EVALUATION OF POTENTIAL HEALTH EFFECTS OF EATING FISH FROM BLACK BUTTE RESERVOIR (GLENN AND TEHAMA COUNTIES): GUIDELINES FOR SPORT FISH CONSUMPTION

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FOREWORD

This report provides recommended guidelines for consumption of largemouth bass and channel catfish from Black Butte Reservoir (Glenn and Tehama Counties) as a result of findings of high levels of mercury in fish tested from Black Butte Reservoir. These recommendations are made to protect against possible adverse health effects from methylmercury as consumed from mercury-contaminated fish. The report provides background information and a description of the data and criteria used to develop the guidelines.

To protect public health in the period while this technical support document was being prepared for public comment, the County of Glenn Health Services Agency, Division of Environmental Health, and the County of Tehama Health Services, in consultation with the Office of Environmental Health Hazard Assessment, issued an interim public health advisory for fish from Black Butte Reservoir. This advisory is included in Appendix I. Once finalized, the advisory contained herein will become the final state advisory.

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TABLE OF CONTENTS

LIST OF CONTRIBUTORS i
FOREWORD ii
TABLE OF CONTENTS iii
EXECUTIVE SUMMARY 1
INTRODUCTION 5
BACKGROUND 5
METHYLMERCURY TOXICOLOGY AND HAZARD IDENTIFICATION 7
DOSE-RESPONSE ASSESSMENT FOR METHYLMERCURY 9
EXPOSURE ASSESSMENT OF EATING SPORT FISH FROM BLACK BUTTE RESERVOIR 12
Fish Consumption Data 12
Mercury Contamination Data 13
RISK CHARACTERIZATION OF EATING SPORT FISH FROM BLACK BUTTE RESERVOIR 15
SUPPORTING DATA FOR DEVELOPING FISH CONSUMPTION GUIDELINES 16
GUIDELINES FOR FISH CONSUMPTION 17
REFERENCES 21

APPENDIX 1: *INTERIM FISH CONSUMPTION ADVISORY FOR BLACK BUTTE RESERVOIR* 35
APPENDIX 2: *METHYLMERCURY IN SPORT FISH: INFORMATION FOR FISH CONSUMERS* 40
APPENDIX 3: *RESPONSES TO COMMENTS ON THE REPORT AND ADVISORY* 46

LIST OF FIGURES

FIGURE 1: MAP OF BLACK BUTTE RESERVOIR AND COLLECTION SITES 27

LIST OF TABLES

Table 1: Physical Characteristics of Fish in Composites from Black Butte Reservoir 28
Table 2: Mean Chemical Concentrations in Fish from Black Butte Reservoir for which there are California Lakes Study Screening Values 29
Table 3: Descriptive Statistics for Methylmercury Concentration in Largemouth Bass and Channel Catfish 30
Table 4: Methylmercury Concentration, Exposure Dose and Hazard Index for Fish from Black Butte Reservoir 31
Table 5. Guidelines for Tissue Levels at the Methylmercury Reference Level 32
Table 6. Adjusting Fish Meal Size for Body Weight 34

EXECUTIVE SUMMARY

The Office of Environmental Health Hazard Assessment (OEHHA) performed a study, "Prevalence of Selected Target Chemical Contaminants in Sport Fish from Two California Lakes: Public Health Designed Screening Study," (California Lakes Study) of chemical contamination in sport fish from Black Butte Reservoir. Sampling design for this study was limited by the screening nature of the study and the funding available. The results of that study were used in this evaluation of the potential health effects of consuming sport fish from Black Butte Reservoir. The goal of the health evaluation was to assess the likelihood and degree of exposure to chemical contaminants in fish from Black Butte Reservoir and to determine whether a potential exists for possible adverse effects from this exposure to sport fish consumers using this lake. The study data were used to determine the nature and extent of chemical contamination in sport fish from Black Butte Reservoir. A copy of this report is available at **www.oehha.ca.gov.** Mercury, in the form of methylmercury, was identified as the chemical of concern for persons consuming sport fish from Black Butte Reservoir.

More than 95 percent of the mercury found in fish occurs as methylmercury, which is a more toxic form of the element. Fish consumption accounts for almost 100 percent of the average daily methylmercury intake in adults not occupationally exposed to mercury. 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. The United States Environmental Protection Agency (U.S. EPA) has 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 $1x10^{-4}$ mg/kg-day, based on developmental neurologic abnormalities in infants exposed *in utero*. A second RfD of $3x10^{-4}$ has been set based on central nervous system effects (ataxia and paresthesia) in adults. In this advisory, the RfD based on effects in infants will be used for females of childbearing age and children aged 17 and younger. The adult RfD will be used for females beyond their childbearing years and adult males.

Potential methylmercury exposures using different consumption scenarios were evaluated for persons consuming fish from Black Butte Reservoir. Data were sufficient so that exposures could be well characterized only for largemouth bass and channel catfish. The health evaluation found that fishers consuming these species from this reservoir are potentially exposed to methylmercury concentrations above the reference dose.

A standard exposure and risk assessment could not be conducted for other species because of insufficient sample size; however, the evaluation of supporting data did allow for development of additional consumption guidelines. Supporting data included contamination data for another closely related species or species at a similar trophic level (e.g., advice for carp and crappie is based on channel catfish). When supporting data were not available for a particular species, the U.S. EPA national freshwater sport fish consumption advice for pregnant or nursing women and young children was provided for these sensitive populations. OEHHA recommends that children through age 17 also follow this advice because of continued nervous system development through adolescence. For females beyond their childbearing years and adult males, the OEHHA general advice for sport fish consumption was given.

The risk characterization indicated that the reference dose for methylmercury was consistently exceeded at typical consumption rates for largemouth bass and channel catfish. Consumers should be informed of the potential hazards from eating these fish from Black Butte Reservoir, particularly those hazards relating to the developing fetus and children. All individuals, especially females of childbearing age and children aged 17 and younger, are advised to limit their fish consumption to reduce methylmercury ingestion to a level near the reference dose. To help sport fish consumers achieve this goal, OEHHA has developed separate advisories for black bass species (largemouth, smallmouth and spotted bass), channel catfish, crappie, and carp for Black Butte Reservoir. As noted above, for fish species not included in these advisories but found in these water bodies (e.g., bluegill and green sunfish), OEHHA recommends separate advisories for adult males and females beyond their childbearing years as well as women of childbearing age and children aged 17 and younger. Additionally, OEHHA has developed provisional advisories for Stony Gorge and East Park Reservoirs, which are in the same watershed as Black Butte Reservoir and are expected to contain similar levels of methylmercury in sport fish. These advisories are contained in this report and are available online at: **http://www.oehha.ca.gov/fish/so_cal/nosierra.html.** For more information about mercury in fish and the health effects of methylmercury see the OEHHA web site or the fact sheet Methylmercury in Sport Fish (Appendix 2).

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). 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. Meal sizes should be adjusted to body weight as described in this report in Table 6.

