lake arms using both the observed means and hypothetical values calculated from independent regression equations for fish of equivalent size from each basin. We estimated the mean concentration of mercury in 328-mm largemouth bass for all arms. We chose bass of this size because largemouth bass of all sizes were used in the regression equations to estimate mercury concentration and this was the average length for all largemouth bass from all arms of Clear Lake. The predicted mercury concentrations for a

328-mm largemouth bass were 0.722 ppm from Oaks Arm and 0.372 ppm from the other arms combined (0.418 ppm for Upper Arm and 0.307 ppm for Lower Arm). The measured mean concentration for bass was 0.807 ppm in Oaks Arm and 0.485 ppm in the other arms. Both the predicted and measured mercury concentrations at Clear Lake would warrant different consumption advice for women beyond childbearing age and men at Oaks Arm.

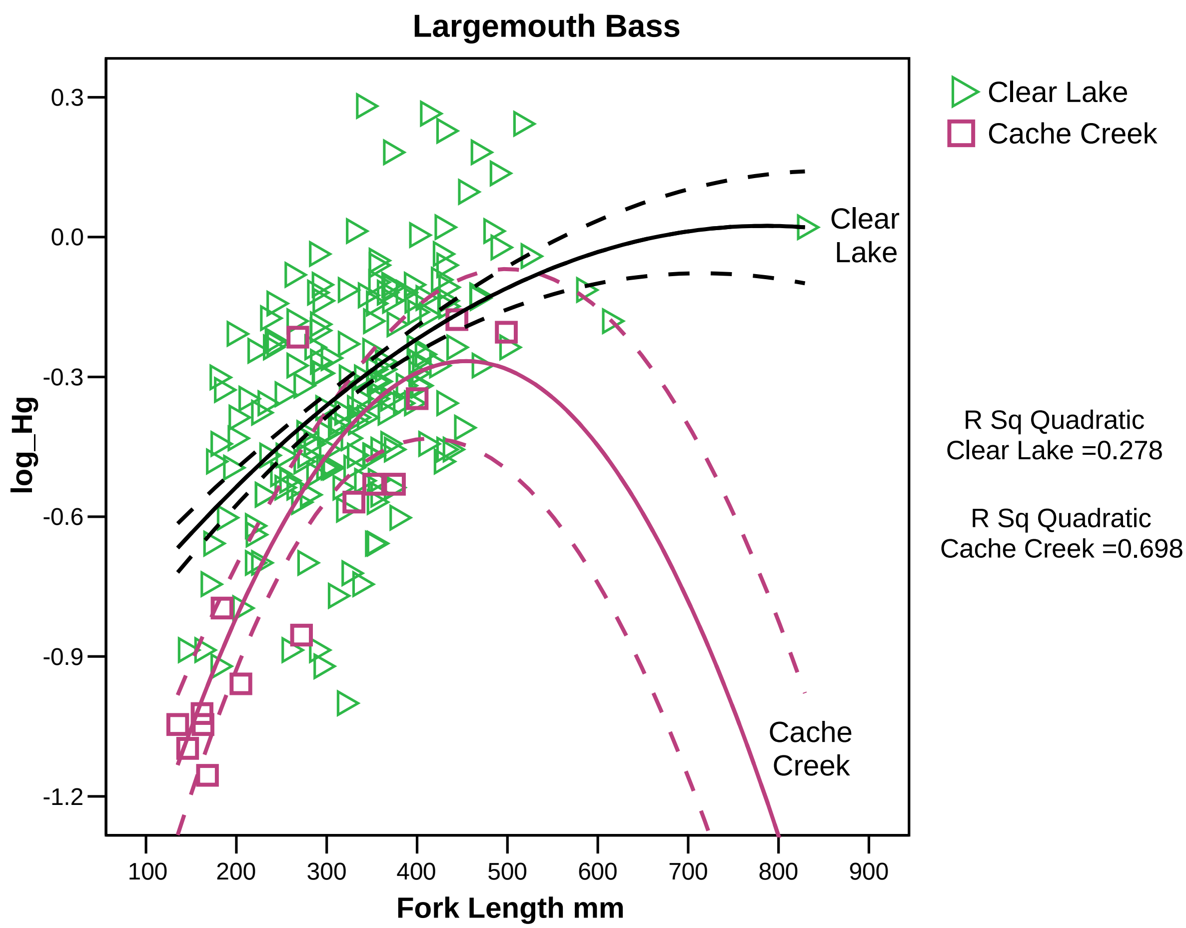
Finally, in white catfish, length was not significant but site was a significant factor ($p < 0.001$) and explained 23 percent unique, additional variance after accounting for length. The test for interaction was non-significant. Therefore, white catfish reflected a significant difference in mercury concentrations attributable to site, and because the interaction factor was non-significant, we used the regression equation to predict mercury concentrations in different arms for similarly sized fish. We estimated that a 296-mm white catfish (the average size for all of Clear Lake) from Oaks Arm would have a mercury concentration of 0.454 ppm and one from other basins combined would have 0.290 ppm mercury (0.297 for Upper Arm and 0.278 for Lower Arm). The measured mean concentration for white catfish was 0.484 ppm in Oaks Arm and 0.315 ppm in the other arms. Neither the predicted or measured mercury concentrations at Clear Lake would warrant different consumption advice.

