HEALTH ADVISORY AND SAFE EATING GUIDELINES FOR FISH FROM SAN PABLO RESERVOIR (CONTRA COSTA COUNTY)

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FOREWORD

This report provides guidelines for consumption of several fish species taken from San Pablo Reservoir in Contra Costa County. These guidelines were developed as a result of findings of mercury, dieldrin and polychlorinated biphenyl (PCB) concentrations in fish tested from this water body, and are provided to fish consumers to assist them in making choices about the types of fish and frequency of consumption considered safe to eat. Some fish tested from these water bodies showed high levels of these chemicals, and guidelines are provided to protect against possible adverse health effects from consumption of contaminated fish. Additionally, the guidelines provide information to aid consumers in selecting fish that are lower in mercury or other contaminants. This 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, Contra Costa County, in consultation with the Office of Environmental Health Hazard Assessment, issued an interim public health notification for fish from the affected area in 2000 and, again, in 2004. The 2004 notification is included in Appendix 1. The guidelines contained herein are the state advisory.

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EXECUTIVE SUMMARY

Fish samples were collected from San Pablo Reservoir in 1997 because of concerns over potential chemical contamination from urban runoff and local cinnabar-enriched rock, as well as frequent use of this water body by subsistence fishers. Under the guidance of the Office of Environmental Health Hazard Assessment (OEHHA) and funding by the United States Environmental Protection Agency (U.S. EPA), the California Department of Fish and Game (CDFG) collected and analyzed fish for mercury and several organic contaminants. Selected composites were also sent to the Hazardous Materials Lab (HML) (now part of the California Department of Toxic Substances Control) for additional analyses. Sample size was not sufficient in the 1997 sampling for a complete health assessment and, thus, in 2000, the East Bay Municipal Utility District (EBMUD) collected additional fish for analysis with oversight by OEHHA. Samples were analyzed by CDFG with funding from the Toxic Substances Monitoring Program (TSMP). To protect public health in the period while this technical support document was being prepared, Contra Costa County, in consultation with the Office of Environmental Health Hazard Assessment, issued an interim public health notification for fish from the affected area in 2000 and, again, in 2004. The 2004 notification is included in Appendix 1.

Following publication of OEHHA's advisory tissue levels (ATLs, see below; Klasing and Brodberg, 2008) the contaminant data were re-evaluated by OEHHA to determine whether consumption advice provided by the interim advisory should be modified and to issue a state advisory. Newer "safe eating guidelines" also identify fish species with low contaminant levels considered safe to eat frequently. Based on this evaluation, a health advisory and safe eating guidelines were developed that allow fishers to select fish to eat from San Pablo Reservoir in quantities that maintain contaminant exposures within safe levels while supporting the benefits of fish consumption.

Mercury contamination of fish is a national problem that has resulted in the issuance of fish consumption advisories in most states, including California (U.S. EPA, 2003). Mercury is a trace metal that can be toxic to humans and other organisms in sufficiently high doses. Mercury occurs naturally in the environment, and is also redistributed in the environment as a result of human activities such as mining and the burning of fossil fuels. Once mercury is released into the environment, it cycles through land, air, and water. In aquatic systems, it undergoes chemical transformation to the more toxic organic form, methylmercury, which accumulates in fish and other organisms. Almost all fish contain detectible levels of mercury, more than 95 percent of which occurs as methylmercury. Consumption of fish is the major route of exposure to methylmercury in the United States.

The critical target of methylmercury toxicity is the nervous system, particularly in developing organisms such as the fetus and children. Methylmercury toxicity can occur to the fetus during pregnancy even in the absence of symptoms in the mother. In 1985, U.S. EPA set a reference dose (RfD; that is the daily exposure likely to be without significant risks of deleterious effects during a lifetime) for methylmercury of $3x10^{-4}$ mg per kg of body weight per day (mg/kg-day), based on central nervous system effects (ataxia, or loss of muscular coordination; and paresthesia, a sensation of numbness and tingling) in adults. This RfD was lowered to $1x10^{-4}$

mg/kg-day in 1995 (and confirmed in 2001), based on neurodevelopmental abnormalities in infants exposed *in utero*.

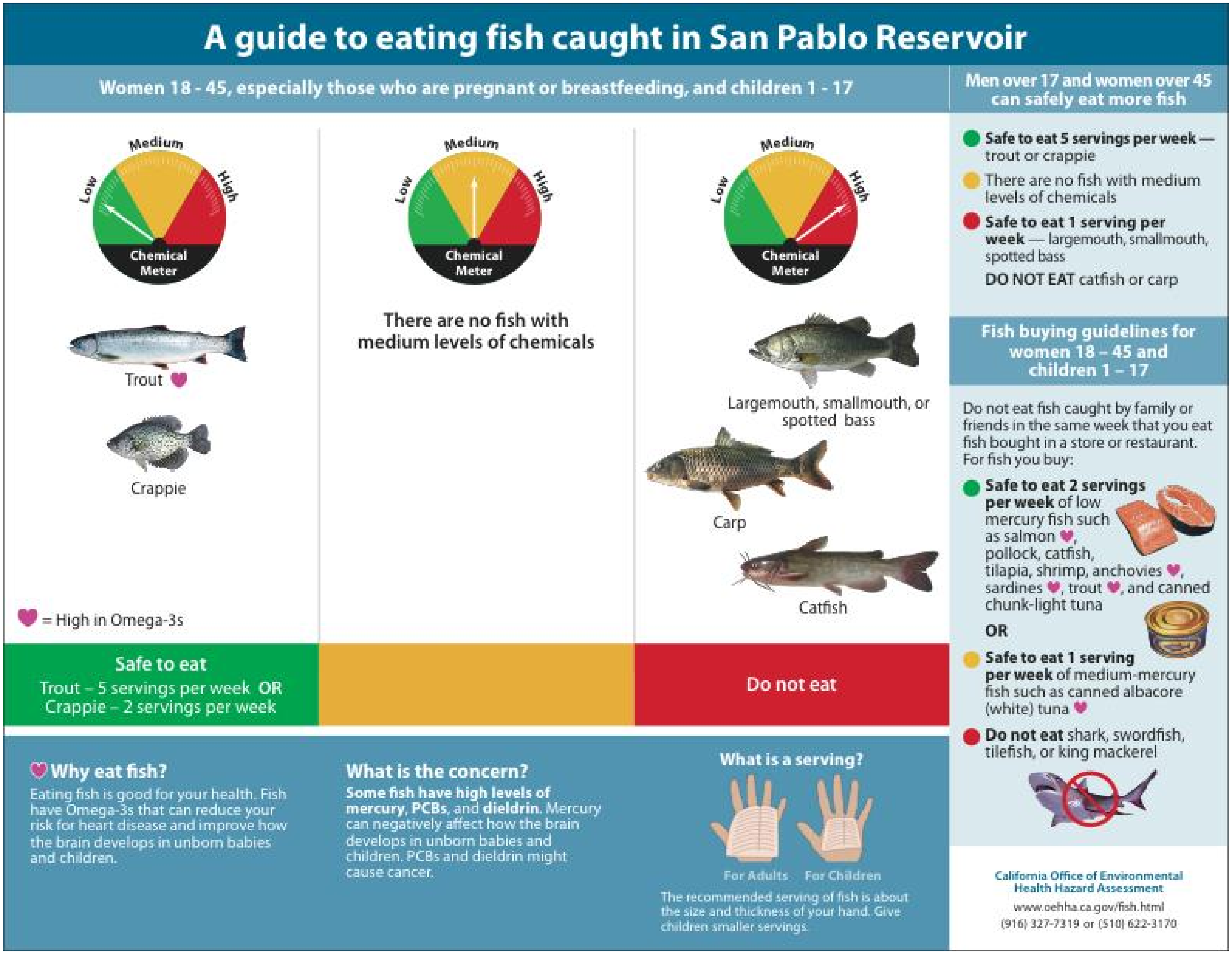
OEHHA finds convincing evidence that the fetus is more sensitive than adults to the neurotoxic effects of mercury, but also recognizes that fish play an important role in a healthy diet, particularly when it replaces other, higher fat sources of protein. These potential beneficial effects are thought to stem largely from unique fatty acids found in fish (docosahexaenoic and eicosapentaenoic acids) and include reduced rates of cardiovascular disease and stroke, decreased inflammation, and improvements in cognitive and visual function. Fish consumption during pregnancy, in particular, has been associated with higher cognitive scores in young children. Nevertheless, because the fetus has increased vulnerability to methylmercury, OEHHA will use the current U.S. EPA RfD, based on effects in the fetus, to establish fish consumption advice for women of childbearing age (18-45 years) and children 1-17 years. At the same time, OEHHA will encourage women 18-45 years to select and eat fish that are low in mercury or other contaminants and high in the fatty acids described above, which can benefit the developing fetus. The previous U.S. EPA RfD, based on effects in adults, will be used to establish fish consumption advice for women over 45 years and men, who are generally less sensitive to methylmercury.