Based on the evaluation of data showing elevated levels of mercury present in fish, OEHHA recommends the following consumption guidelines for fish taken from Black Butte, Stony Gorge and East Park Reservoirs:

FISH CONSUMPTION GUIDELINES FOR BLACK BUTTE RESERVOIR AND PROVISIONAL GUIDELINES FOR STONY GORGE, AND EAST PARK RESERVOIRS*		
Fish Species	**Females of Childbearing Age and Children Age 17 and Younger**	**Females Beyond Childbearing Years and Adult Males**
	Maximum Meals Per Month**	**Maximum Meals Per Month****
All Bass	**1**	**2**
Channel Catfish Carp Crappie	**2**	**4**
Other Sport Fish***	**4**	**12**

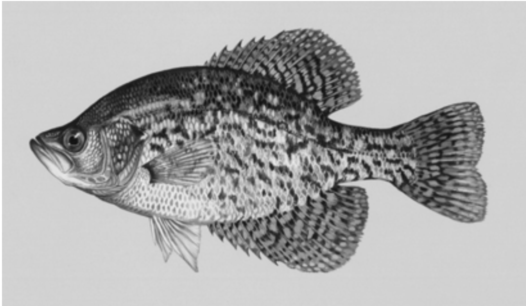
* Although the data for mercury concentrations in nearby lakes or reservoirs are limited, they indicate that other water bodies in the Stony Creek watershed may also have mercury contamination problems. Consumers should apply fish consumption advice developed for Black Butte Reservoir to Stony Gorge and East Park Reservoirs until specific data are available for these reservoirs.

**Consumption limits for each species assume that no other contaminated fish are being eaten. If you eat multiple fish species at multiple sites, limit your total consumption to the amount recommended for the fish with the fewest recommended meals. If you also eat fish from a store or restaurant, do not eat more than the lowest number of meals recommended for the water bodies where you fish.

***All fish species were not evaluated at this reservoir. OEHHA recommends consumption of no more than 4 or 12 meals per month of any fresh water sport fish for sensitive and general adult population groups, respectively, if stricter guidelines are not in place.

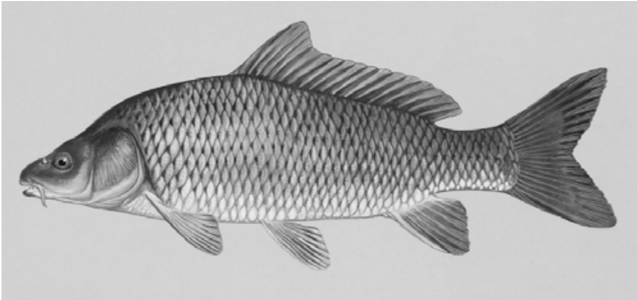
Fish are nutritious and should be part of a healthy, balanced diet. As with many other kinds of food, however, it is prudent to consume fish in moderation. OEHHA provides this consumption advice to the public so that people can continue to eat fish without putting their health at risk.

Black Butte Sport Fish



Black Crappie (*Pomoxis nigromaculatus*)

Channel Catfish *(Ictalurus punctalus)*



Common Carp *(Cyprinus carpio)*

Largemouth Bass *(Micropterus salmoides)*

Note: Pictures are not to scale.

INTRODUCTION

OEHHA conducted a study to sample selected sport fish species and measure the levels of target chemicals in these fish from Black Butte Reservoir. This study was part of a cooperative agreement with the U.S. EPA, in which two lakes in California were sampled. The objective of the study was to provide an initial database to determine whether additional sampling and health evaluations were warranted in either lake. Although the extent of the study in each lake was restricted by the funding available, it was possible to sample several species of popular sport fish from Black Butte Reservoir.

The Final Project Report (FPR), "Prevalence of Selected Target Chemical Contaminants in Sport Fish from Two California Lakes: Public Health Designed Screening Study" (Brodberg and Pollock, 1999) concluded that a health evaluation of the results was warranted for people eating largemouth bass and channel catfish from Black Butte Reservoir. This health evaluation was based on the potential exposure to methylmercury through consumption of sport fish from Black Butte Reservoir and addressed the associated potential health hazards of such exposure. Nearly all fish (sport and commercial) contain mercury at a measurable level. While the measurements are made as total mercury, most of the mercury in fish is present as methylmercury, which is the most toxic form of mercury. The health risk from consumption of fish containing methylmercury depends on the concentration of methylmercury in the fish and the amount of fish being consumed.

OEHHA is the agency responsible for evaluating potential public health risks from chemical contamination of sport fish, and issuing advisories, when appropriate, for the State of California. OEHHA's authorities to conduct these activities are based on mandates in the California Health and Safety Code, Section 205 (protecting public health), and Section 207 (advising local health authorities), and in the California Water Code, Section 13177.5. Fish advisories developed by OEHHA are published in the California Sport Fishing Regulations and California Sport Fish Consumption Advisories (OEHHA, 2001).

BACKGROUND

Under the cooperative agreement, OEHHA and U.S. EPA jointly selected sites and fish species to be sampled and chemicals to be analyzed. Black Butte Reservoir was selected for this study because of a combination of characteristics. First, it is in the California Coast Range where mercury contamination has been observed in fish from other lakes. Second, it is a more rural recreational facility operated by the U.S. Army Corps of Engineers, and third, it is a popular fishing site for Hmong fishers living nearby in the Central Valley (personal communication, Glenn County Health Department). Black Butte Reservoir, along with Stony Gorge and East Park, is one of three reservoirs on Stony Creek (DWR, 1993; 2002a; 2002b; 2002c). Black Butte is the largest of the three reservoirs, with a surface area of 4,460 acres and a storage capacity of 144,000 acre-feet (DWR, 2002a). The reservoir has a crest elevation of 515 feet and drains 741 square miles (DWR, 1993). The lake itself straddles Glenn and Tehama Counties and is also used for camping, boating, and hunting.

Four sport fish species were collected for analysis of chemical contaminants from Black Butte Reservoir. The species collected and analyzed were largemouth bass, channel catfish, crappie, and carp. Fish were collected from three regions of the lake (see Figure 1): Burris Creek Arm, Stony Creek Arm, and Angler's Cove (the area including Fisherman's Cove and extending to the dam). Samples were collected on November 25, and December 4 and 5, 1997. The California Department of Fish and Game (DFG) Water Pollution Control Laboratory (WPCL) sampled fish and prepared composites of muscle tissue from individual fish for chemical analysis. One composite each of carp and crappie, nine composites of largemouth bass (two from Angler's Cove, four from Stony Creek Arm, and three from Burris Creek Arm), and eight composites of channel catfish (one from Angler's Cove, four from Stony Creek Arm, and three from Burris Creek Arm) were prepared for analysis. The average size, weight, and other characteristics of fish in these composites are shown in Table 1. Fish sampling and sample preparation methods are described in more detail in the FPR (Brodberg and Pollock, 1999).

It is not possible to determine in advance how many samples of each fish species from a site will be necessary in order to statistically interpret contamination data for consumption advisories. However, U.S. EPA does recommend 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 site should be analyzed for this type of pilot study. Fish samples should be collected from multiple (legal/edible-) size classes. 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 exposure assessment.

Sufficient sample size (considered to be ≥9 fish per species for this study) was only available for two fish species at Black Butte Reservoir. Those were largemouth bass and channel catfish.

OEHHA and U.S. EPA jointly selected the chemical contaminants to be analyzed. The chemicals analyzed for this study included four metals, 35 organic compounds plus 46 polychlorinated biphenyl (PCB) congeners, and chlorinated dibenzodioxin and dibenzofuran (dioxins/furans) compounds that could potentially accumulate in fish in California lakes. The reason for including a broad spectrum of chemicals and fish species in the analysis was to screen for those chemicals and fish species that posed the greatest potential health concern. Using this method, future monitoring might be limited to specific species and fewer chemicals. DFG WPCL analyzed metals and organic compounds. The California Department of Toxic Substances Control Hazardous Materials Control Laboratory analyzed composite tissue samples for dioxins/furans and three coplanar PCB congeners. The chemicals analyzed and the analytical methods are described in more detail in the FPR (Brodberg and Pollock, 1999).