To summarize, the statistical analyses of these four species showed a different pattern in each species. Although the influence of site (Oaks Arm versus other basins) was not straightforward, it was significant in two of the four species: largemouth bass and white catfish. Because we found some evidence of higher mercury concentrations in some fish species in Oaks Arm, we calculated the mean mercury concentrations for Oaks Arm, Upper Arm, and Lower Arm separately for each species with a minimum of nine fish in Oaks Arm and nine fish in at least one of the other arms (black crappie, carp, channel catfish, white catfish, and largemouth bass). These mean values were compared to their respective levels of consumption advice. We found that in nearly all cases, although there were trends toward higher mercury concentrations in fish from Oaks Arm, the advice would be the same for each basin. For two species, channel catfish and black crappie, mean mercury concentrations were highest in Upper Arm, but the advice would also remain the same. This evaluation suggested that more conservative advice could be appropriate for Oaks Arm for largemouth bass. In this species, more conservative advice would be appropriate for the general (non-sensitive) population only, *i.e.*, women beyond childbearing age and men. In effect, if a person from this population ate predominantly largemouth bass, always caught it from Oaks Arm, and followed OEHHA's advisory for Clear Lake (in this report), this consumer would slightly exceed the reference dose. Using the measured mean mercury concentration for Oaks Arm (0.807 ppm), the Hazard Quotient, a measure of exposure relative to the reference dose (*i.e.*, exposure dose/reference dose) was 1.15 for largemouth bass. As indicated in the report, exposure at a level above the reference dose does not mean that adverse effects will occur, only that the possibility of adverse effects occurring has increased, and in this case, the increased risk is quite small. Therefore, OEHHA does not believe that this scenario poses a serious risk or warrants increasing the complexity of the advisory message by adding different advice for women beyond childbearing age and men for consumption of just one species (largemouth bass) from Oaks Arm. However, if residents of the area prefer to fish in (and eat their catch from) Oaks Arm, they may choose to modify their consumption patterns to reduce their potential exposure to methylmercury by eating fewer fish, especially bass, from Oaks Arm, eating them less frequently, and/or fishing in other locations.

Figure 1. A Comparison of Largemouth Bass from Clear Lake and Cache Creek



1a. Scatterplot before log-transformation of mercury (as in Appendix VIII of the draft report) showing regression line and confidence intervals for Clear Lake and Cache Creek combined



1b. Scatterplot with log-transformation of mercury showing regression lines and confidence intervals for Clear Lake and for Cache Creek

Figure 2. Comparison of Channel Catfish from Oaks Arm and All Other Clear Lake: Scatterplot with log-transformation of mercury showing regression lines for Oaks Arm and for the other Clear Lake Arms