Dieldrin is a chlorinated cyclodiene pesticide that was widely used in the United States until its registration was cancelled by U.S. EPA in 1989. Dieldrin accumulates in the aquatic environment and, thus, fish consumption can be a major source of human exposure. The nervous system is the most sensitive target organ in humans who have been acutely or chronically exposed to dieldrin; however, human data are not sufficient to derive toxicity criteria for this chemical. In 1990, U.S. EPA set an RfD for dieldrin of $5x10^{-5}$ mg/kg-day, based on increased liver weights in rats. A cancer slope factor (an upper-bound estimate of the probability that an individual will develop cancer over a lifetime as a consequence of exposure to a given dose of a carcinogen) for dieldrin of 16 $(mg/kg\text{-}day)^{-1}$ was also set by U.S. EPA, based on development of liver cancer in mice. OEHHA will use these values to establish fish consumption advice for dieldrin.

Polychlorinated biphenyls (PCBs) are a class of synthetic organic chemical mixtures that were used in the United States from about 1930 to 1977 as coolants, hydraulic fluids, lubricating oils, and plasticizers. Although no longer produced, PCBs still exist in the environment as a result of previous accidental spills and leaks from PCB-containing products. Once in the environment, PCBs resist degradation; their chemical properties allow them to accumulate and biomagnify in the food chain, particularly in fish. Marine and freshwater fish consumption may account for a significant portion of human dietary PCB exposure. In humans, occupational or accidental high-level PCB exposures have been found to cause chloracne, a severe form of acne. Potential adverse effects resulting from low level PCB exposures (such as those currently found in the environment) have been difficult to confirm in humans; therefore, animal studies have been used to set toxicity criteria for this contaminant and have been derived from experiments using commercial PCB mixtures sold under the trade name Aroclors. Fish consumption is considered a PCB exposure route of high risk and persistence, so recommended health effects criteria are based on the cancer and non-cancer toxicity of the most toxic and persistent Aroclors. The RfD for high-risk PCB exposure of $2x10^{-5}$ mg/kg-day was set by U.S. EPA in 1996 and is based on ocular inflammation, distorted nail growth, and decreased immune response in monkeys. Similarly, the cancer slope factor for high-risk PCB exposure of 2.0 $(mg/kg\text{-}day)^{-1}$ is set for the most toxic and persistent Aroclors and is based on development of liver cancer in rats. OEHHA will use these values to establish fish consumption advice for PCBs.

In order to provide fish consumption guidelines for various fish species, contaminant concentrations in fish from a water body are compared to OEHHA advisory tissue levels (ATLs) for those chemicals, which are designed to determine the appropriate consumption rate (quantity of fish or shellfish consumed in a given time period) that would prevent exposure to more than the average daily RfD for non-carcinogens or a cancer risk level of $1x10^{-4}$ (1 in 10,000) for carcinogens. Best professional judgment is used to determine the most suitable data evaluation approach as well as the most appropriate method to convert a complex data set into more simplified and unified consumption advice for risk communication purposes. Ultimately, a health advisory and safe eating guidelines identify those fish species with high contaminant levels whose consumption should be avoided as well as those low-contaminant fish that may be consumed frequently as part of a healthy diet. For San Pablo Reservoir, a statistically representative sample size was available to provide safe eating guidelines for largemouth bass, channel catfish, carp, black crappie, and rainbow trout. Supporting data (such as mercury concentrations for a closely related species at a similar trophic level) were used to develop additional consumption guidelines for other black bass, trout, and catfish species.

For general advice on how to limit your exposure to chemical contaminants in sport fish (e.g., eating smaller fish of legal size), as well as a fact sheet on methylmercury in sport fish, see the California Sport Fish Consumption Advisories (http://www.oehha.ca.gov/fish.html) and Appendices 2 and 3. 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 the concentration of many fat-soluble organic contaminants (e.g., DDTs, dieldrin and PCBs) can be reduced by various cooking and cleaning techniques, such as removing the skin and trimming the fat and using a cooking method that allows the juices to drain away from the fish (see Appendix 3). However, these methods will not reduce the methylmercury content of fish, which is bound to the fillet muscle. There are no known ways to prepare fish (such as soaking in milk) that will reduce the methylmercury content of fish. Meal sizes should be adjusted to body weight. Consumers weighing less than 160 pounds should eat smaller portions than the standard eight-ounce portion (equal to six ounces after cooking), and children should also eat smaller portions, about half as much as adults for children up to the age of 12. The complete recommendations for consumption of fish from San Pablo Reservoir for women 18-45 years and children 1-17 years, and for women over 45 years and men are presented below.


A guide to eating fish caught in San Pablo Reservoir
Women 18 - 45, especially those who are pregnant or breastfeeding, and children 1 - 17
Medium
Low
High
Chemical Meter
Trout
Crappie
= High in Omega-3s
There are no fish with medium levels of chemicals
Largemouth, smallmouth, or spotted bass
Carp
Catfish
Safe to eat
Trout – 5 servings per week OR
Crappie – 2 servings per week
Do not eat
Why eat fish?
Eating fish is good for your health. Fish have Omega-3s that can reduce your risk for heart disease and improve how the brain develops in unborn babies and children.
What is the concern?
Some fish have high levels of mercury, PCBs, and dieldrin. Mercury can negatively affect how the brain develops in unborn babies and children. PCBs and dieldrin might cause cancer.
What is a serving?
For Adults
For Children
The recommended serving of fish is about the size and thickness of your hand. Give children smaller servings.
Men over 17 and women over 45 can safely eat more fish
Safe to eat 5 servings per week — trout or crappie
There are no fish with medium levels of chemicals
Safe to eat 1 serving per week — largemouth, smallmouth, spotted bass
DO NOT EAT catfish or carp
Fish buying guidelines for women 18 – 45 and children 1 – 17
Do not eat fish caught by family or friends in the same week that you eat fish bought in a store or restaurant. For fish you buy:
Safe to eat 2 servings per week of low mercury fish such as salmon, pollock, catfish, tilapia, shrimp, anchovies, sardines, trout, and canned chunk-light tuna
OR
Safe to eat 1 serving per week of medium-mercury fish such as canned albacore (white) tuna
Do not eat shark, swordfish, tilefish, or king mackerel
California Office of Environmental Health Hazard Assessment
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INTRODUCTION

Fish consumption advisories have been issued in 48 states and cover approximately 38 percent and 26 percent of the country's total lake acreage and river miles, respectively (U.S. EPA, 2007). Mercury contamination of fish, in particular, is a national problem that resulted in the issuance of 534 new advisories in 2006 alone (U.S. EPA, 2007). Polychlorinated biphenyls (PCBs) and chlorinated pesticides such as chlordane and dichlorodiphenyltrichloroethane and its metabolites (DDTs) are also a frequent basis for fish consumption advisories throughout the United States (U.S. EPA, 2007). In northern California, elevated levels of mercury associated with historic gold and mercury mining have been found in fish in numerous reservoirs and stream sites. As a result, fish consumption advisories based on mercury contamination have been issued by the Office of Environmental Health Hazard Assessment (OEHHA) for various water bodies in at least 29 counties in central and northern California. Similarly, advisories based on organic contaminants, such as PCBs and DDTs, have been issued for the San Francisco Bay and coastal regions of Los Angeles and Orange counties. Because of concerns over potential chemical contamination from urban runoff and local cinnabar-enriched rocks as well as the fact that San Pablo Reservoir may be used frequently by subsistence fishers (Brodberg and Pollock, 1999), fish samples were collected from this lake in 1997 in order to conduct a public health assessment. Under the guidance of OEHHA and with funding by the U.S. Environmental Protection Agency (U.S. EPA), the California Department of Fish and Game (CDFG) collected and analyzed fish for mercury and several organic contaminants. Selected composites were also sent to the Hazardous Materials Lab (HML) (now part of the California Department of Toxic Substances Control) for additional analyses. Sample size was not sufficient in the 1997 sampling for a complete health assessment and, thus, in 2000, the East Bay Municipal Utility District (EBMUD) collected additional fish for analysis with oversight by OEHHA. Samples were analyzed by CDFG with funding from the Toxic Substances Monitoring Program (TSMP). To protect public health in the period while this technical support document was being prepared, Contra Costa County, in consultation with the Office of Environmental Health Hazard Assessment, issued an interim public health notification for fish from the affected area in 2000 and, again, in 2004. The 2004 notification is included in Appendix 1.

OEHHA is the agency responsible for evaluating potential public health risks from chemical contamination of sport fish. This includes 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 59009, to protect public health, and Section 59011, to advise local health authorities, and the California Water Code Section 13177.5, to issue health advisories. Fish advisories developed by OEHHA are published in the California Sport Fishing Regulations of CDFG. OEHHA now emphasizes "safe eating guidelines" as part of health advisories in an effort to inform consumers of healthy choices in fish consumption as well as those that should be avoided or restricted.