This study was designed to incorporate U.S. EPA (1995) guidance for analysis of fish potentially used for fish advisories. U.S. EPA (1995) recommends using screening values (SVs) to identify which chemical contaminants in sport fish tissue are at concentrations that may be of human health concern for frequent consumers of sport fish. Specific SV tissue concentrations were established in the FPR (Brodberg and Pollock, 1999). The SV tissue concentrations were not intended to indicate a tissue level at which a consumption advisory would be issued. Tissue concentrations that exceed the SV for a chemical in a species indicate that this species warrants a health evaluation if enough samples were analyzed. And, if samples were insufficient, more fish of this species should be collected and analyzed so that a health evaluation can be done. A more detailed discussion of the SVs and a comparison between them and the chemical concentrations in the sport fish species sampled from Black Butte Reservoir are presented in the FPR (Brodberg and Pollock, 1999). The mean (i.e., average) chemical concentrations for chemicals of potential health concern in Black Butte fish are presented in Table 2. The average lake wide concentrations were used in this health evaluation because chemical concentrations in individual species of fish from different collection sites were similar. Fishers are likely to eat some fish of a specific species that have higher concentrations of a chemical and some with lower concentrations. It is reasonable to assume that a consumer's exposure from several meals will be closer to the averaged concentration for a chemical than the lowest or highest concentration. Thus, the lake wide average (mean) chemical concentration of mercury in a fish species represents the typical catch and consumption exposure for consumers eating that species from the lake.

Mercury was the only chemical that exceeded the study SV; consequently, it was the only chemical for which a health evaluation was warranted. Although mean mercury concentrations exceeded the SV in all species tested, as noted above, sufficient sample size to adequately estimate exposure and risk were only available for largemouth bass and channel catfish. However, qualitatively, it is evident that mercury is also accumulating in carp and crappie. The level of accumulation in these species is similar to that in channel catfish. Consequently, the potential health concerns in carp and crappie are likely to be similar to those for channel catfish. Additional samples and mercury analyses for these species from Black Butte are needed to characterize the concentration of mercury in carp and crappie, to confirm the validity of the analytical results, and support a specific health evaluation for these species. Interpretation of carp and crappie data given limited sample size is discussed in the exposure assessment, risk characterization, and guidelines sections of this document.

METHYLMERCURY TOXICOLOGY AND HAZARD IDENTIFICATION

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. In this study, total mercury was measured and assumed to be 100 percent methylmercury for the purposes of risk assessment.

Fish consumption accounts for almost 100 percent of the average daily methylmercury intake in adults not occupationally exposed to this chemical (ATSDR, 1999). As noted above, 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 44-74 days in humans (Aberg, 1969; Smith et al., 1994), meaning that it takes approximately 44-74 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 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 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.

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 are 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 actions, OEHHA has administratively listed methylmercury compounds on the Proposition 65 list of carcinogens. A cancer potency factor (an estimate of the increased cancer risk from lifetime exposure to a chemical) has not yet been developed for methylmercury.

DOSE-RESPONSE ASSESSMENT FOR METHYLMERCURY

A reference dose (RfD) is an estimate of daily human exposure to a chemical that is likely to be without significant risk of adverse effects during a lifetime (including to sensitive population subgroups), expressed in units of mg/kg-day (IRIS, 1995). This 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 $3x10^{-4}$ 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 200-500 μg/L and 50-125 μg/g in adults, respectively. In cases where ingested mercury dose could be estimated (based, for example, on bread mercury concentration 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 are 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 $\mu g/kg\text{-}day^{-1}$) 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 based on 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 $1x10^{-4}$ mg/kg-day, to protect against developmental neurological abnormalities in infants (IRIS, 1995). This fetal RfD superseded the previous RfD, which was based on effects in adults.

The two previous 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 $1x10^{-4}$ 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 46-79 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 interindividual toxicokinetic variability in ingested dose estimation from cord-blood mercury levels and pharmacodynamic variability and uncertainty, leading to an RfD of $1x10^{-4}$ 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 $1x10^{-4}$ mg/kg-day (IRIS, 2001). U.S. EPA uses this RfD for all populations.

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). 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 balance the risks of methylmercury contamination in different populations with 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, the majority of states issue separate consumption advice for sensitive (e.g., children) and general population groups. Thus, the U.S. EPA RfD of $1x10^{-4}$ based on the Faroe Island data will be used in this advisory for females of childbearing age and children aged 17 and younger. An RfD of $3x10^{-4}$ will be used for females beyond their childbearing years and adult males.

EXPOSURE ASSESSMENT OF EATING SPORT FISH FROM BLACK BUTTE RESERVOIR

The exposure assessment for eating largemouth bass and channel catfish from Black Butte Reservoir estimates exposures currently experienced or anticipated under different conditions for sport fish consumers eating these fish species from the reservoir. The chemical concentrations reported in the FPR are considered representative of the nature and extent of chemical contamination in sport fish species from the reservoir. Mean concentrations are used to represent the central tendency (average) of exposure for the population in question. Methylmercury was identified in the FPR as the chemical of concern for persons consuming sport fish from Black Butte Reservoir. As noted previously, in the United States, the primary route of exposure to methylmercury for most of the population is via consumption of finfish (U.S. EPA, 1997). This is especially true for sport fish consumers. The consumption of sport fish species from Black Butte Reservoir was the only path of methylmercury exposure considered in this exposure assessment. The exposure assessment is applicable to local consumers of fish from Black Butte Reservoir and other persons who eat fish caught in the lake.

Fish Consumption Data

Different exposure scenarios for the amount and frequency of fish consumption are used in exposure assessments to calculate likely exposures for various segments of the population annually consuming fish caught from a water body. Consumption rates determined for a wide demographic of fishers in Santa Monica Bay served as a model for fish consumption in other water bodies in California including Black Butte Reservoir (Gassel, 2001). Consumption rates corresponding to three different segments of the population of fishers catching and consuming sport fish were selected for this exposure assessment: a median and mean value, representing two estimates of central tendency of fish intake, and a 90^{th} percentile, representing a high fish intake. The median is the consumption rate representing the 50^{th} percentile in any study. An equal number of fish consumers in the study population consumed fish at more than this rate as consumed fish at less than this rate. The reported median from the Santa Monica Bay study was 21 g/day ($2.1x10^{-2}$ kg/day) (Southern California Coastal Water Research Project (SCCWRP) and MBC Applied Environmental Sciences, 1994; and Allen et al., 1996). In practical terms, this is equivalent to consuming just less than three standard (eight ounce) meals per month of sport fish from Black Butte Reservoir during a year and would be considered a lower-level exposure rate. The mean represents the mathematical average consumption rate and would, thus, be typical of an average sport fish consumer. The reported mean from the Santa Monica Bay study was 50 g/day ($5.0x10^{-2}$ kg/day) (SCCWRP and MBC, 1994; and Allen et al., 1996), which corresponds too less than seven standard meals per month of fish. High-level consumers are typically viewed as those between the 90^{th} and 99.9^{th} percentile. The 90^{th} percentile was chosen in this case because the exposure assessment and risk characterization were based on consumers eating a single species at this rate from only this location. This is a conservative assumption because fishers are more likely to eat meals of different fish species from different locations during a year. Using a higher percentile for a single species assessment would lead to unrealistic exposure estimates based on few actual consumers in the extreme tail of the population distribution. The reported 90th percentile from Santa Monica Bay was 107 g/day (10.7×10^{-2} kg/day) (SCCWRP and MBC, 1994; and Allen et al., 1996), which is equivalent to about 14 meals per month annually. This rate was used to represent high-level (e.g., subsistence) consumers in the exposure assessment. These three scenarios considered together characterize a reasonable range of consumption for the population fishing at the reservoir.