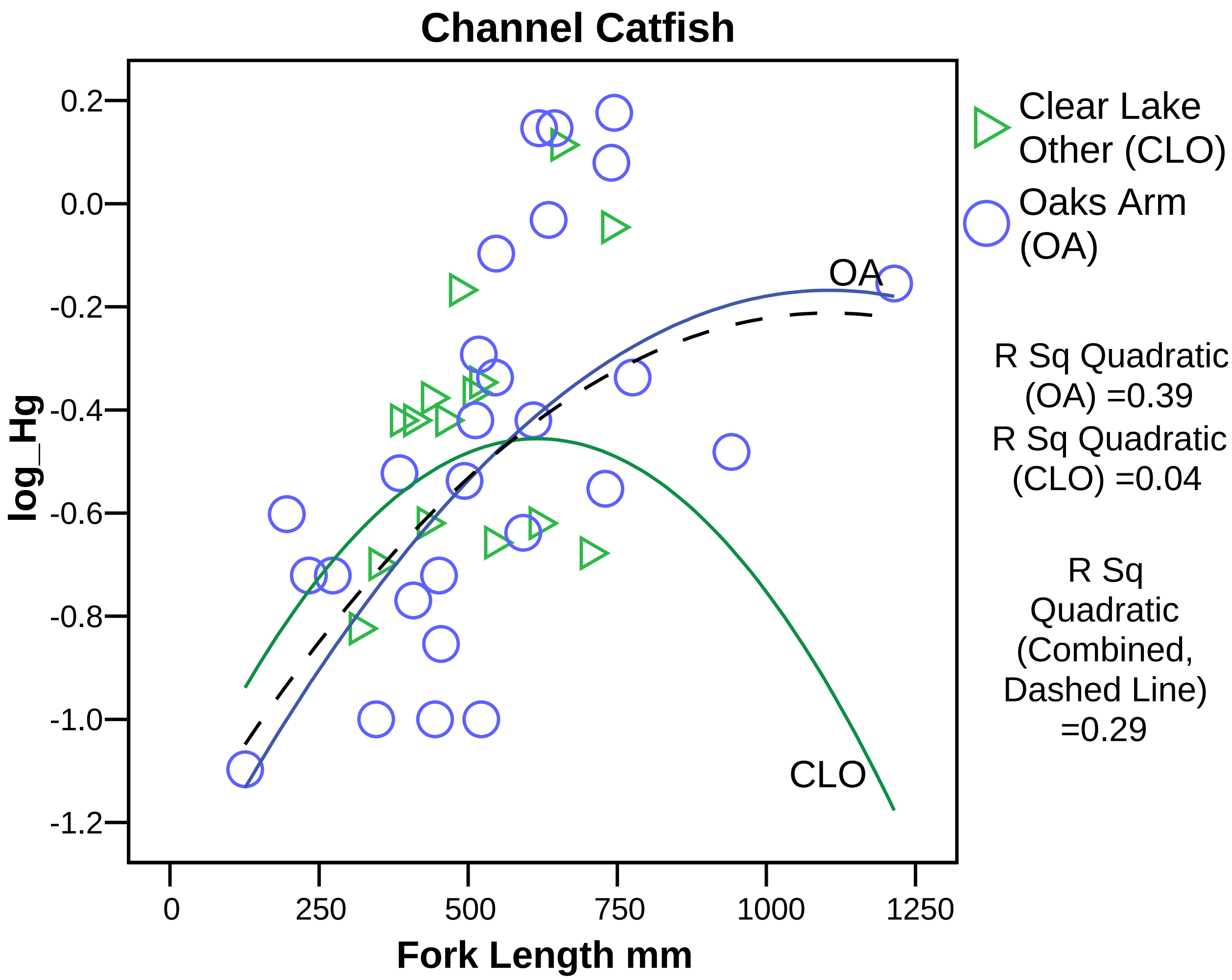


Figure 3. Comparison of Black Crappie from Oaks Arm and All Other Clear Lake: Scatterplot with log-transformation of mercury showing regression lines for Oaks Arm and for the other Clear Lake Arms

