HEALTH ADVISORY

GUIDELINES FOR CONSUMPTION OF FISH AND SHELLFISH FROM TOMALES BAY (MARIN COUNTY)

October 2004

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HEALTH ADVISORY:

GUIDELINES FOR CONSUMPTION OF FISH AND SHELLFISH FROM TOMALES BAY (MARIN COUNTY)

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FOREWORD

This report provides recommended guidelines for consumption of fish from Tomales Bay (Marin County). These guidelines are provided to the public as a result of findings of high levels of mercury in fish tested from Tomales Bay. These recommendations were developed to protect against possible adverse health effects that may result from consumption of 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 interim period while this report was prepared and made available for public comment, the Marin County Department of Health and Human Services issued a public health advisory for fish from Tomales Bay in consultation with the Office of Environmental Health Hazard Assessment. The interim advisory is included in Appendix I.

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EXECUTIVE SUMMARY

Sampling and analysis of fish and shellfish from Tomales Bay were conducted under the Coastal Fish Contamination Program, a state program designed to monitor the concentrations of chemical contaminants in fish and shellfish that sport fishers catch in California nearshore waters. This program was designed to provide data for the assessment of human health risks from consumption of these fish. An evaluation of the results from Tomales Bay showed the main chemical of concern to be methylmercury, the primary form of mercury in fish.

Mercury is a heavy metal that can be toxic to humans and other organisms. Mercury occurs naturally in the environment, and is also redistributed in the environment as a result of human activities such as mining and the burning of fossil fuels. Once mercury is released into the environment, it cycles through land, air, and water. In aquatic systems, it undergoes chemical transformation to the more toxic organic form, methylmercury, which accumulates in fish and other organisms. More than 95 percent of the mercury found in fish 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 young children. Significant methylmercury toxicity can occur to the fetus during pregnancy even in the absence of symptoms in the mother. (For more information on mercury, see Appendix II.)

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

Based on a preliminary review of initial data from Tomales Bay, an interim health advisory was issued by the Marin County Department of Health and Human Services, in consultation with OEHHA, on December 4, 2000 (Appendix I). This report contains a description of a more comprehensive evaluation using additional data, and provides a state fish consumption advisory for Tomales Bay.

Mercury concentrations in fish and shellfish from Tomales Bay were compared to guidance tissue levels for methylmercury, which are designed so that individuals consuming no more than a preset number of meals should not exceed the RfD for this chemical. Sufficient data were available to set consumption guidelines for California halibut, redtail surfperch, shiner surfperch, jacksmelt, leopard shark, brown smoothhound shark, Pacific angel shark, bat ray, and red rock crab. A comparison of limited data for pile surfperch to data for other surfperch species was used to include this species in the advisory.

Evaluation of data and comparison with guidance tissue levels for methylmercury indicated that development of a fish consumption advisory was appropriate for Tomales Bay. Consumers should be informed of the potential hazards from eating fish from this water body, particularly those hazards relating to the developing fetus and children. All individuals, especially women of childbearing age and children aged 17 years and younger, are advised to limit their fish consumption to reduce methylmercury ingestion to a level as close to the reference dose as possible. To help sport fish consumers achieve this goal, OEHHA has developed the advisory below for Tomales Bay. Meal sizes should be adjusted to body weight as described in the advisory table.

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

HEALTH ADVISORY FOR TOMALES BAY

Fish are nutritious, providing a good source of protein and other nutrients, and are recommended as part of a healthy, balanced diet. As with many other kinds of food, however, it is prudent to consume fish in moderation and to make informed choices about which fish are safe to eat. OEHHA provides this consumption advice to the public so that people can continue to eat fish without putting their health at risk.

TOMALES BAY **FISH AND SHELLFISH CONSUMPTION GUIDELINES**	
WOMEN OF CHILDBEARING AGE AND CHILDREN AGED 17 YEARS AND YOUNGER **EAT NO MORE THAN:**	
DO NOT EAT	ALL SHARKS including brown smoothhound shark, leopard shark, and Pacific angel shark
ONCE A MONTH	Bat rays ***OR***
ONCE A WEEK	California halibut; redtail, pile, or shiner surfperch; or red rock crab ***OR***
3 TIMES A WEEK	Jacksmelt
WOMEN BEYOND CHILDBEARING AGE AND MEN **EAT NO MORE THAN:**	
ONCE A MONTH	Brown smoothhound sharks or leopard sharks ***OR***
ONCE A WEEK	Pacific angel sharks or bat rays ***OR***
3 TIMES A WEEK	California halibut; redtail or pile surfperch; or red rock crab ***OR***
UNRESTRICTED	Jacksmelt or shiner surfperch

***MANY OTHER WATER BODIES ARE KNOWN OR SUSPECTED TO HAVE ELEVATED MERCURY LEVELS.** If guidelines are not already in place for the water body where you fish, women of childbearing age and children aged 17 years and younger should eat no more than one sport fish meal per week and women beyond childbearing age and men should eat no more than three sport fish meals per week **from any location**.

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

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

SERVE SMALLER MEALS TO CHILDREN. MEAL SIZE IS ASSUMED TO BE EIGHT OUNCES FOR A 160-POUND ADULT. If you weigh more or less than 160 pounds, add or subtract 1 oz to your meal size, respectively, for each 20-pound difference in body weight.