Exposure calculations are based on a mg/kg-day basis (i.e., mg of chemical per kg of body weight per day) (U.S. EPA, 1989). In risk assessment, a body weight of 70 kg is generally used to represent a typical adult weight. The daily human exposure to methylmercury from fish consumption can be calculated with the following formula:

$$\text{mg methylmercury/kg-day} = \frac{\text{(mg methylmercury/kg fish)(kg fish/day)}}{\text{70 kg body weight}}$$

For individuals weighing more or less than 70 kg, it is assumed that their consumption rates will be proportionately higher or lower, respectively, yielding an overall similar exposure level following consumption of equally contaminated fish.

Mercury Contamination Data

The concentrations of methylmercury used in the exposure assessment were based on the average (i.e., mean) concentration measured in the raw fish tissue as it was prepared for compositing. Largemouth bass, crappie, and carp tissues were all prepared with the skin on. Channel catfish tissues were prepared with the skin off. The average concentrations of mercury in the fish species sampled from Black Butte Reservoir were 700 parts per billion (ppb) for largemouth bass and 400 ppb for channel catfish (see Table 2).

The average mercury concentration measured in largemouth bass was based on nine composites each containing three fish. These composites represent a full size range of largemouth bass from the lake: two composites were made of large fish (>500 mm in length); two composites were made of medium-sized fish (370-499 mm in length); and five composites were made of small fish at or just over the legal size limit (see Table 1). These composites reflect the abundance of different size classes of largemouth bass during field collection so these samples are representative of what fishers are expected to catch and consume. The resulting mercury concentrations depart somewhat from a normal distribution. This is evident from the difference between the mean mercury concentration (700 ppb), the median concentration (530 ppb), and the geometric mean concentration (628 ppb) (see Table 3). This shift in the mean from the center of the distribution is due to the statistical effect that the higher mercury concentrations in the composites made of large-sized bass have on the computed mean. The average mercury concentration in this case is still a good measure of central tendency for mercury concentrations in bass because it will be representative of possible infrequent exposures to high concentrations (>1 ppm) from large fish. The average mercury concentration in largemouth bass was thus used for estimating exposures of fishers catching and consuming this species from Black Butte Reservoir.

The average mercury concentration in channel catfish was based on eight composites, each containing four fish. Four of these composites were made of large-sized fish (>500 mm in length) and four were made of medium-sized fish (see Table 1). Smaller catfish were not evident in the field collections, so these samples are representative of what fishers are expected to catch and consume. Mercury concentrations in channel catfish were normally distributed. The mean mercury concentration (400 ppb), median concentration (380 ppb), and geometric mean concentration (398 ppb) were nearly the same (Table 3). Therefore, the mean should be a good representation of central tendency for methylmercury concentrations in channel catfish and, thus, it was used to represent typical methylmercury levels to estimate exposures for fishers catching and consuming channel catfish from Black Butte Reservoir.

Table 2 also gives values for the mercury concentrations in crappie (340 ppb) and carp (300 ppb). Only one composite was made for each of these species. As noted above, this is insufficient sample size to be able to judge whether these concentrations are representative of the populations of these species in Black Butte Reservoir. The fact that these concentrations are similar to those in channel catfish suggests that methylmercury does accumulate in these fish species in this lake. This is not surprising because the feeding habits of channel catfish overlap those of carp and crappie. Although more samples of carp and crappie should be collected and analyzed, these similar mercury concentrations suggest the mercury level in these populations will be similar to that found in channel catfish. In contrast, largemouth bass have a more piscivorous feeding habit, as is evident from the greater bioaccumulation of mercury in this fish species.

The calculated daily exposures at different consumption levels for the mean mercury levels in Black Butte largemouth bass and channel catfish are shown in Table 4.

RISK CHARACTERIZATION OF EATING SPORT FISH FROM BLACK BUTTE RESERVOIR

In order to calculate potential adverse effects from exposure to hazardous substances, intake estimates developed during the exposure assessment must be compared to toxicity values using the formula E/RfD, where E equals the exposure level (intake) and RfD equals the reference dose (U.S. EPA, 1989). This ratio is called the hazard quotient (HQ). If the HQ is less than unity (i.e., intake is less than the RfD), it is considered unlikely that even sensitive subpopulations will experience adverse health effects from this chemical exposure. If the HQ is greater than unity (intake is greater than the RfD), there is increasing risk of negative health effects, particularly when exposure is a multiple of the RfD (U.S. EPA, 1989). Table 4 shows HQs for methylmercury for consuming sport fish species from Black Butte Reservoir at different consumption rates using the RfDs for both populations of interest.

HQs calculated for largemouth bass and channel catfish presented in Table 4 are based on multiple composites of each of these species. These are adequate samples for human health evaluation because the sample size is large enough to be reasonably sure that the measured levels are accurate representations of the true levels in these fish populations. The risks of consuming largemouth bass and channel catfish from Black Butte Reservoir are characterized separately as if people ate exclusively one species of fish. This serves to show which species contributes more to potential health risks. The risks of consuming crappie and carp from Black Butte Reservoir cannot be characterized because the number of samples was inadequate (one composite each) to estimate and characterize the methylmercury level in populations of these fish species. One sample is not adequate for quantitative human health evaluation because by chance it could be unusually high or low (i.e., it could be in a tail of the distribution of the chemical in the fish population). Additional composites of these fish species should be sampled and analyzed.

Ingestion of largemouth bass contaminated with methylmercury poses the greatest potential hazard to consumers of sport fish from Black Butte Reservoir, especially to females of childbearing age and children aged 17 and younger. HQs from eating largemouth bass suggest that these consumers eating only a few meals a month (i.e., lower-level consumers) are potentially at increased risk. Average and high-level consumers are exposed at increasing multiples of the methylmercury RfD. Members of this sensitive population consuming large amounts of bass (e.g., subsistence fishers) would be exposed to mercury at more than ten times the RfD. Adult males and females beyond their childbearing years would be exposed above the RfD at average and high consumption levels.

Ingestion of channel catfish contaminated with methylmercury also poses a potential risk to consumers of sport fish from Black Butte Reservoir. Lower-level consumers of channel catfish in the sensitive population are marginally at risk. But average and high-level consumers from this population eating channel catfish at the average mercury concentration would be exposed to increasing multiples of the RfD for methylmercury. Adult males and females beyond their childbearing years would also be exposed above the RfD at high consumption levels.

Although the risk characterization indicates that there are potential hazards associated with consuming largemouth bass and channel catfish from Black Butte Reservoir, it does not follow that consumers will show adverse effects. This is because the reference dose incorporates some margin of safety to account for uncertainties in data and differences among individuals. Among all consumers, the subpopulation of greatest concern is females of childbearing aging and children aged 17 and younger who frequently eat large amounts of bass or catfish from Black Butte Reservoir.

SUPPORTING DATA FOR DEVELOPING FISH CONSUMPTION GUIDELINES

Fish consumption guidelines are appropriate whenever there are sufficient data to suggest that adverse health effects may occur from unrestricted consumption of individual fish species at certain sites. Although the exposure assessment and risk characterization sections of this report utilized only data that were considered statistically valid for each species, other information may be useful to help develop additional recommendations. When there are less than nine individual or three composite samples at a site for a given species, data for that species may be extrapolated from other, similar species at that site or from the same species at a similar site to develop a weight-of-evidence approach. This method is acceptable when evaluation of the entire data set shows clear trends that justify the issuance of prudent, protective health advice even in the absence of a statistically representative sample. For example, it may be reasonable to provide consumption advice for a particular species with little or no data for that species (e.g., crappie, carp, and other bass species) when the mercury concentrations in similar species at that site (e.g., largemouth bass and channel catfish) are significantly elevated. Because the feeding habits of carp and crappie are similar to those of channel catfish, there is good reason to believe that methylmercury concentrations in the population of carp and crappie will be similar to those in the well-characterized channel catfish population. In this case, channel catfish are a suitable interim exposure model for consumption of carp and crappie and the same consumption advice to reduce potential methylmercury exposure should be applied to all three fish species. Additionally, other bass species in the same water body are likely to have similar methylmercury concentrations as largemouth bass. Thus, it is recommended that consumers follow the largemouth bass consumption advice for all bass species caught in Black Butte Reservoir.