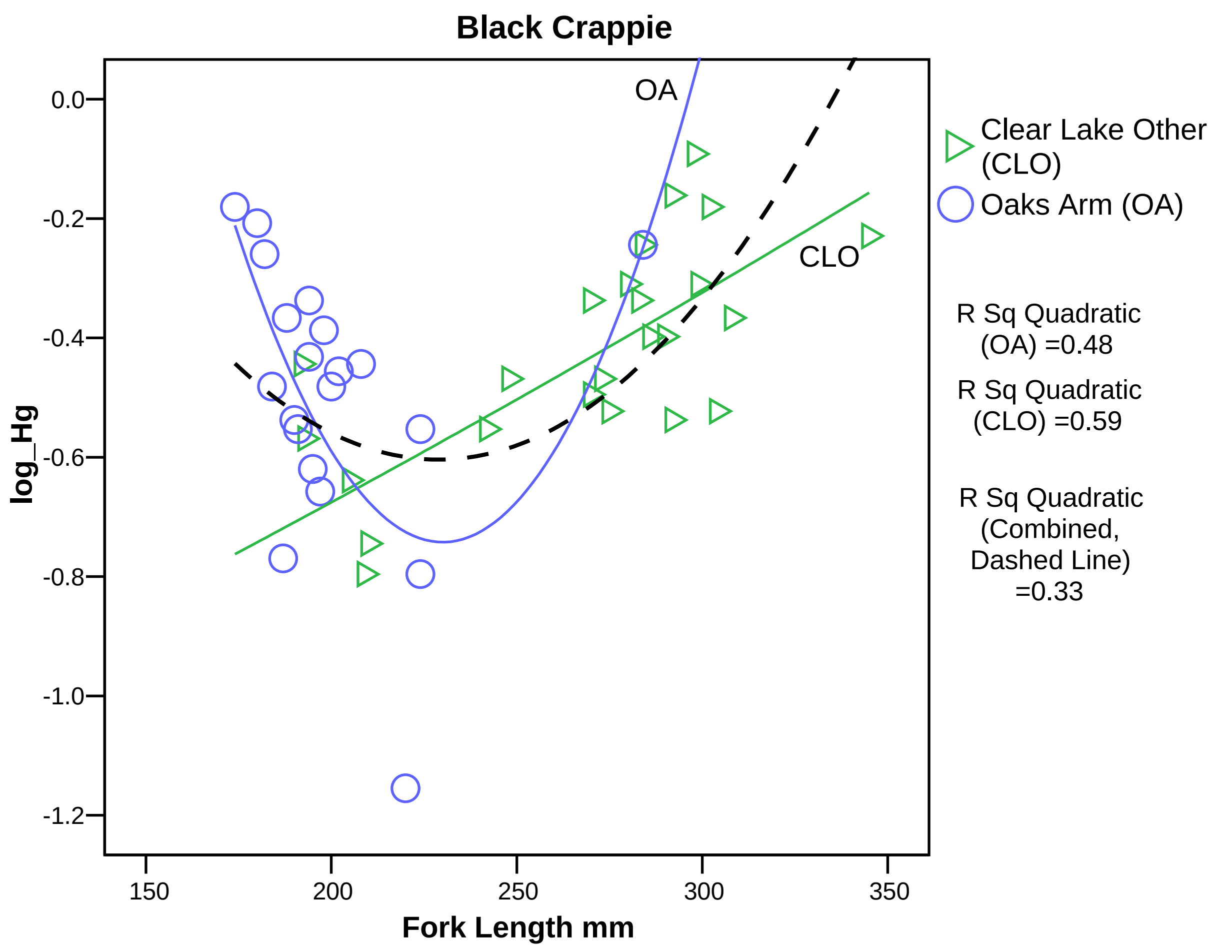


Figure 4. Comparison of Largemouth Bass from Oaks Arm and All Other Clear Lake: Scatterplot with log-transformation of mercury showing regression lines for Oaks Arm and for the other Clear Lake Arms