Although evaluating contaminants that may be found in fish must be of primary concern, OEHHA has also determined that there is a significant body of evidence and general scientific consensus that eating fish at dietary levels that are easily achievable, but well above national average consumption rates, appears to promote significant health benefits, including decreased mortality. These potential beneficial effects are thought to stem largely from unique omega-3 fatty acids found in fish (docosahexaenoic acid or DHA and eicosapentaenoic acid or EPA) and include reduced rates of cardiovascular disease and stroke, decreased inflammation, and improvements in cognitive and visual function. Fish consumption during pregnancy, in particular, has been associated with higher cognitive scores in young children. In order to take these benefits into account and best promote the overall health of the fish consumer, OEHHA has expanded the advisory process beyond a simple risk paradigm (see Klasing and Brodberg [2008] for more discussion). OEHHA encourages people of all ages, especially women of childbearing age (18-45 years) and children, to select and eat fish that are low in mercury or other contaminants and high in omega-3 fatty acids (DHA and EPA).

CONTAMINANT TOXICOLOGY

Methylmercury

Mercury is a trace metal that occurs naturally in the environment, and exists in various forms including elemental or metallic mercury, inorganic, and organic mercury (ATSDR, 1999; IARC, 1993). Mercury enters the environment from the breakdown of minerals in rocks and leaching from old mine sites. Cinnabar ores, naturally rich in mercury, are common in northern California, and mercury was extensively mined in California in the 1800s and early 1900s. Mercury is also emitted into air from cement kilns, the burning of fossil fuels, and other industrial sources, as well as from volcanic eruptions. Mercury contamination thus occurs as a result of both natural and anthropogenic sources and processes.

Once mercury is released into the environment, it cycles through land, air, and water. The deposition of mercury in aquatic ecosystems is a concern for public and environmental health because microorganisms (bacteria and fungi) in the sediments can convert inorganic mercury into organic methylmercury, a more toxic form of mercury. Once formed, methylmercury is ingested by aquatic animals and subsequently by the fish that feed on them. In this way, methylmercury "biomagnifies," reaching the highest levels in fish and other organisms at the top of the food web. Concentrations of methylmercury in fish tissues can therefore be orders of magnitude greater than concentrations found in the water in which they reside.

Methylmercury contamination of fish is a national problem that has resulted in the issuance of fish consumption advisories in most states, including California (U.S. EPA, 2003). Methylmercury can be toxic to humans and other organisms in sufficiently high doses and can pose a variety of human health risks (NRC/NAS, 2000). Fish consumption is the major route of exposure to methylmercury in the United States (ATSDR, 1999). Almost all fish contain detectable levels of this chemical, more than 95 percent of which occurs as methylmercury. For this reason, concentrations in fish are usually measured as total mercury, and the conservative assumption is made that measured mercury is methylmercury. "Mercury" and "methylmercury" may thus be used interchangeably in this report. Whether consumption of fish is harmful depends on the concentrations of methylmercury in the fish and the amount of fish consumed.

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 resulting illness was manifested largely by neurological signs and symptoms such as loss of sensation in the hands and feet and, in extreme cases, loss of gait coordination, slurred speech, sensory deficits including blindness, and mental disturbances (Bakir et al., 1973; Marsh, 1987). 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). For additional discussion of the toxicity of methylmercury, see Klasing and Brodberg (2008).

Risks from exposure to methylmercury in fish are evaluated by comparing measured concentrations to a reference dose (RfD), which 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), and is expressed in units of milligrams per kilogram per day (mg/kg-day; IRIS, 1995). This estimate includes a safety factor to account for data uncertainty. The underlying assumption of an RfD is that, unlike carcinogenic effects, there is a threshold dose below which certain toxic effects will not occur. The RfD for a particular chemical is derived from review of relevant toxicological and epidemiological studies in animals or humans. Based on these values and the application of uncertainty factors to account for incomplete data and sensitive subgroups of the population, an RfD 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 on the earliest symptom of methylmercury toxicity (paresthesias or numbness and tingling sensations) that occurred in a small percentage of exposed Iraqi adults. U.S. EPA applied a 10-fold uncertainty factor to the lowest adverse effect level to generate the RfD (U.S. EPA, 1997). In 1995, 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). The oral RfD from these studies was set at $1x10^{-4}$ mg/kg-day, including a 10-fold uncertainty factor, to protect against developmental neurological abnormalities in infants (IRIS, 1995). This fetal RfD was deemed protective of infants and sensitive adults.

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 (NRC/NAS, 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 Faroe Islands, the Seychelle Islands, and New Zealand. The residents' diets on these islands rely heavily on consumption of fish and marine mammals, which provide a continual source of methylmercury exposure (NRC/NAS, 2000). 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 since published an updated 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). For additional discussion of the derivation of the RfD for methylmercury, see Klasing and Brodberg (2008). For advisories based on mercury levels in fish, OEHHA will use two separate RfDs to assess risk for different population groups. The current RfD of $1x10^{-4}$ mg/kg-day, based on effects in infants, will be used for women 18-45 years, including pregnant and breastfeeding women, and children 1-17 years. The previous RfD of $3x10^{-4}$ mg/kg-day, based on effects in adults, will be used for women over 45 years and men.

Dieldrin

Dieldrin is a chlorinated cyclodiene insecticide widely used in the United States from the 1950s to 1970s on crops such as corn and cotton and as a termiticide, in subsequent years, until its registration was canceled by U.S. EPA in 1989 (ATSDR, 2002; Stevenson et al., 1999; WHO, 1989a). Dieldrin is considered one of the most persistent compounds ever known (Matsumura, 1985) and, as such, is still found in the environment, particularly in soil, sediment, and animal fat (ATSDR, 2002).

The Agency for Toxic Substances and Disease Registry (ATSDR, 2002) and the World Health Organization (WHO,1989a) have extensively reviewed the toxicity of dieldrin. Similar to other chlorinated cyclodienes, dieldrin has relatively high acute toxicity following oral or inhalation exposures compared to most organochlorine pesticides, with signs and symptoms including dizziness, vomiting, motor hyperexcitability, and convulsions that generally appear within 20 minutes to 24 hours post-exposure (Ecobichon, 1991; 2003; Klassen and Watkins, 1999; WHO, 1989a). The nervous system is the most sensitive target organ following acute and chronic oral exposures in humans (ATSDR, 2002); adverse neurological effects, including electroencephalographic abnormalities, have been reported in workers occupationally exposed to dieldrin (Hoogendam et al., 1962; Hoogendam et al., 1965). Inconclusive data indicate that dieldrin may also affect the endocrine, reproductive and immune systems.

Whether dieldrin can cause cancer in human populations is controversial. The International Agency for Research on Cancer (IARC) has listed dieldrin as not classifiable as to its carcinogenicity in humans, with limited evidence of carcinogenicity in animals (IARC, 1987). In contrast, U.S. EPA lists dieldrin as a probable human carcinogen (IRIS, 1993) and OEHHA has administratively listed dieldrin on the Proposition 65 list of carcinogens. For additional discussion of the toxicity of dieldrin, see Klasing and Brodberg (2008).

Data for determining No Observed Adverse Effect Level (NOAEL) or Lowest Observed Adverse Effect Level (LOAEL) values for dieldrin in humans are inadequate; thus, U.S. EPA derived an RfD for this chemical based on animal studies. In contrast to humans, where neurotoxicity appears to be the most sensitive endpoint for acute and chronic toxicity, hepatic lesions are the chronic critical effect reported in animals (IRIS, 1990). U.S. EPA chose Walker et al. (1969) as the principal study for the RfD because it supported the critical effect and was a comparatively comprehensive chronic toxicity assessment (IRIS, 1990). Although minimal neurotoxic effects were also seen in this study, they occurred at a 10-fold higher dose level than did the hepatotoxic effects (ATSDR, 2002) and were thus not used in deriving a RfD.

Walker et al. (1969) fed five-week-old male and female CFE rats diets containing 0, 0.1, 1.0, and 10.0 ppm dieldrin for two years. U.S. EPA identified 0.1 and 1.0 ppm, respectively, as the NOAEL and LOAEL values for this study (IRIS, 1990) based on liver changes. To the NOAEL (corresponding to 0.005 mg/kg-day), U.S. EPA applied a 100-fold uncertainty factor (10 for interspecies conversion and 10 to protect sensitive humans), leading to an RfD of $5x10^{-5}$ mg/kg-day (IRIS, 1990). ATSDR (2002) has developed a chronic oral minimum risk level (MRL) of $5x10^{-5}$ mg/kg-day, also based on the Walker et al. (1969) study, which is identical to the U.S. EPA RfD. This RfD will be used to evaluate dieldrin non-cancer risk for OEHHA fish consumption advisory guidelines.

Studies to assess the carcinogenicity of dieldrin in humans are inadequate; however, dieldrin has been shown to cause cancer in multiple mouse strains and is structurally related to other known rodent carcinogens (e.g., aldrin, chlordane, heptachlor, and heptachlor epoxide) (IRIS, 1993). U.S. EPA combined the results of 13 liver carcinoma data sets for male and female mice and rats to determine carcinogenicity for this chemical. A geometric mean of the slope factors for the data sets was used to set an oral slope factor for dieldrin of 16 $(mg/kg\text{-}day)^{-1}$ (IRIS, 1993). This oral slope factor will be used to evaluate dieldrin cancer risk for OEHHA fish consumption advisory guidelines.