Mercury concentrations have also been measured in a few fish samples in nearby reservoirs in the same watershed. A single channel catfish sample from East Park Reservoir had a mercury concentration of 0.62 ppm. Two relatively small largemouth bass from that reservoir had a mean mercury concentration of 0.47 ppm. At Stony Gorge Reservoir, a black crappie sample had a mercury concentration of 0.22 ppm, while a moderate sized largemouth bass contained 0.46 ppm mercury. This very limited data set is similar to the range of mercury in fish from Black Butte Reservoir. This supports the results from Black Butte Reservoir and suggests that it would be prudent for consumers to also apply fish consumption advice developed for Black Butte Reservoir to Stony Gorge and East Park reservoirs until specific data are available for these reservoirs.

GUIDELINES FOR FISH CONSUMPTION

On the basis of adequate data on mercury levels in largemouth bass and channel catfish, and likely consumption rates for these species, the risk characterization has shown that the methylmercury levels found in these species from Black Butte Reservoir consistently exceed the HQ. 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 females of childbearing age and children aged 17 and younger, are advised to limit their fish consumption to reduce methylmercury ingestion to a level near the RfD.

Guidance tissue levels have been developed that relate the number and size of recommended fish meals to methylmercury concentrations found in fish (Table 5). These are 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 g) portion of uncooked fish (approximately 6 ounces after cooking) for adults who weigh approximately 70 kg or 154 lbs. 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). 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 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 females beyond their childbearing years and adult males are approximately three times higher than for sensitive populations because of the 3-fold higher RfD level used for this population group.

It is very important to note that guidance values are based on consumption of only one fish species. If an individual consumes multiple species or catches 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 meal per month category, he or she should not eat another fish species at any site where there is a fish consumption advisory for that species for at least one month.

OEHHA recommends that females of childbearing age and children aged 17 and younger eat no more than one meal of bass or two meals of channel catfish, carp, or crappie per month from Black Butte Reservoir to protect them from the potential health effects of exposure to methylmercury as a result of sport fish consumption. For other fish in this reservoir and in other water bodies throughout California, it is recommended that females of childbearing age and children aged 17 and younger follow the recent U.S. EPA national freshwater sport fish consumption advice for pregnant or nursing women and young children of no more than four meals per month of fresh water fish (U.S. EPA, 2001).

OEHHA also recommends that females of childbearing age and children aged 17 and younger follow the FDA advice for pregnant women, women of childbearing age who may become pregnant, nursing mothers, and young children on commercial fish consumption. FDA advises these individuals not to eat shark, swordfish, king mackerel, or tilefish because of their high levels of mercury. FDA also recommends that these women can safely eat up to an average of 12 ounces per week of other cooked fish from a store or restaurant such as shellfish, canned fish, smaller ocean fish or farm-raised fish. Children should limit consumption to less than 12 ounces of cooked fish per week. Also, if 12 ounces of cooked fish from a store or restaurant are eaten in a given week, then sport fish caught from Black Butte Reservoir should not be eaten in the same week.

For females beyond their childbearing years and adult males, OEHHA recommends that bass from Black Butte Reservoir be consumed no more than two times per month. Additionally, consumption of channel catfish, crappie, or carp from this reservoir should be limited to no more than four times per month for these individuals. Because of the general pattern of mercury contamination in all fish sampled from Black Butte Reservoir, OEHHA advises that consumption of all other fish for which no specific advice is given above be restricted to no more than 12 meals per month for females beyond their childbearing years and adult males from this reservoir. Additionally, OEHHA recommends that females beyond their childbearing years and adult males take into account the commercial fish they eat, especially high-mercury fish such as shark, swordfish, king mackerel, or tilefish. If they consume these species, they should not eat more than the lowest number of meals recommended for the water bodies where they fish.

As noted above the consumption advice for Black Butte Reservoir should also be applied to Stony Gorge and East Park Reservoirs, which are part of the same watershed. This is prudent because the U.S. EPA national freshwater sport fish consumption advice would not be protective if additional samples confirmed limited results on mercury levels in fish from these reservoirs.

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. 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 this report in Table 6.

FISH CONSUMPTION GUIDELINES FOR BLACK BUTTE RESERVOIR AND PROVISIONAL GUIDELINES FOR STONY GORGE, AND EAST PARK RESERVOIRS*		
Fish Species	**Females of Childbearing Age and Children Age 17 and Younger**	**Females Beyond Childbearing Years and Adult Males**
	Maximum Meals Per Month**	**Maximum Meals Per Month****
All Bass	**1**	**2**
Channel Catfish **Carp** **Crappie**	**2**	**4**
Other Sport Fish***	**4**	**12**

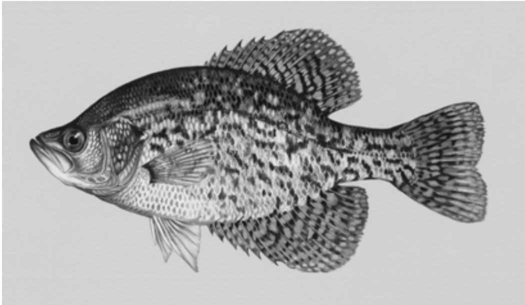
* Although the data for mercury concentrations in nearby lakes or reservoirs are limited, they indicate that other water bodies in the Stony Creek watershed may also have mercury contamination problems. Consumers should apply fish consumption advice developed for Black Butte Reservoir to Stony Gorge and East Park Reservoirs until specific data are available for these reservoirs.

** Consumption limits for each species assume that no other contaminated fish are being eaten. If you eat multiple fish species at multiple sites, limit your total consumption to the amount recommended for the fish with the fewest recommended meals. If you also eat fish from a store or restaurant, do not eat more than the lowest number of meals recommended for the water bodies where you fish.

*** All fish species were not evaluated at this reservoir. OEHHA recommends consumption of no more than 4 or 12 meals per month of any fresh water sport fish for sensitive and general adult population groups, respectively, if stricter guidelines are not in place.

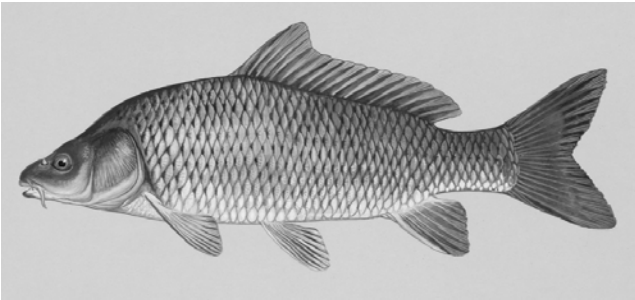
Fish are nutritious and should be part of a healthy, balanced diet. As with many other kinds of food, however, it is prudent to consume fish in moderation. OEHHA provides this consumption advice to the public so that people can continue to eat fish without putting their health at risk.

Black Butte Sport Fish



Black Crappie (*Pomoxis nigromaculatus*)

Channel Catfish *(Ictalurus punctalus)*



Common Carp *(Cyprinus carpio)*

Largemouth Bass *(Micropterus salmoides)*

Note: Pictures are not to scale.