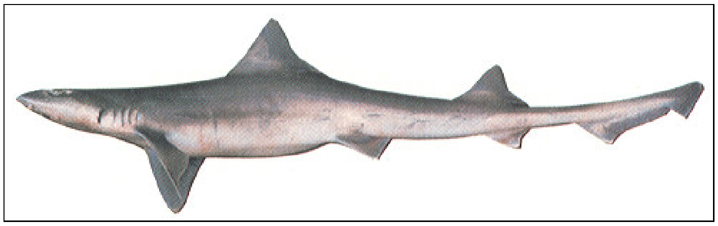
CONSIDER YOUR TOTAL FISH CONSUMPTION. Fish from many sources (including stores and restaurants) can contain elevated levels of mercury and other contaminants. If you eat fish with lower contaminant levels (including commercial fish) you can safely eat more fish. The American Heart Association recommends that healthy adults eat at least two servings of fish per week. Shrimp, king crab, scallops, farmed catfish, wild salmon, oysters, tilapia, flounder, and sole generally contain some of the lowest levels of mercury.

This advisory does NOT apply to commercial oysters, clams, and mussels from Tomales Bay; elevated levels of mercury have not been found in commercially grown shellfish.

TOMALES BAY FISH AND SHELLFISH SPECIES

NOTE: Images are not to scale.

Brown smoothhound shark *(Mustelus henlei)*

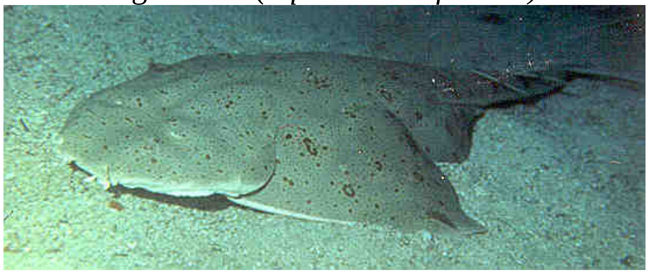


California Department of Fish and Game

Leopard shark *(Triakis semifasciata)*

NOAA Fisheries, SWFSC

Pacific angel shark *(Squatina californica)*

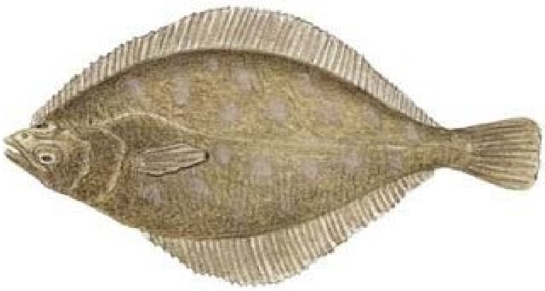


NOAA Fisheries, SWFSC / Tony Chess photo

Bat ray *(Myliobatis californica)*

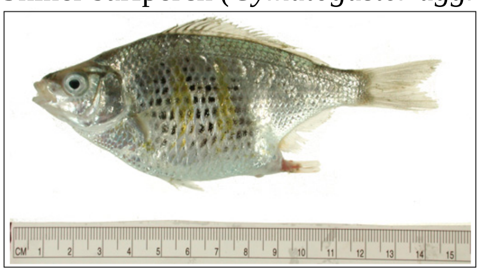
Photo by Daniel W. Gotshall

California halibut *(Paralichthys californicus)*



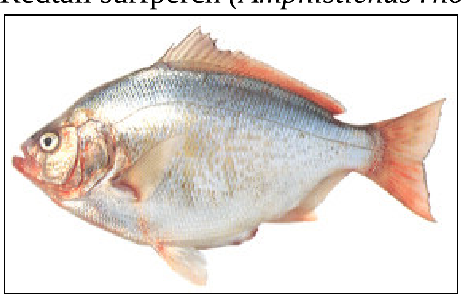
Source: http://www.insidesportfishing.com

Shiner surfperch *(Cymatogaster aggregata)*



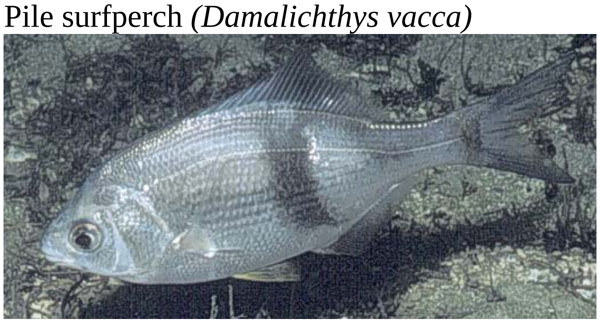
California Academy of Sciences

Redtail surfperch *(Amphistichus rhodoterus)*



California Department of Fish and Game

Pile surfperch *(Damalichthys vacca)*



Courtesy of Philip Lambert

Jacksmelt *(Atherinopsis californiensis)*

Aquarium of the Bay

Red rock crab *(Cancer productus)*

Glenn and Martha Vargas © California Academy of Sciences

INTRODUCTION

Fish and shellfish from Tomales Bay, a large estuary on the northern California coast, were sampled and analyzed for mercury and other chemical contaminants primarily[1] through the Coastal Fish Contamination Program (CFCP), a state program designed to monitor chemical contamination of sport fish and assess the health risks from consumption of these fish. The San Francisco Bay Regional Water Quality Control Board (SFBRWQCB) targeted Tomales Bay for study in 1999 because of the presence of an abandoned mercury mine from which discharge of mercury into Tomales Bay had been documented.

Preliminary review of the data by the Office of Environmental Health Hazard Assessment (OEHHA) indicated that a health advisory should be developed for people eating sport fish from Tomales Bay. Although almost all sport and commercial fish contain measurable levels of mercury, as methylmercury, exposure can be increased to unacceptable levels in areas with environmental mercury contamination. This health evaluation was based on the potential exposure to methylmercury through consumption of fish from Tomales Bay.