Polychlorinated Biphenyls (PCBs)

Polychlorinated biphenyls (PCBs) are a class of synthetic persistent lipophilic organic chemicals containing complex mixtures of biphenyls that are chlorinated to varying degrees (ATSDR, 2000; U.S. EPA, 2000a). The chemical formula for PCBs is $C_{12}H_{10-n}Cl_n$, where n equals the number of chlorine atoms ranging from one to ten (WHO, 1993). PCBs were manufactured in the United States from about 1930 to 1977 for use as coolants in electrical transformers and capacitors, and as hydraulic fluids, lubricating and cutting oils, and plasticizers (ATSDR, 2000; Erickson, 2001). Although there are 209 possible individual chlorinated biphenyl compounds (known as congeners), only approximately 130 are found in commercial products (U.S. EPA, 2000a; WHO, 1993). In the United States, PCBs were generally sold as mixtures of congeners under the trade name Aroclor (ATSDR, 2000; Nessel and Gallo, 1992).

PCBs are found chiefly in soil, sediment, and fatty biological tissue, where they accumulate and biomagnify in the food chain (Dekoning and Karmaus, 2000; Menzer, 1991; Moser and McLachlan, 2001). Bioconcentration factors of some congeners are reported to reach as high as $1x10^7$ in fish (Erickson, 2001). PCB residue levels in fish are affected by sediment characteristics (e.g., organic carbon content), fish species and lipid content, and trophic structure of the food chain (Eisler, 1996).

The toxicity of PCBs following occupational exposure has been known since 1936 when the development of chloracne (a severe form of acne) in PCB-exposed workers resulted in the setting of a workplace threshold limit value for these compounds (Erickson, 2001). Occupational exposure has also been reported to result in ocular effects such as Meibomian gland hypersecretion, swollen eyelids, and abnormal conjunctival pigmentation (ATSDR, 2000). Numerous epidemiological studies since that time have attempted to determine whether PCBs pose a human health risk at levels currently found in the environment. Many authors have subsequently reported an association between oral environmental PCB exposures and cancer as well as various adverse neurological, reproductive, and developmental effects (ATSDR, 2000). Neurological effects have also been observed in infants, children, and adults following PCB poisonings (ATSDR, 2000). To date, the most sensitive effects of PCB toxicity have been identified in monkeys, including clinical signs showing developmental effects such as ocular exudate, inflamed Meibomian glands, and distorted growth of finger and toenails, as well as immunological effects such as decreased antibody response to sheep erythrocytes (IRIS, 1996).

As has been the case with various non-cancer endpoints, epidemiological research in humans has also found an association between exposure to PCBs and mortality rates from cancers of the liver, gall bladder, biliary tract, and brain, as well as non-Hodgkin's lymphoma and malignant melanoma (see Cogliano, 1998 and ATDSR, 2000, for discussion). Numerous experimental investigations in rodents have clearly shown the ability of various commercial Aroclor mixtures to cause cancerous or pre-cancerous hepatic and gastrointestinal lesions (see Cogliano et al., 1998 and ATSDR, 2000, for discussion). IARC has listed PCBs as probable human carcinogens, based on limited evidence of hepatobiliary cancer in humans and sufficient evidence of malignant liver neoplasms in rodents (IARC, 1987). U.S. EPA also designates PCBs as probable human carcinogens based on tumors found in female mice exposed to Aroclors 1260, 1254, 1242, and 1016 and also in male rats exposed to Aroclor 1260 (IRIS, 1997). Based on these actions, OEHHA has administratively listed PCBs on the Proposition 65 list of chemicals known to the State of California to cause cancer. For additional discussion of the toxicity of PCBs, see Klasing and Brodberg (2008).

Studies to identify an RfD or cancer slope factor for PCBs have been conducted with the specific Aroclor mixtures that were prevalent as commercial products during the period that Aroclors were actively manufactured and used. However, as noted above, PCBs found in fish or other environmental media have undergone weathering that can selectively increase or decrease individual congeners, possibly increasing the overall toxicity of the mixture (Cogliano, 2001). U. S. EPA has adopted an approach that matches the expected environmental persistence and toxicity of congeners to the congener profile and toxicity of different Aroclors (Cogliano, 2001). Fish consumption is considered an exposure of high risk and persistence, so recommended health effects criteria values are based on the cancer and non-cancer toxicities of Aroclors 1260 and 1254, which show the greatest toxicity and content of environmentally persistent chlorines (U.S. EPA, 1996).

Because PCB dose-response data for non-cancer endpoints in humans are inadequate, the U.S. EPA RfD for these compounds has been derived from animal data. The RfD for Aroclor 1254 is $2x10^{-5}$ mg/kg-day (IRIS, 1996), based on a series of studies in adult female Rhesus monkeys (Arnold et al., 1993a,b; Tryphonas et al., 1989; 1991a,b) that were treated for 23 to 55 months. The critical effects noted in treated adults were ocular exudate, inflamed Meibomian (tarsal) glands, distorted finger and toenail growth, as well as a decreased antibody response to sheep erythrocytes, all of which occurred at the lowest tested dose of 0.005 mg/kg-day (IRIS, 1996). To this LOAEL, an uncertainty factor of three hundred (ten for sensitive individuals, three for extrapolation from rhesus monkey to humans, a partial factor for the use of a minimal LOAEL [i.e., the effects were not severe], and three to convert from subchronic to chronic) was applied to develop the RfD (IRIS, 1996). This RfD of $2x10^{-5}$ mg/kg-day will be used to evaluate PCB non-cancer risk for OEHHA fish consumption advisory guidelines.

Human cancer dose-response data for PCBs are also inadequate and, thus, the PCB cancer slope factor has been generated based on animal studies. Because of the differential ability of different PCB mixtures to cause cancer, U.S. EPA developed a range of cancer slope factors based on

Aroclors 1016, 1242, 1254, and 1260. These include the range of typical congeners found in various environmental media such as water and fish (IRIS, 1997). For food chain exposure, such as fish consumption, where environmental processes increase risk, a "high risk" cancer slope factor of 2.0 $(mg/kg\text{-}day)^{-1}$ is used based on the carcinogenic potential of Aroclors 1254 and 1260 (U.S. EPA, 1996). This value was derived from a study of male and female rats (Brunner et al., 1996; Norback and Weltman, 1985). A significant, dose-related increase in the number of liver adenomas or carcinomas was found in female rats exposed to all Aroclors and in male rats exposed to Aroclor 1260 (IRIS, 1997). Aroclors 1254 and 1260 are the most frequently detected Aroclors sampled in California fish (Brodberg and Pollock, 1999; LACSD, 2000). The cancer slope factor of 2.0 $(mg/kg\text{-}day)^{-1}$ will be used to evaluate PCB cancer risk for OEHHA fish consumption advisory guidelines.

For fish consumption advisories, cancer and non-cancer health effects criteria are applied to the sum of detected Aroclors (generally 1248, 1254, and 1260) or a sum of congeners in fish tissue, as recommended by U.S. EPA (U.S. EPA, 2000b). For additional discussion of the derivation of the RfD and cancer slope factor for PCBs, see Klasing and Brodberg (2008).

EVALUTION OF CONTAMINANT LEVELS IN FISH FROM SAN PABLO RESERVOIR

San Pablo is an 866-acre reservoir, open from mid-February to October, located on the western side of the coast range near San Francisco Bay. It is the most popular public recreation lake in the Bay Area and considered one of the most consistent fisheries in California (Stienstra, 2004). The reservoir is stocked with trout annually by CDFG and is also known for excellent catfish, smallmouth bass, largemouth bass, bluegill, and crappie fishing (EBMUD, 2008; Stienstra, 2004).

Data Collection and Evaluation

In an effort to assess the bioaccumulation of mercury and selected organic contaminant bioaccumulation in San Pablo Reservoir, a total of five sport fish species were collected by electrofishing equipment or fyke or gill nets in 1997 and 2000. Species collected included largemouth bass, channel catfish, black crappie, carp, and rainbow trout. Fish were measured and weighed and grouped by species and total length. Composites were made from muscle tissue of individual fish; boneless and skinless fillets were submitted to the CDFG Water Pollution Control Laboratory or the California Department of Toxic Substances Control Hazardous Materials Laboratory for chemical analyses. Homogenized tissue was analyzed for mercury levels by cold-vapor atomic absorption spectroscopy while organic contaminants were analyzed by gas chromatography, using mass spectrometry (GC/MS) for chlorinated hydrocarbon determination.

It is not possible to determine in advance how many samples of each fish species from each site will be necessary in order to statistically interpret contamination data for fish consumption guidelines. 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 developing fish consumption advisories. More samples will provide a better estimate of the mean contaminant level in various fish species and are especially important for large water bodies.