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FIGURE 1: MAP OF BLACK BUTTE RESERVOIR AND COLLECTION SITES

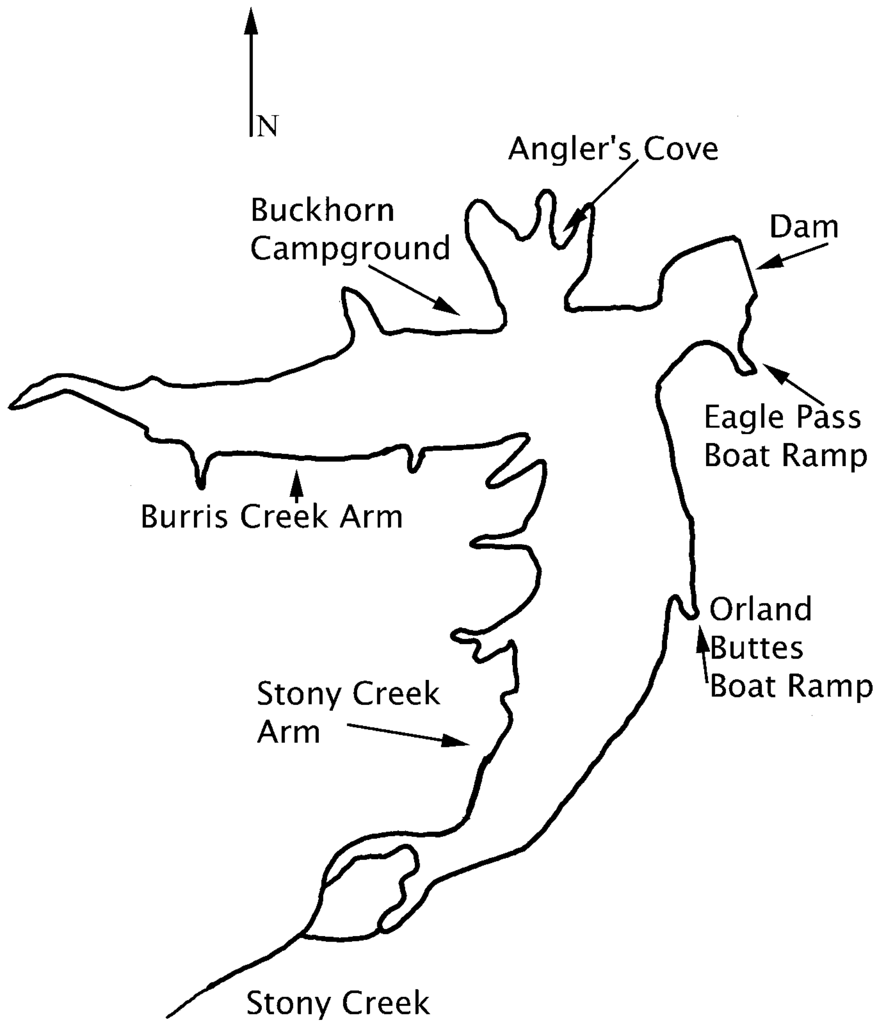

Table 1: Physical Characteristics of Fish in Composites from Black Butte Reservoir

Composite	Fish per composite	Total length (mm)	Weight (gm)	Percent lipid	Estimated age (yrs)
Crappie-MS-A	3	345	646	0.2	4
Carp-AC-A	3	478	1126	1.6	4
Largemouth bass-AC-A	3	503	2141	1.7	6
Largemouth bass-AC-B	3	402	960	0.3	4
Largemouth bass-SCA-A	3	372	716	0.1	4
Largemouth bass-SCA-B	3	312	398	0.1	3
Largemouth bass-SCA-C	3	308	388	0.2	3
Largemouth bass-SCA-D	3	302	384	0.1	3
Largemouth bass-BCA-A	3	507	2012	0.2	6
Largemouth bass-BCA-B	3	318	461	0.1	3
Largemouth bass-BCA-C	3	315	380	0.3	3
Channel catfish-AC-A	4	484	1016	2.4	6
Channel catfish-SCA-A	4	519	1227	2.3	7
Channel catfish-SCA-B	4	500	1142	3.8	7
Channel catfish-SCA-C	4	439	703	2.6	6
Channel catfish-SCA-D	4	426	647	1.8	5
Channel catfish-BCA-A	4	534	1460	4.9	8
Channel catfish-BCA-B	4	531	1382	3.0	8
Channel catfish-BCA-C	4	435	665	1.7	6

AC: composite collected from Angler's Cove
BCA: composite collected from Burris Creek Arm
SCA: composite collected from Stony Creek Arm
A, B, C, D: indicate different composites from the same area
Tabled values for length, weight, and percent lipid are the mean values for the fish in each composite.

Table 2: Mean Chemical Concentrations in Fish from Black Butte Reservoir for which there are California Lakes Study Screening Values (concentrations in ppb wet weight except as noted)

CHEMICAL	Channel catfish	Carp	Crappie	Largemouth bass
Chlordane	2.6	2.2	0.5*	0.8
Chlorpyrifos	0.4*	0.4*	0.4*	0.4*
Total DDT	13	9.3	2.2*	4.4
Diazinon	12.5*	12.5*	12.5*	12.5*
Disulfoton	LC	LC	LC	LC
Dieldrin	0.4	0.3*	0.3*	0.3*
Total endosulfan	3.2	3*	3*	3*
Endrin	0.6*	0.6*	0.6*	6*
Ethion	7.5*	7.5*	7.5*	7.5*
Heptachlor epoxide	0.3*	0.3*	0.3*	0.3*
Hexachlorobenzene	0.1*	0.1*	0.1*	0.1*
γ-hexachloro-cyclohexane	0.1*	0.1*	0.1*	0.1*
Toxaphene	14	10*	10*	10*
PCBs as Aroclors	ND*	ND*	ND*	2.2
Dioxin TEQ (ppt)	0.07	NA	NA	0.1
Arsenic	40	25	220	160
Cadmium	5*	10	5*	5*
Mercury	400	300	340	700
Selenium	210	590	490	460

*: all values below Method Detection Limit (MDL).
ND: Not Detected and there is no numerical MDL for Aroclors determined by this method.
LC: chemical lost on extraction column, no result.
NA: not analyzed for dibenzodioxins or dibenzofurans.
Shaded boxes indicate fish species for which the mean chemical concentration of the samples exceeds the SV.

Table 3: Descriptive Statistics for Mercury Concentration in Largemouth Bass and Channel Catfish

Composite	Mercury concentration in ppb	Size of fish in composite	Descriptive Statistics
Largemouth bass-AC-A	1100	Large	Mean: 700 ppb Standard deviation: ±360 Median: 530 ppb Geometric mean: 628 ppb Skew: 0.86 Kurtosis: -1.12
Largemouth bass-AC-B	700	Medium	
Largemouth bass-SCA-A	590	Medium	
Largemouth bass-SCA-B	470	Small	
Largemouth bass-SCA-C	430	Small	
Largemouth bass-SCA-D	410	Small	
Largemouth bass-BCA-A	1300	Large	
duplicate	1200	Large	
Largemouth bass-BCA-B	370	Small	
Largemouth bass-BCA-C	440	Small	
Channel catfish-AC-A	420	Medium	Mean: 400 ppb Standard deviation: ±56 Median: 380 ppb Geometric mean: 398 ppb Skew: 0.63 Kurtosis: -0.91
Channel catfish-SCA-A	350	Large	
Channel catfish-SCA-B	370	Large	
Channel catfish-SCA-C	380	Medium	
Channel catfish-SCA-D	350	Medium	
Channel catfish-BCA-A	500	Large	
Channel catfish-BCA-B	460	Large	
duplicate	440	Large	
Channel catfish-BCA-C	340	Medium	

Table 4: Mercury Concentration, Exposure Dose and Hazard Quotient for Largemouth Bass and Channel Catfish from Black Butte Reservoir

	Daily exposure (mg/kg-day) x10^{-4}			HQ at 1x10^{-4} (mg/kg-day) RfD			HQ at 3x10^{-4} (mg/kg-day) RfD		
Consumption Rate (g/day)	21	50	107	21	50	107	21	50	107
Largemouth Bass (700 ppb mercury)	2.1	5.0	10.7	2.1	5.0	10.7	0.7	1.8	3.6
Channel catfish (400 ppb mercury)	1.2	2.9	6.1	1.2	2.9	6.1	0.4	1.0	2.0

Table 5. Guidance Tissue Levels (ppm total mercury or methylmercury*, wet weight) for Two Population Groups

	12 Meals/ Month* (90.0 g/day)	8 Meals/ Month (60.0 g/day)	4 Meals/ Month (30.0 g/day)	2 Meals/ Month (15.0 g/day)	1 Meal/ Month (7.5 g/day)	No Consumption
Females of childbearing age and children aged 17 and younger	≤ 0.08	>0.08-0.12	>0.12-0.23	>0.23-0.47	>0.47-0.93	>0.93
Females beyond their childbearing years and adult males	≤0.23	>0.23-0.35	>0.35-0.70	>0.70-1.40	>1.40-2.80	>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.