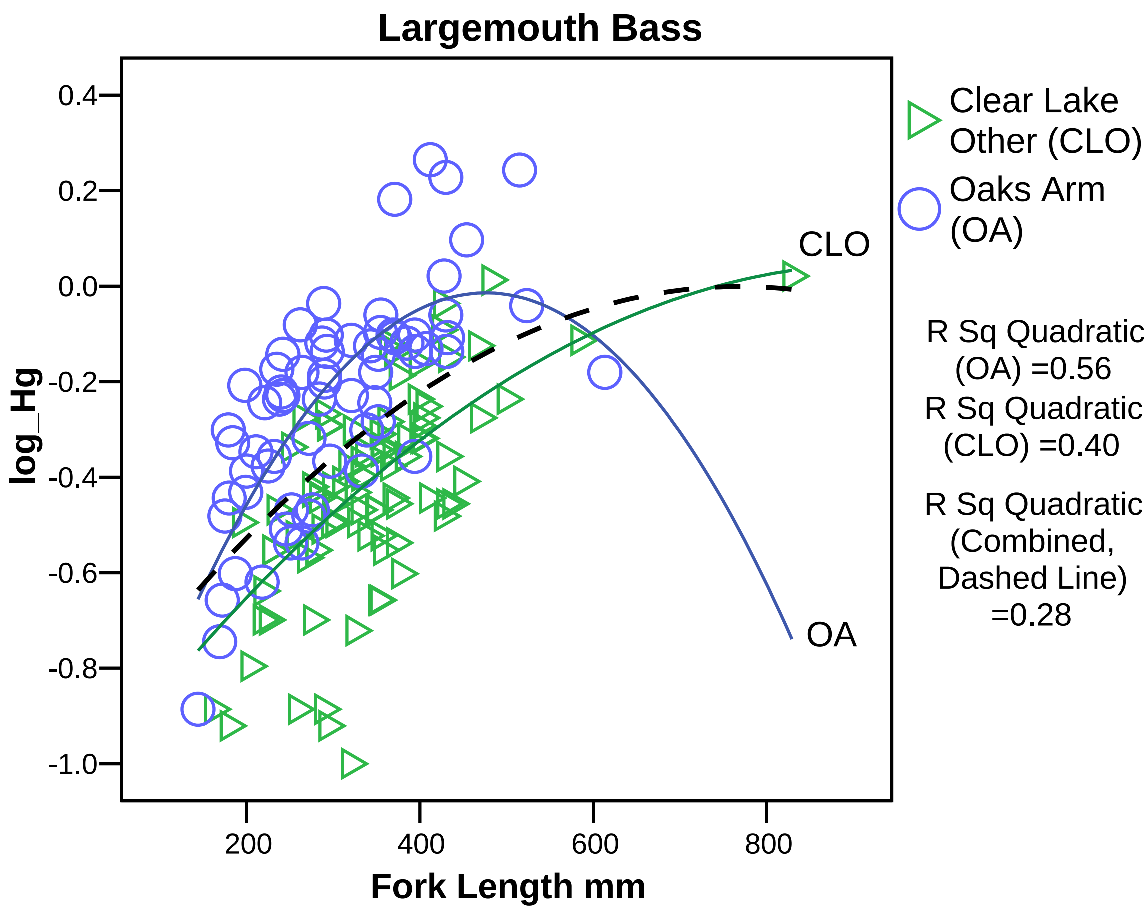
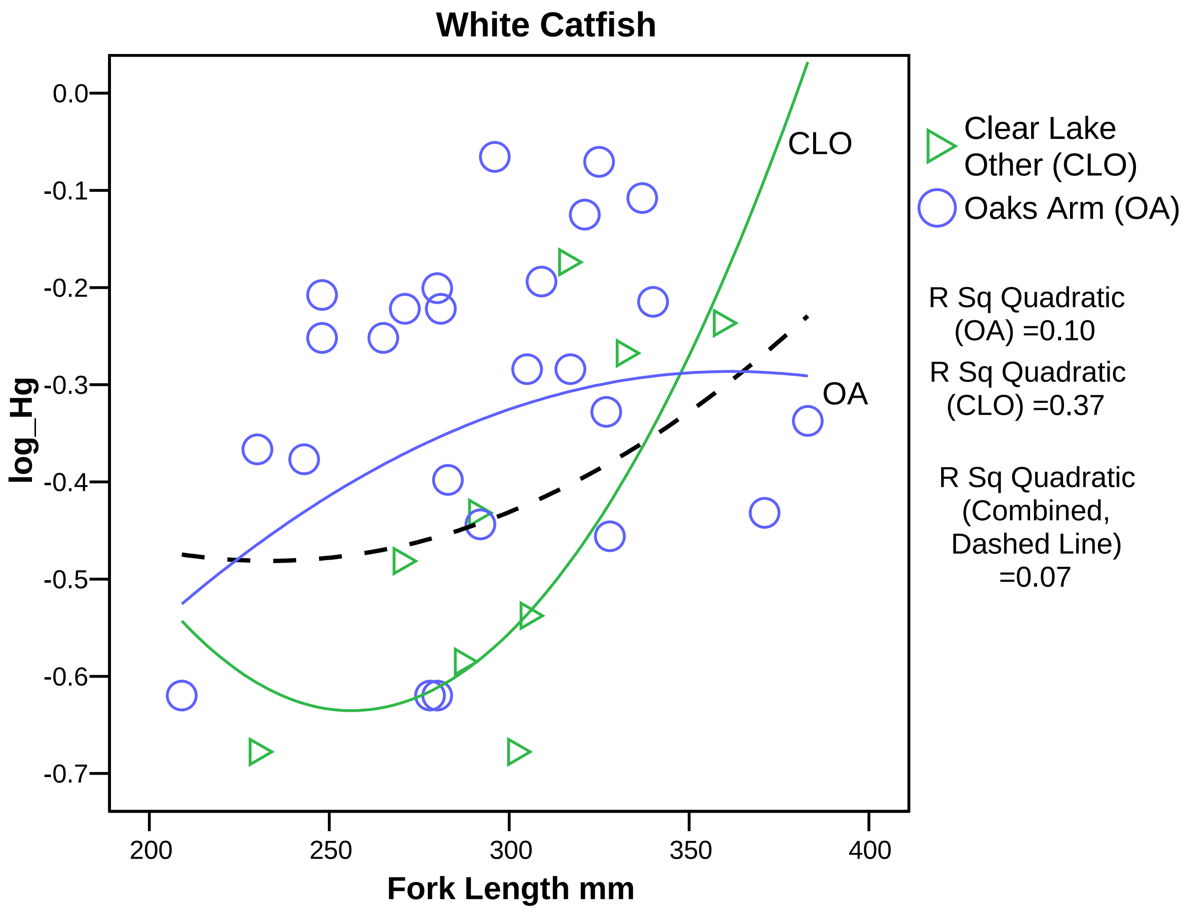