Of the samples collected from San Pablo Reservoir, largemouth bass (n = 15 in five composites), channel catfish (n = 20 in five composites), black crappie (n = 19 in four composites), carp (n = 20 in five composites), and rainbow trout (n = 14 in four composites) had sufficient sample size (≥ 9 fish per species) of legal/edible size fish (see Table 1) to be considered representative of contaminant levels in those species, thereby allowing adequate estimation of the health risks associated with their consumption. Assessment of other fish species that may exist in the reservoir but were not analyzed are addressed in the guidelines for fish consumption section of this report.

Chemical concentrations for the data presented below are reported in wet weight. Arithmetic means, rather than geometric means, were used to represent the central tendency (average) of mercury concentrations for all species in this report. In general, arithmetic means for environmental chemical exposures are more health-protective than geometric means, and are commonly used in human health risk assessments. Chemical concentrations that are presented in Table 1 and discussed in the text are rounded based on laboratory reporting of three significant digits in results, where the third reported digit is uncertain (estimated). Tabled values are rounded to the second digit, which is certain. The original laboratory values are presented in Appendices 4 and 5.

Mercury

Mercury concentrations in fish and other biota are dependent on the mercury level of the environment, which can vary based on differences in pH, redox potential, temperature, alkalinity, buffering capacity, suspended sediment load, and geomorphology of individual water bodies (Andren and Nriagu, 1979; Berlin, 1986; WHO, 1989b). Other factors also affect the accumulation of mercury in fish tissue, including fish diet, species, and age (as inferred from length) (WHO, 1989b; 1990). Fish at the highest trophic levels (i.e., predatory fish) generally have the highest levels of mercury. Additionally, because of the long biological half-life of methylmercury in fish (approximately 2 years), tissue concentrations in fish increase with increased duration of exposure (Krehl, 1972; Stopford and Goldwater, 1975; Tollefson and Cordle, 1986). As a result, tissue methylmercury concentrations are expected to increase with increasing age and length within a given species, particularly in piscivorous fish.

For legal/edible sized fish, the mean mercury concentration, length, and sample size of composites for each species collected and analyzed from San Pablo Reservoir are presented in Table 1. Complete descriptive statistics for these fish can be found in Appendix 4; mercury concentrations and lengths of individual composite samples of fish can be found in Appendix 5. Mercury concentrations in fish of all species ranged from 8 ppb in a rainbow trout composite to 770 ppb in a largemouth bass composite. The following mercury concentrations and fish lengths were determined: mean mercury concentration for largemouth bass composites was 520 ppb, with a range of 370 to 770 ppb. Largemouth bass composite averages ranged in length from 353 to 543 mm, with an overall mean of 436 mm. Mercury concentrations in black crappie composites ranged from 130 to 160 ppb, with a mean of 140 ppb. Lengths in this species ranged from composite averages of 191 mm to 252 mm and had an overall mean of 207 mm. Mercury concentrations in channel catfish composites ranged from 60 to 160 ppb, with a mean of 110 ppb; lengths in this species ranged from 456 to 582 mm, with an overall mean for composites of 509 mm. Rainbow trout composites had a mean mercury concentration of 17 ppb (range: 8 to 34 ppb) and a mean length for composites of 380 mm (range: 338 to 519 mm). Carp composites had a mean mercury concentration of 140 ppb, with a minimum and maximum of 52 and 200 ppb, respectively. Overall mean length for composites of this species was 524 mm, with a range of 508 to 537 mm.

Dieldrin

Mean dieldrin concentrations for composites of each species are also presented in Table 1, with descriptive statistics in Appendix 4 and dieldrin concentrations and lengths of composite samples of fish shown in Appendix 5. Dieldrin levels in fish samples collected from San Pablo Reservoir ranged from 2 ppb in a rainbow trout composite to 120 ppb in a channel catfish composite. In largemouth bass composites, dieldrin concentrations ranged from 4 to 9 ppb, with a mean of 7 ppb. Black crappie composites had a mean dieldrin concentration of 5 ppb (range: 3 to 5 ppb). Dieldrin levels in rainbow trout composites ranged from 2 to 8 ppb, with a mean of 4 ppb. Carp and channel catfish had the highest dieldrin concentrations, with overall composite means of 61 and 78 ppb, respectively. Dieldrin levels ranged from 14 to 110 ppb in carp composites and 42 to 120 ppb in channel catfish composites.

Polychlorinated Biphenyls (PCBs)

PCB levels in fish from San Pablo Reservoir are presented in Table 1; complete descriptive statistics and PCB concentrations in individual composite fish samples can be found in Appendices 4 and 5, respectively. The level of detection for PCBs as Aroclors was 10 ppb; fish with PCB levels below detection limits for all Aroclors were assigned a value of one-half the lowest detection limit (5 ppb). Fish from San Pablo Reservoir had PCB concentrations ranging from below detection limits (assigned a value of 5 ppb) in all composite samples of black crappie to 250 ppb in a channel catfish composite. As was the case with dieldrin, carp and channel catfish also had significant levels of PCBs. The overall mean PCB concentration in channel catfish composites was 160 ppb, with a range of 43 to 250 ppb. Carp PCB levels in composites ranged from 30 to 130 ppb, with an overall mean of 93 ppb. Largemouth bass composite PCB levels ranged from 17 to 24 ppb (overall composite mean: 19 ppb), while rainbow trout composite PCB concentrations ranged from 5 to 20 ppb (overall composite mean: 11 ppb).

Other Chemicals

Aldrin, chlordane, chlorpyrifos, dacthal, DDTs, diazinon, dioxin equivalents (TEQ), disulfoton, endosulfan, endrin, ethion, hexachlorocyclohexane, hepataclor, heptachlor epoxide, hexachlorobenzene, methoxychlor, oxadiazon, and toxaphene levels were also measured (as described above for other organic chemicals) in fish collected from San Pablo Reservoir. Mean values of these chemicals for each species were below levels of concern.

GUIDELINES FOR FISH CONSUMPTION FOR SAN PABLO RESERVOIR

OEHHA has developed advisory tissue levels for contaminants found in fish (Klasing and Brodberg, 2008) similar to risk-based consumption limits recommended by U.S. EPA (2000b). Advisory tissue levels relate the number and size of recommended fish meals to contaminant concentrations found in fish (Table 2). These values were designed so that individuals consuming no more than a preset number of meals should not exceed the RfD for non-carcinogenic contaminants, on average, or a risk level of $1x10^{-4}$ for carcinogens. Advisory tissue levels for methylmercury for women beyond their childbearing years and men are approximately three times higher than for sensitive populations because of the three-fold higher RfD used for this population group. The sensitive population for methylmercury is defined as women of childbearing age (18-45 years), including women who are pregnant or breastfeeding, and children aged 1-17 years. Non-cancer and cancer risks for dieldrin and PCBs are the same for all population groups. Meal sizes were based on a standard eight-ounce (227 grams) portion of uncooked fish, which is approximately six ounces after cooking, for adults who weigh roughly 70 kilograms (equivalent to 154 pounds). OEHHA recommends that people who weigh less than 70 kilograms eat smaller portions of fish and that, in particular, children up to age 12 eat about half as much. A description of the process of developing advisory tissue levels, including other assumptions, can be found in Klasing and Brodberg (2008).

OEHHA’s current policy is to issue site-specific consumption advice beginning at a consumption frequency of one eight-ounce serving per week (a total of six ounces of cooked fish per week), which corresponds to the minimum weekly fish consumption rate recommended by the American Heart Association (AHA, 2008). Fish that can be eaten at this frequency represent fish with relatively low levels of mercury and/or other contaminants. If, based on very low contaminant concentrations, fish can be consumed even more frequently than six ounces per week, advice for consumption of two or three meals per week, or more, as appropriate, may also be provided. ATLs for four, five, six, and seven servings per week can be calculated, as in Klasing and Brodberg (2008), using consumption rates of 128, 160, 192, and 224 grams/day, respectively. In addition, because of the potential beneficial effects from regular fish consumption, thought to stem largely from unique omega-3 fatty acids in fish, OEHHA encourages people of all ages, especially women 18-45 years and children 1-17, to eat fish that are low in mercury or other contaminants and high in omega-3 fatty acids. OEHHA recommends that consumers avoid regular consumption of fish that cannot be safely eaten at a minimum of six ounces (after cooking) a week.

Mean contaminant concentrations for all fish species with a minimum of nine fish per sample were compared to the advisory tissue levels to develop consumption guidelines. As noted above, for San Pablo Reservoir, sample size was sufficient to issue fish consumption guidelines for black crappie, carp, channel catfish, rainbow trout, and largemouth bass. For women over 45 years and men, black crappie and rainbow trout had mercury concentrations that fell into the four and seven servings per week category, respectively (ATL values not shown). Because mercury concentrations neared the five servings per week cutoff for black crappie, and for ease of communication, these species were combined and consumption advice for five servings per week was provided for both species for this population group.

When sample size for a particular species from a water body is too small to assure a statistically representative sample, other information may be useful to help develop consumption recommendations for that species. When there are less than nine individual or three composite samples at a site for a given species, advice for that species may be extrapolated from data for other, similar species at that site or from the same species at a similar site. 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 few or no data (e.g., smallmouth bass) when adequate data are available for another, related fish species at that site (e.g., largemouth bass).