** OEHHA's general consumption advice protects fishers who eat up to twelve meals per month of sport fish. Twelve meals per month is representative of an upper bound consumption rate for frequent sport fish consumers in California (Gassel, 2001). OEHHA begins issuing site specific consumption advice if data indicate that consumption of twelve meals per month is potentially hazardous.

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

Table 5. Guidance Tissue Levels (ppm total mercury or methylmercury*, wet weight) for Two Population Groups (continued)

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 females of childbearing age and children aged 17 and younger. An RfD of $3x10^{-4}$ mg/kg-day was used for females beyond their childbearing years and adult males. 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 (see Table 6). The standard portion size eaten by an average adult (body weight 70 kg or 154 pounds) is eight ounces (227 g) (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 $3.24\ x10^{-2}$ kg/day, and three meals per week is equivalent to $9.72\ x10^{-2}$ kg/day.

Table 6. Adjusting Fish Meal Size for Body Weight

Body Weight		**Meal Size**	
pounds	**kilograms**	**ounces**	**grams**
19	9	1	28
39	18	2	57
58	26	3	85
77	35	4	113
96	44	5	142
116	53	6	170
135	61	7	199
154	70	8	227
173	79	9	255
193	88	10	284
212	96	11	312
231	105	12	340
250	113	13	369
270	123	14	397
289	131	15	425
308	140	16	454

APPENDIX 1

INTERIM FISH CONSUMPTION ADVISORY FOR BLACK BUTTE RESERVOIR

COUNTY OF GLENN
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Interim Fish consumption Advisory, Black Butte Lake

The Office of Environmental Health Hazard Assessment (OEHHA) of Cal/EPA has tested the fish from Black Butte Lake and has determined that they contain mercury at a level that may require a fish consumption advisory. Since OEHHA will not be able to complete it's advisory until sometime next year, the Glenn County Health Department is providing this interim fish consumption advisory based on a State advisory from Clear Lake, where mercury levels in the fish are similar. Bass species other then largemouth bass should be consumed at the same rate for equal sized largemouth bass. Catfish species other then channel catfish should be consumed at the same rate for equal sized channel catfish. Fish not listed should be consumed at the same rate as small crappie. Note that the fish consumption advisory finally published by OEHHA for Black Butte Lake may differ from the Clear Lake advisory.

Almost all fish, whether commercial or sport are contaminated with some level of mercury. Mercury is a naturally occurring element in Coast Range rock formations. Similar levels of mercury contamination in fish flesh have been found in many Northern California lakes and reservoirs. Following the consumption guidelines in this advisory provides a safe way to catch and enjoy your favorite sport fish.

CONSUMPTION RECOMMENDATIONS for CLEAR LAKE

1.Eating sport fish in amounts slightly greater than what is recommended should not present a health hazard if only done occasionally such as eating fish caught during an annual vacation.
2.Nursing and pregnant women and young children may be more sensitive to the harmful effects of some of the chemicals and should be particularly careful about following the advisories. Because contaminants take a long time to leave the body after they accumulate, women who plan on becoming pregnant should begin following the more restrictive consumption advice, a year before becoming pregnant. In this way, the levels of chemicals stored in the body can go down.
3.The limits given below for each species and area assume that no other contaminated fish is being eaten. If you consume several different listed species from the same area, or the same species from several areas, your total consumption still should not exceed the recommended amount. One simple approach is to just use the lowest recommended amount as a guideline to consumption.

Clear Lake (Lake County)
Because of elevated mercury levels, adults should eat no more than the amounts indicated below per month (See Note No. 3 above). **Women who are pregnant or may become pregnant, nursing mothers, and children under age six should not eat fish from these lakes.** Children 6-15 years of age should eat no more than one-half the amounts indicated for adults.

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FISH SPECIES	CLEAR LAKE ADVICE
largemouth bass over 15"	1 lb
largemouth bass under 15"	2 lbs
channel catfish over 24”	1 lb
channel catfish under 24"	3 lbs
Crappie over 12”	1 lb
Crappie under 12”	3 lbs

Adjusting Fish Meal Size for Body Weight

In the site-specific guidance that follows, OEHHA often gives consumption advice in terms of meals for a given period such as a meal a week, and uses an eight-ounce meal size as the standard amount allowed for the "average" adult. The average adult weighs approximately 150 pounds (equivalent to 70 kg). Because you and your family members may weigh more or less than the average adult, you can use the chart below to adjust serving sizes to stay within the recommended consumption guidelines.

How big is a meal?

IF YOU WEIGH…		YOUR MEAL SIZE SHOULD NOT EXCEED	
Pounds or	kilograms	Ounces	or grams
19	9	1	28
39	18	2	57
58	26	3	85
77	35	4	113
96	44	5	142
116	53	6	170
135	61	7	199
154	70	8	227
173	79	9	255
193	88	10	284
212	96	11	312
231	105	12	340
250	113	13	369
270	123	14	397
289	131	15	425
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November 2, 1999

NEWS RELEASE

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Glenn County Health Department, 934-6588

Cal EPA's Office of Environmental Health Hazard Assessment recently released the results of a fish study in Black Butte Lake. The study included chemical sampling of 57 fish taken from the lake in November and December of 1997. Analysis of the fish showed that the levels of organic chemicals (including PCBs, dioxin and some pesticides) are not a concern. However, the analysis also showed that fish from Black Butte Lake have somewhat elevated levels of mercury in their flesh. Even low levels of mercury in the diet are a concern because mercury can have an adverse affect on the neurological development of children. Higher levels of mercury are toxic to the nervous system of adults.

Almost all fish whether purchased commercially or caught as sport fish contain mercury. Mercury is a widespread contaminant in California lakes and reservoirs, especially in the coast range where there are naturally high levels of mercury in the rock formations. The average level of mercury encountered in Black Butte lake fish was lower then the federal action level for commercially marketed fish (one part per million), but similar to levels of mercury in sport fish from other Northern California lakes where fish consumption advisories were published by the state. The levels of mercury in Black Butte Lake fish are close to levels found in fish from Clear Lake. The state does not anticipate completing a risk analysis and consumption advisory until next May. Since eating fish from Black Butte Lake could represent a hazard to the public, the Glenn County Health Department has adopted the Clear Lake Consumption Advisory as an interim fish consumption guidance document.