Figure 5. Comparison of White Catfish from Oaks Arm and All Other Clear Lake: Scatterplot with log-transformation of mercury showing regression lines for Oaks Arm and for the other Clear Lake Arms



Appendix IX. Response to Comments on the Draft Health Advisory: Guidelines for Consumption of Fish and Shellfish from Clear Lake, Cache Creek, and Bear Creek (Lake, Yolo, and Colusa Counties), May 11, 2004

Commenter 1: *I suggest rewriting the later part of the section "Why is mercury found in fish from this region?" and start with the sentence "Once mercury accumulates...." and replace "accumulates" with "deposits". I think the description of how methylmercury accumulates could be stated in a different way and suggest a rewrite.*

I think what is needed is a simple, yet better description of how methylmercury bioaccumulates in the food chain from the bottom to the top. Also, stating that bacteria converts the inorganic form of mercury into a more toxic, organic form is probably not entirely accurate. I believe that there are factors other than bacteria that can change the structure of elemental mercury as it transitions to methyl mercury. I'm not suggesting overcomplicating the text.

Response: This comment was made in reference to the draft fact sheet (distributed at the same time that the draft report was released) rather than the draft report. We have considered rewording descriptions of mercury bioaccumulation. We are adding the following information about mercury deposition to the fact sheet. "Mercury contamination in fish is a global problem. Emissions from volcanoes and coal-burning power plants release mercury into the air where it can be carried worldwide before being deposited in oceans, lakes, and rivers." The accumulation of mercury in sediments is a concern because the more mercury that accumulates, the greater the opportunity for transformation to methylmercury. Further information about bioaccumulation of methylmercury in fish is included in the report for the Clear Lake, Cache Creek, and Bear Creek advisory, and in OEHHA's fact sheet on methylmercury (also included as an appendix of the report).

Although physical and chemical characteristics of water bodies can affect the methylation process, the conversion of inorganic mercury to methylmercury by bacteria and other microorganisms is an essential part of the methylation process that creates the more toxic organic form of mercury, methylmercury, which is taken up by fish. We have omitted these kinds of details to keep the fact sheet simple.

Commenter 2: *We feel that in general this Report and Advisory appropriately addresses methyl mercury (MeHg) contamination of sport fish and their associated risk for human consumption. However, based on our knowledge of the spatial distribution of fish Hg and bioaccumulation rates in these water-bodies we have some specific concerns regarding the generality of the advisories, as well as technical concerns with some of the statistical analyses employed.*

In evaluating the available data on fish tissue concentrations in Clear Lake and Cache Creek, OEHHA determined that these concentrations were not significantly different between sites and decided to pool the data, issuing a blanket consumption guideline for both water bodies. Overall *this is a valid approach, however the evaluation failed to investigate the spatial gradient of fish Hg concentrations in Clear Lake. Because Clear Lake is comprised of three large (limnologically distinct) basins with a relatively narrow connection, we suggest that each basin might better be treated as a different site. While fish from each basin possess the ability to move about the lake freely, it is likely that they often remain in an individual basin for considerable periods of time, and may be exposed to Hg on a basin-specific basis.*