For San Pablo Reservoir, supporting data were examined to determine whether they could be used to assist in the development of fish consumption advice. Because different species of black bass often contain similar levels of the same contaminant in the same water body, it is recommended that consumers of smallmouth and spotted bass caught in this water body follow the advice for largemouth bass. Similarly, different species of trout often contain comparable levels of contaminants. Thus, it is recommended that consumers follow the rainbow trout advice for other trout species that may be caught in these water bodies. OEHHA also recommends that fishers follow the channel catfish advice for white catfish caught in this water body.

RECOMMENDATIONS FOR WOMEN 18-45 YEARS, INCLUDING PREGNANT AND BREASTFEEDING WOMEN, AND CHILDREN 1-17 YEARS FOR EATING FISH FROM SAN PABLO RESERVOIR

- Women 18-45 years and children 1-17 years can eat a total of five servings a week of rainbow trout or other trout species from San Pablo Reservoir. Serving size for women is six ounces of fish after cooking (equal to eight ounces before cooking). Serving size for children up to age 12 is about half as much as adults (3 ounces of cooked fish).

- Alternatively, a maximum of two servings a week can be eaten of black crappie.

- Women age 18-45 years and children 1-17 years should not eat any largemouth, smallmouth, or spotted bass; carp; or catfish from San Pablo Reservoir.

RECOMMENDATIONS FOR WOMEN BEYOND CHILDBEARING AGE AND MEN FOR EATING FISH FROM SAN PABLO RESERVOIR

- Women over 45 years and men can eat 5 servings a week of black crappie or trout. Serving size is six ounces of fish after cooking (about eight ounces before cooking) for an adult weighing about 160 pounds. Serving size can be adjusted to add one ounce for every 20 pounds above, or subtract one ounce for every 20 pounds below, the average weight of 160 pounds.

- As an alternative, women over 45 years and men can eat up to one serving a week of largemouth bass, smallmouth bass, or spotted bass from San Pablo Reservoir.

- Women beyond childbearing age and men should not eat carp or catfish from San Pablo Reservoir.

OTHER RECOMMENDATIONS

Regular consumption of fish is recommended as part of a healthy diet due to evidence for health benefits associated with consistent fish consumption (AHA, 2008, IOM, 2007). The "one meal a month" advice used in the interim advisory for San Pablo Reservoir has been combined with the "no consumption" category in recent advisory tables and labeled "do not eat" to reflect that eating fish from this category is not health protective because the higher levels of mercury or other chemicals prevent regular safe consumption of fish. OEHHA encourages consumers to select fish for consumption that can be safely eaten at least once a week and that contain higher levels of omega-3 fatty acids. Typically, these species include river-run salmon and trout, and for women over 45 and men only, black bass including largemouth, smallmouth, and spotted bass. To obtain adequate levels of omega-3 fatty acids, especially at water bodies with limited or no species that can be eaten one or more times a week, consumers are advised to maintain regular consumption of fish by eating sport fish from other water bodies with less restrictive advice, or low-mercury commercial fish that are high in omega-3 fatty acids from stores or restaurants (including salmon, trout, herring, and sardines), in order to obtain the health benefits from fish consumption. Newer safe eating guidelines from OEHHA indicate fish species with high omega-3 levels.

It is very important to note that, if an individual consumes multiple species or catches fish from more than one location with an advisory, the recommended guidelines for different species and locations should not be combined (*i.e.*, added). If a person eats six ounces of cooked fish with a recommendation of one serving a week, no other fish should be eaten that week. An individual can eat one species of fish one week, and the same or a different species from the one-serving category the next week. When the recommended consumption is two, three or more servings a week, fish species in that category can be interchanged, but not added to consumption of a species from the one-serving-a-week category. River-run or ocean salmon and trout are among the best choices for all consumers because they are very low in mercury and high in omega-3 fatty acids. Regular consumption of these salmon and trout by pregnant women can confer neurological advantages to the developing fetus (Oken et al., 2005; Cohen, et al., 2005). Women 18-45 years and children 1-17 years must be careful when choosing salmon and large trout from reservoirs, however, as salmon and large trout residing in a mercury-rich reservoir environment may accumulate high levels of mercury, similar to bass species.

OEHHA also recommends that women 18-45 and children 1-17 follow the Joint Federal Advisory for Mercury in Fish for commercial fish (U.S. EPA, 2004, see http://www.epa.gov/waterscience/fishadvice/advice.html). This advisory recommends that these individuals do not eat shark, swordfish, king mackerel, or tilefish[1] because of the high levels of mercury in these species. The federal advisory also states that these individuals can safely eat up to two meals (12 ounces cooked) of a variety of other fish purchased at stores or restaurants such as shrimp, canned light tuna, wild salmon, pollock, or (farm-raised) catfish. Albacore ("white") tuna is known to contain more mercury than canned light tuna; it is therefore recommended that no more than six ounces of albacore tuna (*e.g.*, one six-ounce can) be consumed per week.

For fish consumers who only eat sport fish occasionally, for example, on an annual vacation, consumption of a relatively high contaminant species such as carp from San Pablo Reservoir would not be a cause for concern provided their other fish intake did not include regular consumption of high-contaminant commercial or sport fish.

For general advice on how to limit your exposure to chemical contaminants in sport fish (*e.g.*, eating smaller fish of legal size), as well as a fact sheet on methylmercury in sport fish, see the California Sport Fish Consumption Advisories (http://www.oehha.ca.gov/fish.html) and Appendices 2 and 3. Unlike the case for many fat-soluble chlorinated hydrocarbon contaminants (*e.g.*, DDTs and PCBs), however, various cooking and cleaning techniques will not reduce the methylmercury content of fish. Additionally, there are no known ways to prepare fish (such as soaking in milk) that will reduce the methylmercury content of the fish. Meal sizes should be adjusted to body weight. Consumers weighing less than 160 pounds should eat smaller portions than the standard eight-ounce portion (equal to six ounces after cooking), and children should also eat smaller portions, about half as much as adults for children up to the age of 12. The complete recommendations for consumption of fish from San Pablo Reservoir for women 18-45 years and children 1-17 years, and for women over 45 years and men are presented below.

[1] King mackerel and tilefish are common on the east coast but rarely found in California or other western states, whereas shark and swordfish are more commonly available on the west coast.