Mercury is a heavy metal that can be toxic to humans and other organisms. Mercury occurs naturally in the environment, and exists in various forms including elemental or metallic mercury, inorganic, and organic mercury (ATSDR, 1999; IARC, 1993). Cinnabar ores, naturally rich in mercury, are common in northern California, and mercury was extensively mined in California in the 1800s and early 1900s. Mercury enters the environment from the breakdown of minerals in rocks and leaching from old mine sites. It is also emitted into air from mining deposits, the burning of fossil fuels, and other industrial sources, as well as from volcanic emissions. Mercury contamination thus occurs as a result of both natural and anthropogenic sources and processes. Once mercury is released into the environment, it cycles through land, air, and water. The deposition of mercury in aquatic ecosystems is a concern for public and environmental health because microorganisms (bacteria and fungi) in the sediments can convert inorganic mercury into organic methylmercury, a particularly toxic form of mercury. Once formed, methylmercury accumulates or "biomagnifies" in the aquatic food chain, reaching the highest levels in fish and other organisms at the top of the food web. Concentrations of methylmercury in fish tissues can therefore be orders of magnitude (*e.g.*, 10, 100, or 1000 times) greater than concentrations in water. Consumption of fish is the principal route of exposure to methylmercury. Whether consumption of fish is harmful depends on the concentrations of methylmercury in the fish and the amount of fish consumed.

OEHHA is the agency responsible for evaluating public health impacts from chemical contamination of sport fish, and issuing advisories, when needed, for the state of California. OEHHA's authorities to conduct these activities are based on mandates in the California Health and Safety Code, Section 205, to protect public health, and Section 207, to advise local health authorities; and the California Water Code Section 13177.5, to issue health advisories. Fish advisories developed by OEHHA are published in the California Sport Fishing Regulations of the California Department of Fish and Game (CDFG).

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[1] Some of the analyses of clams were conducted under different programs and funding sources, but were analyzed by the same laboratory.

BACKGROUND

Tomales Bay is a large estuary, approximately 7,820 acres, located in Marin County (Figure 1). Tomales Bay is well known for its commercial oyster beds and recreational fishing. The population of recreational fishers using Tomales Bay is comprised of residents and visitors.

A mercury mine known as the Gambonini mine is located approximately six miles upstream from Tomales Bay. The mine was operated as a large open pit cinnabar mine from the late 1960s through the early 1970s under lease to the Buttes Gas and Oil Company. Mercury from the mine was extracted for use in thermometers, dental fillings, fluorescent lights, and high-temperature military gauges. The mine operations generated over 300,000 cubic meters (m^3) of mercury-containing waste (Whyte, 2002). Mine tailings that accumulated on site were shored up, but a major storm event in 1982 resulted in the release of tailings containing mercury. Drainage from the mine flows into Walker Creek, the second largest tributary entering Tomales Bay. Water quality studies suggest that hundreds to thousands of kilograms of mercury were discharged from the mine site to downstream waters, even though mining ceased in 1972 (Whyte, 2002). In October 1998, the SFBRWQCB and the United States Environmental Protection Agency (U.S. EPA) initiated a Superfund clean-up action at the site in order to eliminate, to the maximum extent feasible, the discharge of mercury-laden soil and sediments from the twelve-acre mining waste pile. The remediation activities included constructing a gravity buttress to stabilize the failing waste pile, installing diversion structures for storm water runoff, and re-vegetating the area with native plants. The clean-up activities were completed in October 1999, and the SFBRWQCB has been conducting post-remediation monitoring (Whyte, 2002).

Fish samples were collected and analyzed from Tomales Bay through the CFCP. Sampling was initiated at Tomales Bay in 1999 in order to study potential effects from the nearby mine and associated discharges. Although CFCP sampling was discontinued in 2003 due to state budget constraints, comprehensive sampling was performed for Tomales Bay before sampling was halted. The data[2] on chemical contaminants in fish and shellfish from Tomales Bay were used to conduct an evaluation of the potential health risks from consumption of these fish as described in this report.

Tomales Bay contains numerous fish species that are popular among sport fishers. Eight species of finfish (California halibut, redtail surfperch, shiner surfperch, jacksmelt, leopard shark, brown smoothhound shark, Pacific angel shark, and bat ray) were collected from Tomales Bay in 1999 for chemical analysis. Six of the same fish species were sampled again in 2001 (including all species except jacksmelt and redtail surfperch); one additional species, pile surfperch, was also collected and analyzed. Images and scientific names of the sampled species are shown after the Executive Summary, beginning on page 4, “Fish and Shellfish Species in Tomales Bay.”

Fish species were collected by CDFG using nets or hook and line. For the purpose of issuing advisories, legal-sized fish were targeted. Fish samples consisted of skinless “fillets” (edible

[2] Coastal Fish Contamination Program Electronic Database, 2003. Office of Environmental Health Hazard Assessment and State Water Resources Control Board

muscle tissue)[3]. The sizes of sampled fish were measured as total length (TL), which is a measure from the tip of the snout to the end of the tail fin, unless otherwise indicated. Mean lengths for fish samples are shown in Table 1.

Both individual fish and composite samples were analyzed. Composite samples (including tissues taken from more than one individual of a given species) were used to maximize the amount of information gained without incurring higher analytical costs from additional individual samples. Differences in the size of the smallest and largest fish in each composite were no greater than 25 percent with the exception of two composites of shiner surfperch and one composite of bat ray, each of which exceeded the acceptable range by two to three millimeters. For some species, individual fish were analyzed in order to provide information on the relationship between size of fish and mercury concentration, and to provide additional information on the amount of variability among individual fish. The species analyzed as individuals in 1999 were leopard shark and Pacific angel shark. In 2001, individual samples were analyzed for all shark species, bat rays, and California halibut.