The Consumption Advisory also identifies that Clear Lake contains a large Hg point-source on the shores of the Oaks Arm (Sulphur Bank Mine). As a result, fish collected in the Oaks arm have a significantly higher body burden of Hg than fish from the rest of the lake. This is of concern because some residents of the area (particularly those living near the shores of the Oaks Arm) may prefer to angle in these waters and consume their catch. If the Oaks Arm fish contain Hg concentrations high enough to significantly increase human health risk, then this advisory should consider the Oaks Arm separately from the other sites.

In their analysis of the available data, the authors of the draft advisory utilize a multivariate stepwise linear regression to compare Hg concentrations in fish from Clear Lake and Cache Creek, resulting in the conclusion that most of the variance in fish Hg concentrations (~27%) was due to length, while site (water body) only explained ~1% of the variance. This conclusion led OEHHA to pool the data from Clear Lake and Cache Creek, and issue a blanket consumption advisory for both water bodies. We feel that the statistical model used in the above approach is somewhat invalid for the available data and suggest a different approach. First, there is an abundance of literature showing that the relationship between fish Hg concentration and length is not linear, and the figure in Appendix VIII of the consumption advisory suggests a logarithmic shaped curve. In order to meet the assumptions of the linear regression used in the analysis, the data should be log-transformed. This will linearize the data and allow a valid comparison of both slope and intercept for fish from each water body. In addition, we recommend employing a different model for the log-transformed data. We feel that a more informative and efficient approach is a two-way analysis of covariance (ANCOVA) model with species and site as the independent variables, Hg concentration as the dependent variable, and fish length as the covariate. This approach will allow for multiple comparisons across and within sites/species, and will provide more information on the factors controlling the variance of Hg concentrations in fish from these locations.

Response: In response to the comment, we log-transformed mercury and selected length and length-square as the covariate, since a curve analysis indicated a quadratic model as the best fit for these data. Log-transforming length did not improve the model. In the case of largemouth bass from Clear Lake versus Cache Creek, with mercury log-transformed, and length and length-square as the covariate, R^2 increased from 27 percent (before the transformation) to 35 percent, indicating that length accounted for 35 percent of the variance in mercury concentrations. Site predicted an additional four percent of unique variance (compared to one percent before transforming the data). Although the transformation improved R^2, the results still support our original conclusion that length is the important factor in predicting mercury concentrations, and the influence of site, although statistically significant, is likely quite small.

Regarding choice of models, we used the linear regression approach to conduct an analysis of covariance. Multiple regression/correlation analysis (MRC) is the appropriate strategy for analyzing non-experimental research (Keppel and Zedeck, 1989[1]). We performed an analysis of covariance by using a stepwise approach with length as a covariate. Although an ANCOVA strategy is often appropriate for analyzing experimental data, where there is random assignment to treatment, MRC is a better strategy for analyzing this non-experimental research. We consulted with Dr. Steve Selvin, Professor of Biostatistics and Epidemiology at the University of California at Berkeley and he affirmed this point.

Nevertheless, as a result of reviewing our statistical analyses, we also reconsidered the comparisons of data from different locations (*e.g.*, Clear Lake and Cache Creek). As indicated above, the analysis showed that site (Clear Lake versus Cache Creek) explained an additional four percent of unique variance after controlling for length. However, there was also a significant interaction between length and site ($p < 0.05$), and overall, the data were insufficient to explore potential differences between the water bodies in greater detail or with certainty. Further details of the analysis can be found in Appendix VIII.

Because OEHHA's objective is to determine appropriate levels of advice, after closer inspection we did not find the regression analyses particularly useful in meeting this objective. The small number of samples from Cache Creek for species collected in both Clear Lake and Cache Creek made it difficult to conduct reliable comparisons. Therefore, statistical analyses did little to resolve questions about whether the two water bodies can be considered together in the advisory or should be addressed separately.