APPENDIX 2

METHYLMERCURY IN SPORT FISH: INFORMATION FOR FISH CONSUMERS

OEHHA OFFICE OF ENVIRONMENTAL HEALTH HAZARD ASSESSMENT

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 stores, restaurants, and 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. For more information on fish contamination in California, contact:

Office of Environmental Health Hazard Assessment (OEHHA)
Pesticide and Environmental Toxicology Section (PETS)

1515 Clay St., 16th Floor
Oakland, California 94612
(510) 622-3170
FAX (510) 622-3218

P.O. Box 4010
Sacramento, California 95812-4010
(916) 327-7319
FAX (916) 327-7320

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.

updated June 2003

APPENDIX 3

RESPONSES TO COMMENTS ON THE REPORT AND ADVISORY:

EVALUATION OF POTENTIAL HEALTH EFFECTS OF EATING FISH FROM BLACK BUTTE RESERVOIR (GLENN AND TEHAMA COUNTIES): GUIDELINES FOR SPORT FISH CONSUMPTION

COMMENTS FROM PUBLIC WORKSHOP

1) Charlie Alpers, USGS, verbal comment. ***It should be clear in tables as well as text whether mercury (total mercury) or methylmercury was measured in fish tissues. Tables should include complete information and be able to stand alone in case they are separated from the text.***

   Response: The tables have been revised to prevent misinterpretation that methylmercury was measured in fish tissue. Also, the text explains that in the assessment and advisory 100% of the total mercury measured in fish was assumed to be methylmercury. In the text, mercury is used when referring to the chemical measured in fish and methylmercury is used when discussing toxicity and health effects.

2) Brad Long, Army Corps, Joie Roblin, Willows Journal, verbal comment. ***Are the levels in fish toxic to wildlife (e.g., bears)?***

   Response: Wildlife exposures and effects on wildlife are not part of this report, they might be considered by the Resources Agency or the State or Regional Water Board. Staff are not aware of studies concerning the effects of methylmercury on bears. However, studies do suggest that methylmercury can have toxic effects on fish-eating birds.

3) Brad Long, Army Corps, Don Holm, Glenn County Environmental Health, verbal comment. ***Expressed the opinion that the risks and concerns for the general adult population are not as great as for pregnant women and children, therefore the advice should also be different. They felt that different advice targeted to separate subpopulations would be more helpful for fishers and their families.***

   Response: The report has been updated to include a discussion of RfDs for two separate subpopulations: females of childbearing age and children aged 17 and younger; and females beyond their childbearing years and adult males. The revised report and advisory propose using an RfD based on neurobehavioral effects observed in children exposed to methylmercury in utero for the population of females of childbearing age and children aged 17 and younger who would be most sensitive to effects on the developing nervous system. The revised report and advisory propose using an RfD based on effects observed in adults (ataxia and paresthesia) following exposure during the Iraqi poisoning for females beyond their childbearing years and adult males.

4) Scott Peweu, Black Butte Marina, verbal comment. ***Expressed feeling that our conservative approach is overly restrictive in the absence of any studies showing that eating California sport fish with a level of mercury similar to that at Black Butte Reservoir have had actual adverse effects on consumers. Thought the Seychelles study and ATSDR MRL based on it was more appropriate because it involved more realistic exposure and doses.***

   Response: OEHHA believes that the approach used in the revised report and advisory (i.e., using two RfDs) balances the potential risks of methylmercury exposure in two different populations with the known benefits of fish consumption for these populations. This object of this balanced approach is to ensure that effects are not observed following consumption of California sport fish.

5) Brad Long, Army Corps, Don Holm, Glenn County Health, verbal comment. ***Issuing warnings is good but they should not be unduly frightening. Found phrase "potent neurotoxin" scary. If warnings are too extreme you get extreme reactions, e.g., some people will be frightened and stop all fish consumption; some people will be alienated and completely ignore all advice because they think it is unrealistic. Some people have been fishing for 20 years and they may feel there is no problem. No warnings are posted at grocery stores for commercial fish that have similar or higher levels of mercury than found at Black Butte, therefore the sport fish warnings seem out of place. Suggested directing the health warning more toward pregnant women, but including assurances that occasionally eating a little bit more than what is advised is OK.***

Response: The revised report and advisory attempt to convey the potential health concerns and effects of high exposure to methylmercury in a way that is accurate but not overly frightening. Mercury contamination in fish is a global problem that is now receiving more attention. The U.S. Environmental Protection Agency and the Food and Drug Administration have issued national advice for sport and commercial fish containing methylmercury. Recently warning signs about mercury levels in certain commercial fish species have been posted in grocery stores. The revised report and advisory stress the importance of following the health warnings for the sensitive population of females of childbearing age and children aged 17 and younger. It is also important to educate and give guidance to females beyond childbearing age and adult males. In addition to these warnings, the report also points out that fish are nutritious and should be part of a balanced diet. The advisories provide a useful guideline for moderate consumption of sport fish from Black Butte Reservoir.

6) Brad Long, Army Corps, Don Holm, Glenn County Health, verbal comment. ***Suggested that more context be provided with all health warnings not just in the fishing brochure and general advice. Don't just include theoretical risks, mention real risks (i.e., no known California effects), benefits, and general advice with advisories.***

Response: It is difficult to include a discussion of benefits, and the differences between theoretical and observed risks in an advisory that is concise enough to still retain peoples' attention. The primary objective of the advisory is to inform people that there is a potential concern and present guidance so that people can continue to eat some fish without putting their health at risk. We have included a brief statement to this effect with the advisory. And our other literature does include more discussion of these issues.

7) Brad Long, Army Corps, verbal. ***Suggested that we need to have advisory literature translated since Hmong and other non-English speaking populations fish the lake. Suggested Hmong, Vietnamese, Lao, and Spanish as other languages.***

Response: We have had our California Sport Fish Consumption Advisories booklet translated into Spanish, Chinese, Vietnamese, Laotian, Hmong, and Korean. We plan to have other advisory literature and fact sheets translated as resources allow.

8) Scott Peweu, Black Butte Marina, verbal comment. ***Suggested focusing advice better on what is consumed. Large bass are not caught and consumed as much as small and medium bass and are often released. Focus on 12-14 inch bass, catfish, and crappie (small 9-10 inch).***

Response: OEHHA supports collection of comprehensive data on contamination levels in all sport fish species in a water body. Collecting multiple size categories would yield a more comprehensive data set. Collecting an adequate sample of different sized fish of a species would enable testing whether differences in mercury levels in different size fish might warrant separate advice. However, collecting a complete data set of this nature would require larger sample sizes, more collections and analyses, and more resources. In the current data set only 4 out of 27 bass were 500 mm or larger. So the focus was actually on small and medium bass.

9) Scott Peweu, Black Butte Marina, verbal comment. ***Asked for more explanation of screening values.***

Response: More explanation of the screening values has been included in the revised report.

10) Brad Long, Army Corps, Don Holm, Glenn County Health, verbal comment. ***Liked draft fact sheet. Think it will be useful for them and their staff to have this to present the public.***

Response: OEHHA will update the fact sheet to include changes in the report and advisory.

11) Brad Long, Army Corps, Don Holm, Glenn County Health, verbal comment. ***Would like information on comparative data on fish from other lakes (especially nearby) and information on future studies.***

Response: OEHHA is working with staff from CALFED Bay-Delta Authority, the State and Regional Water Boards, Department of Fish and Game, U.S. Geological Service, and university scientists to combine data on mercury in fish from multiple lakes and rivers in northern California into a single database. This will make it easier to compare data for nearby water bodies.

OEHHA supports further collection of fish from Black Butte to build a more comprehensive data set. In particular more carp and crappie should be collected and analyzed to facilitate a complete exposure and risk assessment for these species at Black Butte Reservoir. Other game fish such as bluegill or other bass species should also be collected and analyzed. Sport fish should also be collected and analyzed from Stony Gorge and East Park Reservoirs so that exposure and risk assessments specific for these lakes can be done. Additional sampling and analyses will require resources.