Red rock crabs were also collected from Tomales Bay. Three composites of three red rock crabs each were analyzed for total mercury in 1999. Three composites of red rock crab were also collected in 2001 and analyzed for both total mercury and methylmercury. The size of red rock crabs was measured as the mean carapace width (excluding the lateral spines) of the crabs in each composite. Crab samples consisted of the claw meat (muscle tissue). Mean sizes for crab samples are shown in Table 2.

Ten composite samples of clams were collected and analyzed in 1999. Clams were measured at the greatest diameter of the shell. All soft tissues of clams were analyzed. Six composite samples including five clams each were collected from Hamlet. The other four composites contained 16, 20, 22, and 23 clams collected at South Millerton Ramp, Blake's Landing, McDonald, and Millerton Park, respectively. Clams from South Millerton Ramp ranged in size from 30 to 36 mm, with a mean size of 32 mm, which did not meet the minimum legal size requirement of 38 mm (1½ inches). Although the mean sizes of the other three clam composites ranged from 41 to 42 mm, some individual clams within the samples were smaller than legal size. A summary of the samples and sizes of clams is shown in Table 3.

It is not possible to determine in advance how many samples of each species from a water body 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, 2000). Using these guidelines, OEHHA believes that a minimum of three replicates of three fish per composite or, preferably, nine individual fish samples of multiple species from each water body should be analyzed for the purpose of assessing the potential risks from consumption of fish from the water body. Species of fish that do not grow large (*e.g.*, shiner surfperch) and shellfish

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[3] Because jacksmelt and small surfperch species are difficult to fillet, these species were prepared using sections of the main body, with skin and bones included, but excluding the guts; approximately equal portions from each fish in a composite were combined to provide sufficient tissue for analysis.

(*e.g.*, clams) require more than three individuals per composite to provide sufficient tissue for analysis; this additional number of individuals will also make the samples more representative. When feasible, fish samples should be collected from multiple (legal/edible-) size classes when a large size range exists in that species. Following this sampling protocol will allow estimation of the range and variation of contaminant concentrations at a particular site and derivation of a representative mean concentration for use in exposure assessment. However, more samples will provide a better estimate of the mean contaminant level in various fish species and are especially important for large water bodies.

During the two years of sampling in Tomales Bay, the following samples were collected per species: 12 samples of California halibut, three samples of redtail surfperch, seven samples of shiner surfperch, seven samples of jacksmelt, 18 samples of leopard shark, 12 samples of brown smoothhound shark, 18 samples of Pacific angel shark, 12 samples of bat ray, six samples of red rock crab, and ten samples of clams. One sample of pile surfperch was collected. The summary statistics including number of samples and total numbers of fish or shellfish collected for each species, and the sizes of fish and shellfish in these samples are shown in Appendix IV.

Tissue samples were homogenized in the laboratory, and all samples were analyzed for total mercury. Most fish samples were also analyzed for arsenic, cadmium, and selenium. Redtail surfperch and jacksmelt were only analyzed for mercury and arsenic. California halibut and shiner surfperch were analyzed for a full suite of trace metals including silver, arsenic, cadmium, chromium, copper, mercury, lead, nickel, selenium, and zinc. Clams were also analyzed for the full suite of trace metals and for methylmercury. Red rock crabs were analyzed for mercury, methylmercury, arsenic, cadmium, and selenium.

Homogenized tissue from the samples was digested using acid, and analyzed for total mercury by cold vapor atomic fluorescence spectrometry using a Perkin Elmer Flow Injection Mercury System at CDFG Moss Landing Marine Laboratory. Methylmercury was measured in several clam samples from 1999 because the percentage of methylmercury as a fraction of total mercury has been shown to be lower and more variable in shellfish than in finfish (Lasorsa and Allen-Gil, 1995). Analysis of methylmercury was performed on the red rock crab samples in 2001, and archived tissues from some of the 1999 clam samples were also analyzed for methylmercury. Methylmercury was also analyzed by cold vapor atomic fluorescence spectrometry at CDFG Moss Landing Marine Laboratory.

Analyses of organic chemicals (including pesticides and polychlorinated biphenyls or PCBs) were conducted for composites of California halibut and shiner surfperch for the 1999 samples. Homogenized tissue was extracted and analyzed by capillary gas chromatography for chlorinated hydrocarbons utilizing an electron capture detector (GC/ECD), and for aromatic hydrocarbons by gas chromatography mass spectrometry (GC/MS) at the CDFG Water Pollution Control Laboratory. All samples were below OEHHA's screening values (Brodberg and Pollock, 1999) used to indicate whether further sampling and/or evaluation is necessary. And in fact, all organic samples were below detection limits. These results indicate that organic contaminants are not a health concern in these species in Tomales Bay. Additional analyses of organic chemicals were also performed on fish from 2001; these data, however, were not finalized on the same schedule as the trace metals and were not available for this report.

The analysis of trace elements showed relatively high concentrations of arsenic, measured as total arsenic, in several shark species. Total arsenic was measured in tissue digestates by flame atomic absorption spectrometry. Most of the arsenic in marine fish and shellfish tissues is present in the organic form as arsenobetaine, arsenocholine, and organosugars (Balin *et al.*, 1994). Total arsenic was initially measured in samples because the CDFG laboratories are not equipped to speciate arsenic into organic and inorganic forms and different valence states; this analysis is more time consuming and expensive. Instead, the protocol was to measure total arsenic and then measure inorganic arsenic (the most toxic form) when samples exceeded the OEHHA screening value (SV) of 1 ppm for total arsenic (Brodberg and Pollock, 1999). Leopard shark, brown smoothhound shark, Pacific angel shark, and bat ray all had mean concentrations of total arsenic that exceeded the SV. Samples of species exceeding the arsenic SV were subsequently analyzed for inorganic arsenic at Frontier Geosciences using hydride generation atomic absorption spectroscopy.