For our objective it is important to bear in mind that even when statistically significant differences are found, the differences may not be important when the advice level does not differ. So, ultimately, the purpose of the evaluations is to determine what advice is appropriate. The mean mercury concentrations for largemouth bass (the only species with sufficient data to compare Clear Lake and Cache Creek), even though different, would not warrant different levels of advice. In summary, as indicated in the report, we chose to consider the data for both water bodies together, as this would allow for health protective advice to be issued even when some sample sizes were limited. Providing the same advice for Clear Lake and Cache Creek is also consistent with our goal to keep our recommendations as simple as possible so they will be easier for people to understand and follow. While further analysis of the patterns of bioaccumulation of mercury in these water bodies (pending additional data) might be interesting from a biological or ecological perspective, our intent is to provide reasonable guidelines to the public so they can protect their health. The advice provided here for Clear Lake and Cache Creek meets this objective.

Regarding the question of differences between Oaks Arm and other basins in Clear Lake: OEHHA does not usually consider a water body to contain distinct sites because of the mobility of fish and our intent to be protective of the fish consumer who could conceivably catch the same contaminated fish in different places within the same lake or reservoir. In addition, we were

[1] Keppel, G. & Zedeck, S. (1989). Data analysis for research designs: Analysis of variance and multiple regression/correlation approaches. W.H. Freeman and Company: New York. ISBN 0-7167-1991-6.

aware that bass tournaments frequently occur at Clear Lake in which fish are returned to different places than where they were caught. Although sediment patterns in Clear Lake suggest that Oaks Arm would have higher mercury concentrations, accumulation of methylmercury in higher trophic level organisms does not necessarily follow the same pattern. However, given the commenters' point about limnologically distinct basins, and the large size of the basins and distance between them, we re-evaluated the data comparing four fish species for which a reasonable number of samples were collected in Oaks Arm and in other arms of Clear Lake. Again, we log-transformed mercury and used length and length-square as the covariate. The results of the regression analyses can be found in Appendix VIII of the report. To summarize, the statistical analyses of the four species showed a different pattern in each species (see Figures 2-5 in Appendix VIII), and the influence of site (Oaks Arm versus other basins) was significant in two of the four species: largemouth bass and white catfish.

We agree with the commenter that consumers should be provided with protective guidelines if fish from Oaks Arm (or other locations) contain methylmercury concentrations high enough to significantly increase human health risk. Because we did find some evidence of higher mercury concentrations in some fish species in Oaks Arm, we calculated the mean mercury concentrations for Oaks Arm, Upper Arm, and Lower Arm separately for each species with a minimum of nine fish each from Oaks Arm and at least one other arm, and compared the values to their respective levels of consumption advice. We found that in nearly all cases, although there were trends toward higher mercury concentrations in fish from Oaks Arm, the advice would be the same for each basin. The advice would also remain the same for channel catfish and black crappie whose mean mercury concentrations were highest in Upper Arm. The only case in which this evaluation suggested that more conservative advice could be appropriate for Oaks Arm was for largemouth bass. In this species, more conservative advice would be appropriate for the general (non-sensitive) population only, *i.e.*, women beyond childbearing age and men. In effect, if a person from this population ate predominantly largemouth bass, always caught it from Oaks Arm, and followed OEHHA's advisory for Clear Lake (in this report), this consumer would slightly exceed the reference dose (Hazard Quotient, *i.e.*, exposure dose/reference dose = 1.15). Therefore, OEHHA does not believe that this scenario poses a serious risk or warrants increasing the complexity of the advisory message by adding different advice for women beyond childbearing age and men for consumption of just one species (largemouth bass) from Oaks Arm. However, if residents of the area prefer to fish in (and eat their catch from) Oaks Arm, they may choose to modify their consumption patterns to reduce their potential exposure to methylmercury by eating fewer fish, especially bass, from Oaks Arm, eating them less frequently, and/or fishing in other locations.

<u>Commenter 3</u>: *I'm wondering about the clams from Clear Lake. Tribal members eat lots of those.*

<u>Response</u>: Unfortunately, the dataset did not include any data on clams. However, we received some preliminary data from Dr. Tom Suchanek, U.C. Davis, in which two types of clams from Clear Lake (*Anodonta* and *Corbicula*) were tested for total mercury (data not shown). Although it is more likely that people would eat *Anodonta* clams than *Corbicula*, both species showed extremely low concentrations of mercury, and therefore, would be safe to eat.