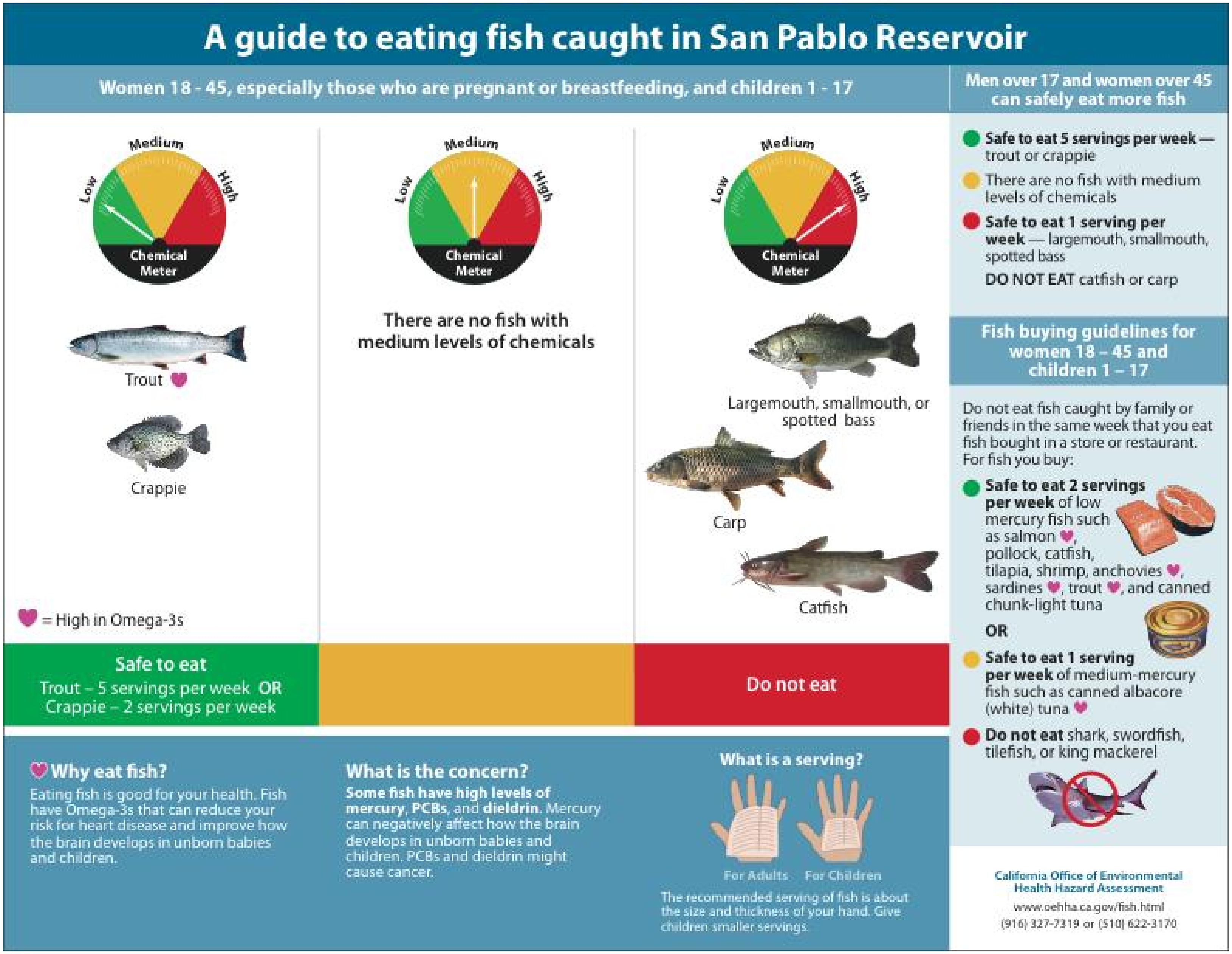
A guide to eating fish caught in San Pablo Reservoir
Women 18 - 45, especially those who are pregnant or breastfeeding, and children 1 - 17
Men over 17 and women over 45 can safely eat more fish
Medium
Low
High
Chemical Meter
Trout
Crappie
= High in Omega-3s
Safe to eat
Trout – 5 servings per week OR
Crappie – 2 servings per week
There are no fish with medium levels of chemicals
Largemouth, smallmouth, or spotted bass
Carp
Catfish
Do not eat
Safe to eat 5 servings per week — trout or crappie
There are no fish with medium levels of chemicals
Safe to eat 1 serving per week — largemouth, smallmouth, spotted bass
DO NOT EAT catfish or carp
Fish buying guidelines for women 18 – 45 and children 1 – 17
Do not eat fish caught by family or friends in the same week that you eat fish bought in a store or restaurant. For fish you buy:
Safe to eat 2 servings per week of low mercury fish such as salmon, pollock, catfish, tilapia, shrimp, anchovies, sardines, trout, and canned chunk-light tuna
OR
Safe to eat 1 serving per week of medium-mercury fish such as canned albacore (white) tuna
Do not eat shark, swordfish, tilefish, or king mackerel
Why eat fish?
Eating fish is good for your health. Fish have Omega-3s that can reduce your risk for heart disease and improve how the brain develops in unborn babies and children.
What is the concern?
Some fish have high levels of mercury, PCBs, and dieldrin. Mercury can negatively affect how the brain develops in unborn babies and children. PCBs and dieldrin might cause cancer.
What is a serving?
For Adults
For Children
The recommended serving of fish is about the size and thickness of your hand. Give children smaller servings.
California Office of Environmental Health Hazard Assessment
www.oehha.ca.gov/fish.html
(916) 327-7319 or (510) 622-3170

FIGURE 1: SAN PABLO RESERVOIR

TABLE 1. OVERALL MEAN[1] MERCURY, DIELDRIN, AND PCB[2] CONCENTRATIONS[3] (PPB, WET WEIGHT) AND LENGTHS[4] (MM) OF FISH FROM SAN PABLO RESERVOIR					
	Black Crappie	**Carp**	**Channel Catfish**	**Largemouth Bass**	**Rainbow Trout**
Mercury	140	140	110	520	17
Dieldrin	5	61	78	7	4
PCBs[2]	5	93	160	19	11
Length	207	524	509	436	380
# Samples	4	5	5	5	4
# Fish	19	20	20	15	14

[1]Data weighted by number of individuals per sample. All fish were legal and/or edible size.
[2]Total PCBs = the sum of Aroclors 1248, 1254, and 1260. If all three values are non-detects, then total PCBs = 5 (1/2 of the lowest method detection limit).
[3]Tabled concentration values are rounded based on laboratory reporting of three significant digits, where the third reported digit is uncertain (estimated). Tabled values are rounded to the second digit, which is certain. Laboratory values are presented in Appendices 4 and 5. Values have also been rounded to the nearest whole number.
[4]Length is presented as total length (the longest length from the tip of the tail fin to the tip of the nose/mouth.) Lengths are not rounded.

TABLE 2. ADVISORY TISSUE LEVELS FOR DIELDRIN, METHYLMERCURY AND PCBS BASED ON CANCER OR NON-CANCER RISK USING AN 8-OUNCE SERVING SIZE (PRIOR TO COOKING) (PPB, WET WEIGHT)				
Contaminant	**Three 8-ounce Servings* a Week**	**Two 8-ounce Servings* a Week**	**One 8-ounce Servings* a Week**	**No Consumption**
Dieldrin	≤15	>15-23	>23-46	>46
Methylmercury (Women 18-45 years and children 1-17 years)	≤70	>70-150	>150-440	>440
Methylmercury (Women over 45 years and men)	≤220	>220-440	>440-1,310	>1,310
PCBs	≤21	>21-42	>42-120	>120

*Serving sizes are based on an average 160-pound person. Individuals weighing less than 160 pounds should eat proportionately smaller amounts (for example, individuals weighing 80 pounds should eat one 4-ounce serving a week when the table recommends eating one 8-ounce serving a week).

Tabled values are rounded based on laboratory reporting of three significant digits, where the third reported digit is uncertain (estimated). Tabled values are rounded to the second digit, which is certain. When data are compared to this table, they should also first be rounded to the second significant digit as in this table.

The development of advisory tissue levels for various contaminants found in sport fish is described in Klasing and Brodberg (2008). ATLs for four, five, six, and seven servings per week can be calculated, as in Klasing and Brodberg (2008), using consumption rates of 128, 160, 192, and 224 grams/day, respectively. As explained in Klasing and Brodberg (2008), OEHHA may also combine consumption categories to simplify consumption advice for communication.

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APPENDIX 1. INTERIM FISH CONSUMPTION ADVISORY FOR SAN PABLO RESERVOIR INTERIM HEALTH ADVISORY* FOR EATING FISH CAUGHT IN SAN PABLO RESERVOIR

To protect health, Contra Costa Health Services is issuing the following interim advice in cooperation with the state Office of Environmental Health Hazard Assessment (OEHHA) to address potential health risks from elevated levels of mercury and PCBs (polychlorinated biphenyls) in fish caught in San Pablo Reservoir. Because these chemicals accumulate in the body, frequent consumption of fish from the lake could, over time, result in harm to the development of fetuses and children and affect the nervous or immune systems in adults, and could increase the long-term risk of cancer. Women of childbearing age and children should be especially careful to follow these guidelines.

Fish Species	Women of childbearing age and children (17 years and younger) (Meals per month)	Women beyond childbearing years and men (Meals per month)
Channel catfish OR	1	1
Carp OR	1	1
Largemouth bass OR	1	4
Black crappie OR	4	12
Rainbow trout OR	12	12
All other fish1	4	12

This advisory does not affect the treated drinking water supplied from San Pablo Reservoir. The water supply is safe.
Advisories have also been issued for nine other reservoirs in Alameda, Contra Costa, Marin, and Santa Clara counties as well as for San Francisco Bay and Delta, and Tomales Bay. The monthly fish consumption recommendations from these water bodies should not be combined. For more information on these advisories, contact OEHHA at (510) 622-3170 or visit OEHHA's Web site at: http://www.oehha.ca.gov/fish/so_cal/bayareares.html. For information about advice on commercial fish consumption, visit: http://www.oehha.ca.gov/fish.html.

For more information on San Pablo Reservoir, contact:
Contra Costa Health Services, at 1(877) 662-8376 or Elizabeth Hill, Ranger Supervisor, at 510-287-2028.
* This advisory replaces the previous interim advisory issued in 2000.

APPENDIX 2: 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 ages 18-45 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 aged 18-45 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; Lake Natoma and the lower American River in Sacramento County; 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; however, these symptoms are also associated with other medical conditions not related to methylmercury exposure.

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

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

CAN MERCURY POISONING OCCUR FROM EATING SPORT FISH IN CALIFORNIA?

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

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

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

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

IS THERE A MEDICAL TEST TO DETERMINE EXPOSURE TO METHYLMERCURY?

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

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

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

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

Most commercial fish have relatively low amounts of methylmercury and can be eaten safely in moderate amounts. However, several types of fish such as large, predatory, long-lived fish have high levels of methylmercury, and could cause overly high exposure to methylmercury if eaten often. The U.S. Food and Drug Administration (FDA) is responsible for the safety of commercial seafood. In 2004, FDA and the U.S. Environmental Protection Agency (U.S. EPA) issued a Joint Federal Advisory for Mercury in Fish advising women who are pregnant or could become pregnant, nursing mothers, and young children not to eat shark, swordfish, king mackerel, or tilefish. The federal advisory also recommends that these individuals can safely eat up to an average of 12 ounces (two average meals) per week of a variety of other cooked fish purchased in stores or restaurants, such as shrimp, canned light tuna, salmon, pollock, or (farm-raised) catfish. Albacore ("white") tuna is known to contain more mercury than canned light tuna; it is therefore recommended that no more than six ounces of albacore tuna be consumed per week. In addition, the federal advisory recommends that women who are pregnant or may become pregnant, nursing mothers, and young children consume no more than one meal per week of locally caught fish, when no other advice is available, and eat no other fish that week. The federal advisory can be found at http://www.cfsan.fda.gov/~dms/admehg.html or http://www.epa.gov/ost/fishadvice/advice.html.