Arsenic is comprised of several different chemical forms, and inorganic forms are most toxic. Inorganic arsenic has established toxic endpoints including cancer and cardiovascular and developmental effects (OEHHA, 2004). Inorganic arsenic was not detected in any of the fish samples that exceeded the SV, and therefore, an evaluation of potential health risks was not performed since these fish do not present a risk for exposure to the more toxic forms of arsenic. Samples of red rock crab and clams also had total arsenic concentrations that exceeded the SV. However, these species were not analyzed for inorganic arsenic, and therefore can not be evaluated at this time for potential health risks from exposure to inorganic arsenic. Since inorganic arsenic seldom exceeds four percent of total arsenic in fish and shellfish (Donohue and Abernathy, 1999), the concentration of inorganic arsenic in these species is also likely to be very low or near the detection limit.

Prevalent organic arsenic compounds (*e.g.*, arsenobetaine) in fish and shellfish are far less toxic than inorganic arsenic and available evidence indicates they are not a health threat for humans (ATSDR, 1998; Donohue and Abernathy, 1999). Methylated inorganic arsenic metabolites (*i.e.*, monomethylarsonic acid and dimethylarsinic acid) also show some toxicity but are found in only trace amounts (Abernathy *et al.*, 1999; Donohue and Abernathy, 1999). Appropriate toxicity criteria have not been established for these arsenic compounds; therefore, it is not possible to assess their risk in these samples.

The analytical results showed mercury at elevated levels in certain of the fish species sampled from Tomales Bay, and indicated a potential cause for concern for public health. OEHHA initially performed a preliminary review of the laboratory results for sport fish and shellfish collected from Tomales Bay in 1999. The preliminary evaluation did not include shellfish (crabs or clams) due to inadequate data on these species. However, analytical results for shellfish that were obtained in the initial study are described here for informational purposes. Additional data were obtained on red rock crabs in 2001. Three composite samples were obtained in 2001, and tissues were analyzed for methylmercury as well as total mercury. Therefore, the results from both years were used to develop recommendations on consumption of red rock crabs from Tomales Bay.

Based on the preliminary evaluation, OEHHA notified the Marin County Department of Health and Human Services, Division of Health Services, of the preliminary findings of mercury in fish from Tomales Bay. They concurred that mercury levels in the fish were a cause for concern for public health, and offered support in disseminating information to the public on the potential impacts for public health. On December 4, 2000, the Marin County Department of Health and Human Services, in consultation with OEHHA, issued an interim advisory for Tomales Bay

(Appendix I). This interim advisory was prepared to provide timely information to the public. The results from the more recent sampling and analysis of trace elements (*i.e.*, mercury and other metals) were combined with the initial data to give a more representative depiction of the concentrations of mercury in fish and shellfish from Tomales Bay. Once the new data were finalized and made available to OEHHA, this report and the consumption guidelines contained herein were developed.

METHYLMERCURY TOXICOLOGY[4]

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.

Consumption of fish is the major route of exposure to methylmercury in the United States (ATSDR, 1999). Almost all fish contain detectable levels of methylmercury, which, when ingested, is almost completely absorbed from the gastrointestinal tract (Aberg *et al.*, 1969; Myers *et al.*, 2000). Once absorbed, methylmercury is distributed throughout the body, reaching the largest concentration in kidneys. Its ability to cross the placenta as well as the blood brain barrier allows methylmercury to accumulate in the brain and fetus, which are known to be especially sensitive to the toxic effects of this chemical (ATSDR, 1999). In the body, methylmercury is slowly converted to inorganic mercury and excreted predominantly by the fecal (biliary) pathway. Methylmercury is also excreted in breast milk (ATSDR, 1999). The biological half-life of methylmercury is approximately 44 to 74 days in humans (Aberg, 1969; Smith *et al.*, 1994), meaning that it takes approximately 44 to 74 days for one half of an ingested dose of methylmercury to be eliminated from the body.

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

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

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

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 were often not recognized until development of cerebral palsy and/or mental retardation many months after birth (Harada, 1978; Marsh *et al.*, 1980; Marsh *et al.*, 1987; Matsumoto *et al.*, 1964; Snyder, 1971).

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

DERIVATION OF REFERENCE DOSES FOR METHYLMERCURY

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

The first U.S. EPA RfD for methylmercury was developed in 1985 and set at $3x10^{-4}$ 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 to 500 micrograms per liter (μg/L) and 50-125 μg/g in adults, respectively. In cases where ingested mercury dose could be estimated (based, for example, on mercury concentration in contaminated bread and number of loaves consumed daily), an empirical correlation between blood and/or hair mercury concentrations and onset of symptoms was obtained. From these studies, WHO determined that methylmercury exposure equivalent to long-term daily intake of 3-7 μg/kg body weight in adults was associated with an approximately 5 percent prevalence of paresthesias (WHO, 1976). U.S. EPA further cited a study by Clarkson *et al.* (1976) to support the range of mercury concentrations at which paresthesias were first observed in sensitive members of the adult population. This study found that a small percentage of Iraqi adults exposed to methylmercury-treated seed grain developed paresthesias at blood levels ranging from 240 to 480 μg/L. U.S. EPA applied a 10-fold uncertainty factor to the LOAEL (3 μg/kg-day) to reach what was expected to be the NOAEL. Because the LOAEL was observed in sensitive individuals in the population after chronic exposure, additional uncertainty factors were not considered necessary for exposed adults (U.S. EPA, 1997).

Although this RfD was derived on the basis of effects in adults, even at that time researchers were aware that the fetus might be more sensitive to methylmercury (WHO, 1976). It was not until 1995, however, that U.S. EPA had sufficient data from Marsh *et al.* (1987) and Seafood Safety (1991) to develop an oral RfD based on methylmercury exposures during the prenatal stage of development (IRIS, 1995). Marsh *et al.* (1987) collected and summarized data from 81 mother and child pairs where the child had been exposed to methylmercury *in utero* during the Iraqi epidemic. Maximum mercury concentrations in maternal hair during gestation were correlated with clinical signs in the offspring such as cerebral palsy, altered muscle tone and deep tendon reflexes, and delayed developmental milestones that were observed over a period of several years after the poisoning. Clinical effects incidence tables included in the critique of the risk assessment for methylmercury conducted by the U.S. Food and Drug Administration (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 was deemed protective of infants and sensitive adults.

The two RfDs for methylmercury were developed using data from high-dose poisoning events. Recently, the National Academy of Sciences was directed to provide scientific guidance to U.S. EPA on the development of a new RfD for methylmercury (NAS/NRC, 2000). Three large prospective epidemiological studies were evaluated in an attempt to provide more precise dose-response estimates for methylmercury at chronic low-dose exposures, such as might be expected to occur in the United States. The three studies were conducted in the Seychelles Islands (Davidson *et al.*, 1995, 1998), the Faroe Islands (Grandjean *et al.*, 1997, 1998, 1999), and

New Zealand (Kjellstrom *et al.*, 1986, 1989). The residents of these areas were selected for study because their diets rely heavily on consumption of fish and marine mammals, which provide a continual source of methylmercury exposure (NAS/NRC, 2000).

Although estimated prenatal methylmercury exposures were similar among the three studies, subtle neurobehavioral effects in children were found to be associated with maternal methylmercury dose in the Faroe Islands and New Zealand studies, but not in the Seychelle Islands study. The reasons for this discrepancy were unclear; however, it may have resulted from differences in sources of exposure (marine mammals and/or fish), differences in exposure pattern, differences in neurobehavioral tests administered and age at testing, the effects of confounding variables, or issues of statistical analysis (NRC/NAS, 2000). After review of these studies, the National Academy of Sciences report supported the current U.S. EPA RfD of $1x10^{-4}$ 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 Islands data (IRIS, 2001). In order to develop an RfD, U.S. EPA used several scores from the Faroe Islands 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 Faroe Islands data (cord blood). The BMDLs for different neuropsychological effects in the Faroe Islands study ranged from 46 to 79 ppb mercury. U.S. EPA then chose a one-compartment model for conversion of cord blood to ingested maternal dose, which resulted in estimated maternal mercury exposures of 0.857-1.472 μg/kg-day (IRIS, 2001). An uncertainty factor of ten was applied to the oral doses corresponding to the range of BMDLs to account for inter-individual toxicokinetic variability in ingested dose estimation from cord-blood mercury levels and pharmacodynamic variability and uncertainty, leading to an RfD of $1x10^{-4}$ 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 Islands 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 now considers this RfD to be protective for all populations (IRIS, 2001); however, in their joint Federal Advisory for Mercury in Fish, U.S. EPA and U.S. FDA only apply this RfD to women who are pregnant or might become pregnant, nursing mothers, and young children (U.S. EPA, 2004).

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

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

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

MERCURY LEVELS IN FISH AND SHELLFISH FROM TOMALES BAY

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

Chemical concentrations in fish and shellfish from Tomales Bay are reported in wet weight. Arithmetic means, rather than geometric means, were used to represent the central tendency (average) of mercury or methylmercury 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. Summary statistics for chemical concentrations can be found in Appendix IV. Case summaries for all samples are presented in Appendix V.

Mercury in Finfish

Table 1 summarizes the analytical results on mercury for fish from Tomales Bay. All finfish species except for pile surfperch consisted of an adequate sample size. The mean concentrations for each species with adequate data were used to represent bioaccumulation of mercury in that species and to develop consumption guidelines. Although the sample size (five fish) for pile surfperch was not sufficient to establish a representative mean concentration for that species, adequate data were available for two related surfperch species. Therefore, the mean concentration in pile surfperch was compared to the mean values for the other species, and similarity in the concentration of mercury was noted. The advice issued for shiner surfperch and redtail surfperch, therefore, can be applied to pile surfperch as well.

Mercury and Methylmercury in Red Rock Crab

A total of six samples (including 18 crabs) was considered adequate to represent average methylmercury concentrations in this species. The samples from 1999, however, were not analyzed for methylmercury. Therefore, the average percentage of methylmercury (90 percent) in the 2001 samples was applied to the results for total mercury in red rock crabs from 1999 to estimate the concentration of methylmercury in those samples. Mean concentrations of methylmercury were used to develop consumption guidelines for red rock crabs from Tomales Bay. A summary of the results for mercury and methylmercury in red rock crabs is shown in Table 2.

Mercury and Methylmercury in Clams

Mean total mercury concentrations in clam samples ranged from 0.04 to 0.56 ppm. Higher values were measured in clams collected at Hamlet. Because there was a strong positive correlation ($r = 0.95$, $p < 0.0001$) between higher mercury concentrations and the Hamlet location, a mean value for the four sample locations other than Hamlet was determined separately from the mean value for Hamlet (0.05 and 0.39 ppm total mercury, respectively). These are reported as overall mean values in Table 3.

The composite samples of clams were analyzed for methylmercury after the initial results were reported. Mean methylmercury concentrations in the four composites collected at locations other than Hamlet ranged from 0.02 to 0.03 ppm, with an overall mean concentration of methylmercury of 0.03 ppm (Table 3). The mean concentration of methylmercury in the clam samples from Hamlet (where total mercury was higher) was 0.06 ppm. The percentage of methylmercury in clam samples ranged from 14 to 60 percent of total mercury. In the samples from Hamlet, the average percentage of methylmercury was only 16 percent, whereas for the other sample locations, the average percentage of methylmercury was just under 50 percent. Thus, although inorganic mercury at Hamlet was higher, the more toxic methylmercury concentration was lower and similar to that at other locations. A summary of the results for clams is shown in Table 3.