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

Where can I get more information?

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

APPENDIX 3. GENERAL ADVICE FOR SPORT FISH CONSUMERS

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

Fishing Practices

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

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

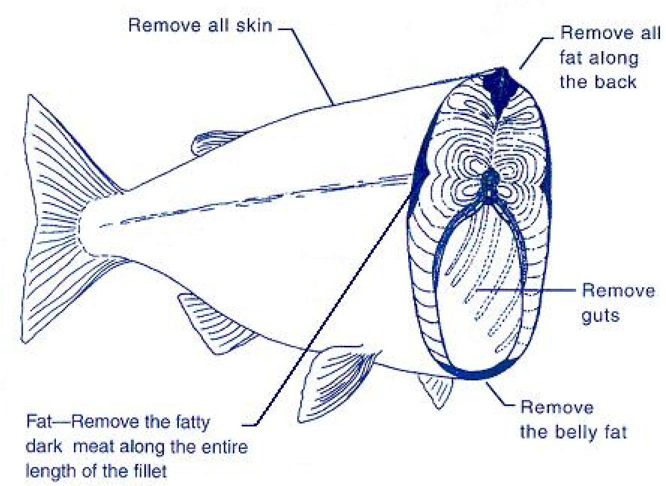
Consumption Guidelines

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

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

Fish Preparation and Consumption

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



Advice for Women 18-45 Years, Including Pregnant and Breastfeeding Women, and Children

Children and fetuses are more sensitive to the toxic effects of methylmercury, the form of mercury of health concern in fish. For this reason, OEHHA's advisories that are based on mercury provide special advice for women 18-45 years and children. Women should follow this advice throughout their childbearing years.

FDA is responsible for the safety of commercial seafood. 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. In 2004, FDA and U.S. EPA issued a Joint Federal Advisory for Mercury in Fish advising women who are pregnant or could become pregnant, nursing mothers, and young children not to eat shark, swordfish, king mackerel, or tilefish. The federal advisory also recommends that these individuals can safely eat up to an average of 12 ounces (two average meals) per week of a variety of other cooked fish purchased in stores or restaurants, such as shrimp, canned light tuna, salmon, pollock, or (farm-raised) catfish. Albacore ("white") tuna is known to contain more mercury than canned light tuna; it is therefore recommended that no more than six ounces of albacore tuna be consumed per week. In addition, the federal advisory recommends that women who are pregnant or may become pregnant, nursing mothers, and young children consume no more than one meal per week of locally caught fish, when no other advice is available, and eat no other fish that week. The federal advisory can be found at http://www.cfsan.fda.gov/~dms/admehg.html or http://www.epa.gov/ost/fishadvice/advice.html.

APPENDIX 4. DESCRIPTIVE STATISTICS FOR MERCURY, DIELDRIN AND PCB CONCENTRATIONS (PPB, WET WEIGHT) AND LENGTH (MM) IN FISH FROM SAN PABLO RESERVOIR

Descriptive Statistics[1] for Mercury, Dieldrin and PCB[2] Concentration (ppb, wet weight) From San Pablo Reservoir[3]

	Mercury ppb						**Dieldrin ppb**						**Total PCBs[2] ppb**					
Species	*Mean*	*Median*	*SD*	*Min*	*Max*	*CI[4]*	*Mean*	*Median*	*SD*	*Min*	*Max*	*CI[4]*	*Mean*	*Median*	*SD*	*Min*	*Max*	*CI[4]*
Black Crappie	143	146	11	129	155	137-148	5	5	1	3	5	4-5	5	5	[5]	5	5	[5]
Carp	135	182	66	52	197	104-166	61	63	40	14	111	42-79	93	105	36	30	127	77-110
Channel Catfish	106	114	39	62	160	88-125	78	63	32	42	120	63-93	156	179	73	43	248	121-190
Largemouth Bass	517	511	146	368	769	437-598	7	7	2	4	9	6-8	19	19	3	17	24	18-21
Rainbow Trout	17	8	12	8	34	10-24	4	4	2	2	8	3-6	11	5	7	5	20	7-15

Descriptive Statistics[1] for Length (mm) From San Pablo Reservoir

	Total Length mm Sample Size						**# Fish per Composite**			**Total # Fish**
Species	*Mean*	*Median*	*SD*	*Min*	*Max*	*CI[4]*	*n = 3*	*n = 4*	*n = 7*	
Black Crappie	207	194	24	191	252	195-219	0	3	1	19
Carp	524	524	10	508	537	520-529	0	5	0	20
Channel Catfish	509	504	42	456	582	489-529	0	5	0	20
Largemouth Bass	436	415	66	353	543	399-472	5	0	0	15
Rainbow Trout	380	340	75	338	519	337-424	2	2	0	14

[1] Data weighted by number of individuals per sample.

[2] Sum of Aroclors 1248, 1254 and 1260. If all 3 non-detected, Total PCBs = 5 (1/2 lowest MDL).

[3] Mean values were rounded to the nearest whole number.

[4] 95 percent Confidence Interval.

[5] Confidence Interval and Standard Deviation omitted since PCB values are constant.

APPENDIX 5. MERCURY, DIELDRIN AND PCB CONCENTRATIONS (PPB, WET WEIGHT) OF INDIVIDUAL FISH TISSUE COMPOSITE SAMPLES FROM SAN PABLO RESERVOIR

All Samples Meet OEHHA Size Criteria

Common Name	Data Source	Collection Date	Site	#	Total Length (mm)	Total Weight (g)	Hg wet (ppb)	Total PCBs (ppb)	Dieldrin (ppb)
Black Crappie	EBMUD/TSM	04/17/2000	San Pablo Reservoir	7	191	129	129.00	5	5.30
Black Crappie	EBMUD/TSM	04/17/2000	San Pablo Reservoir	4	194	129	146.00	5	5.20
Black Crappie	EBMUD/TSM	04/17/2000	San Pablo Reservoir	4	203	142	152.00	5	5.30
Black Crappie	OEHHA	11/13/1997	San Pablo Reservoir/South	4	252	263	155.40	5	2.53
Carp	EBMUD/TSM	04/17/2000	San Pablo Reservoir	4	508	2875	185.00	127	111.00
Carp	EBMUD/TSM	04/17/2000	San Pablo Reservoir	4	530	3008	182.00	121	95.20
Carp	EBMUD/TSM	04/17/2000	San Pablo Reservoir	4	537	3013	197.00	105	62.70
Carp	OEHHA	11/12/1997	San Pablo Reservoir/North	4	524	2331	52.40	30	14.50
Carp	OEHHA	11/05/1997	San Pablo Reservoir/South	4	523	2476	60.55	84	20.10
Channel Catfish	EBMUD/TSM	04/17/2000	San Pablo Reservoir	4	456	1456	62.00	43	63.10
Channel Catfish	EBMUD/TSM	04/17/2000	San Pablo Reservoir	4	494	1973	114.00	110	120.00
Channel Catfish	EBMUD/TSM	04/17/2000	San Pablo Reservoir	4	504	1939	131.00	198	110.00
Channel Catfish	OEHHA	11/13/1997	San Pablo Reservoir/South	4	509	1596	65.67	179	42.40
Channel Catfish	OEHHA	11/13/1997	San Pablo Reservoir/South	4	582	2457	159.51	248	54.20
Largemouth Bass	OEHHA	11/12/1997	San Pablo Reservoir	3	353	612	367.85	19	4.40
Largemouth Bass	OEHHA	11/05/1997	San Pablo Reservoir	3	405	1106	532.25	17	4.65
Largemouth Bass	OEHHA	11/12/1997	San Pablo Reservoir	3	415	1226	404.75	18	8.87
Largemouth Bass	OEHHA	11/12/1997	San Pablo Reservoir/North	3	462	1760	511.43	19	7.18
Largemouth Bass	OEHHA	11/12/1997	San Pablo Reservoir/North	3	543	3141	769.42	24	8.74
Rainbow Trout	EBMUD/TSM	04/17/2000	San Pablo Reservoir	4	338	486	7.50	5	7.60
Rainbow Trout	EBMUD/TSM	04/17/2000	San Pablo Reservoir	4	340	564	7.50	5	3.10
Rainbow Trout	OEHHA	11/12/1997	San Pablo Reservoir	3	519	1861	33.62	20.0	4.61
Rainbow Trout	OEHHA	11/05/1997	San Pablo Reservoir/South	3	352	586	27.33	18	1.62

Total PCBs = Aroclors 1248 + 1254 + 1260; if all 3 are ND, then enter "5" (1/2 the lowest MDL)