The development of guidance for clams from Tomales Bay was restricted by data limitations. Multiple species were combined in the clam samples and the species were not documented for each sample. Although consumers harvesting clams would not likely separate the clams they consume by species, the mixture of species in chemical analyses represents a departure from the scientific protocol OEHHA uses and prevents evaluation of the concentration of mercury (or methylmercury) in a given species. Additionally, several of the clam samples included all or some individuals that were smaller than the minimum legal size requirement. This represents another departure from protocol, as OEHHA does not issue advice for fish or shellfish that are not legal for consumers to eat. Therefore, formal guidance was not provided for clams. However, the concentrations of methylmercury in the clam samples were sufficiently low to preclude any concern for public health.

GUIDELINES FOR FISH CONSUMPTION

Fish consumption guidelines are appropriate when there are sufficient data to suggest that adverse health effects may occur from unrestricted consumption of individual fish species from a water body. OEHHA's guidelines use the concentration of a chemical in a fish species and compare the concentrations of the chemical of concern to acceptable exposure levels based on the relevant RfD. When the measured concentrations are high enough that the consumer would exceed the RfD, consumption advice should be issued so that consumers will know how much they can eat without exceeding the RfD.

OEHHA therefore develops consumption recommendations that indicate how much fish of a certain species (with a certain amount of methylmercury) can be eaten each month without exceeding the level that could cause adverse health effects. The amount of fish that can be eaten in a meal, while staying within the guidelines, also depends on the consumer's body weight. Recommended consumption guidelines are determined on the basis of the average concentration measured in each species, and recommended limits on the amount of fish to consume are developed so that the RfD will not be exceeded if the guidelines are followed. All individuals, especially women of childbearing age and children 17 years and younger, are advised to limit their fish consumption to reduce methylmercury ingestion to a level near or below the appropriate reference dose.

Consumption guidance was developed based on the average concentration of mercury or methylmercury in each fish species for which an adequate number of samples were collected and analyzed from Tomales Bay. Samples were obtained from several places in Tomales Bay. Because fish species, particularly sharks, tend to move around over time, a fisher could conceivably catch the same fish at different locations in the bay. Bioaccumulation of contaminants in mobile fish is not expected to be affected by contaminant levels at discrete sites. Therefore, fish collected from the various sampling locations around Tomales Bay were not treated independently (*i.e.*, as discrete populations of fish), and the mean concentration for each species for the whole bay was used as the basis for consumption advice. As a result, the advice provided for each species pertains to fish caught at any location in Tomales bay. In addition, advice also applies to fish species (*e.g.*, California halibut, sharks, and surfperch) that are caught outside but near Tomales Bay, because some of these fish may swim in and out of the bay at times. The recommended guidance (health advisory) for Tomales Bay is presented below.

Guidance Tissue Levels

OEHHA uses the range of acceptable tissue concentrations at different consumption levels to determine whether fish consumers would exceed the RfD when eating a specific number of fish meals in a month. Separate ranges are based on each of the two RfDs and, therefore, result in different guidance levels for the two subpopulations, one for the sensitive population including women of childbearing age and children 17 years and younger, and one for the general population of women beyond their childbearing years and men. Consumption guidelines are limited to the following categories to simplify the advice that is given to consumers: no consumption, one meal per month, four meals per month (or once a week), and 12 meals per month (equal to three meals per week). In addition, there were a few fish species sampled at Tomales Bay that had tissue concentrations of mercury low enough that they could be eaten every day by women beyond childbearing age and men. For this population, therefore, a category of "unrestricted consumption" based on mercury concentration was included to give these consumers an option for safely eating more fish. In addition, the levels of PCBs and other organic chemicals in these fish species were below quantitation limits. Low, but measurable, levels of PCBs and some organic chemicals are present in many fatty foods, therefore, exposure to PCBs from eating these fish is less than from eating fatty foods (*e.g.*, meats, milk, and other dairy products; Institute of Medicine, 2003).

For each consumption category there is a corresponding range of mercury concentrations in fish tissue that would cause the advice for that species to fall under that particular category. A table showing these Guidance Tissue Levels (GTLs) is shown in Appendix VI.

Meal sizes are based on a standard eight-ounce (227 grams) portion of uncooked fish fillet (approximately six ounces after cooking). This standard meal size is based on an adult weighing approximately 160 pounds or 70 kg. Meal sizes are assumed to correspond to body weight so that persons weighing more or less than the standard would be expected to eat proportionately more or less than eight ounces of fish in a meal. Meal sizes should be adjusted for body weight as described in the advisory table.

Mean concentrations of mercury in fish and methylmercury in red rock crabs from Tomales Bay were compared to GTLs to determine advice for each species. The complete recommendations for consumption of Tomales Bay fish and shellfish are given in the Health Advisory that follows. It is important to note that fish consumption recommendations are based on consumption of only one fish species.

HEALTH ADVISORY FOR TOMALES BAY

Fish are nutritious, providing a good source of protein and other nutrients, and are recommended as part of a healthy, balanced diet. As with many other kinds of food, however, it is prudent to consume fish in moderation and to make informed choices about which fish are safe to eat. OEHHA provides this consumption advice to the public so that people can continue to eat fish without putting their health at risk.

TOMALES BAY FISH AND SHELLFISH CONSUMPTION GUIDELINES	
WOMEN OF CHILDBEARING AGE AND CHILDREN AGED 17 YEARS AND YOUNGER EAT NO MORE THAN:	
DO NOT EAT	ALL SHARKS including brown smoothhound shark, leopard shark, and Pacific angel shark
ONCE A MONTH	Bat rays ***OR***
ONCE A WEEK	California halibut; redtail, pile, or shiner surfperch; or red rock crab ***OR***
3 TIMES A WEEK	Jacksmelt
WOMEN BEYOND CHILDBEARING AGE AND MEN EAT NO MORE THAN:	
ONCE A MONTH	Brown smoothhound sharks or leopard sharks ***OR***
ONCE A WEEK	Pacific angel sharks or bat rays ***OR***
3 TIMES A WEEK	California halibut; redtail or pile surfperch; or red rock crab ***OR***
UNRESTRICTED	Jacksmelt or shiner surfperch

***MANY OTHER WATER BODIES ARE KNOWN OR SUSPECTED TO HAVE ELEVATED MERCURY LEVELS.** If guidelines are not already in place for the water body where you fish, women of childbearing age and children aged 17 and younger should eat no more than one sport fish meal per week and women beyond childbearing age and men should eat no more than three sport fish meals per week **from any location**.

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

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

SERVE SMALLER MEALS TO CHILDREN. MEAL SIZE IS ASSUMED TO BE EIGHT OUNCES FOR A 160-POUND ADULT. If you weigh more or less than 160 pounds, add or subtract 1 oz to your meal size, respectively, for each 20-pound difference in body weight.

CONSIDER YOUR TOTAL FISH CONSUMPTION. Fish from many sources (including stores and restaurants) can contain elevated levels of mercury and other contaminants. If you eat fish (including commercial fish) with lower contaminant levels, you can safely eat more fish. The American Heart Association recommends that healthy adults eat at least two servings of fish per week. Shrimp, king crab, scallops, farmed catfish, wild salmon, oysters, tilapia, flounder, and sole generally contain some of the lowest levels of mercury.

This advisory does NOT apply to commercial oysters, clams, and mussels from Tomales Bay; elevated levels of mercury have not been found in commercially grown shellfish.

The mean mercury concentration in Pacific angel shark, when compared to the GTLs, corresponds to a consumption rate of one meal a month for women of childbearing age and children aged 17 years and younger. However, as noted below, the U.S. Food and Drug Administration (FDA) advises pregnant women and women of childbearing age who may become pregnant, and nursing mothers to avoid eating any shark. Therefore, to provide consistent advice and avoid confusion, and to promote a general incorporation of the FDA advice by pregnant women and other women of childbearing age, Pacific angel sharks were included under the same advice category as all other sharks (*i.e.*, no consumption) even though the mean mercury concentration in Pacific angel sharks in Tomales Bay was less than that of the other shark species. Following this advice will also allow this sensitive population to consume more fish with lower levels of mercury.

COMMERCIAL FISH AND SHELLFISH

The SFBRWQCB tested commercial shellfish including clams, oysters and mussels from Tomales Bay. Results of these tests showed very low levels of mercury (Whyte, 1998). Regulation of commercial shellfish falls under the jurisdiction of FDA and, in California, the Food and Drug Branch of the California Department of Health Services. Nevertheless, measured concentrations in commercial shellfish samples do not indicate a health threat due to methylmercury.

Most commercial fish (in stores and restaurants) have relatively low levels of methylmercury and can be eaten safely in moderate amounts. FDA, in conjunction with U.S. EPA, has recently issued a joint Federal Advisory for Mercury in Fish for women who are pregnant or might become pregnant, nursing mothers, and young children. The federal advice applies to several types of fish that have particularly high levels of methylmercury. Women who eat fish from Tomales Bay should also take into account any commercial fish that they eat and consider the advice provided by FDA and U.S. EPA, which recommends that individuals in this population do not eat shark, swordfish, king mackerel, and tilefish[5]. The Federal Advisory for Mercury in Fish also advises women who are pregnant or might become pregnant, nursing mothers, and young children to limit their total fish consumption to an average of 12 ounces (2 average meals[6]) each week of fish (cooked) that are purchased in stores and restaurants and to select from a *variety* of different kinds of fish. FDA provides tables showing types of fish with differing levels of mercury at the following Web site: http://www.cfsan.fda.gov/~frf/sea-mehg.html. If two meals of 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 federal advice can be found at the following Web sites: http://www.cfsan.fda.gov/~dms/admehg3.html or http://www.epa.gov/waterscience/fishadvice/advice.html.

RECOMMENDATIONS FOR FURTHER SAMPLING

Most of the commonly fished species in Tomales Bay were sampled and included in this advisory. Several species that were not sampled but that can be caught in Tomales Bay,

[5] King mackerel and tilefish are common species on the East Coast but not on the West Coast. Therefore, the species of concern on the West coast include sharks and swordfish.

[6] Children should eat smaller amounts.

including striped bass and white sea bass, are recommended for future sampling. Although there are other species of shark in Tomales Bay that are occasionally caught by fishers, it may not be feasible and practical to sample these infrequent and large species. Sampling and analysis of arsenic and inorganic arsenic in clams and crabs from Tomales Bay should also be considered. Future sampling of clams should target legal-sized clams only, and avoid mixing species.

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Table 1: Summary of Results on Mercury in Fish from Tomales Bay

Species	Number of Samples (Total Number of Fish)	Mean Length (mm)	Mean Mercury (ppm)
Brown smoothhound shark	12 (18)	878	**1.39**
Leopard shark	18 (18)	1013	**0.98**
Bat ray[7]	12 (18)	736	**0.52**
Pacific angel shark	18 (18)	1032	**0.47**
California halibut	12 (18)	664	**0.20**
Redtail surfperch	3 (9)	299	**0.15**
Pile surfperch	1 (5)	326	**0.11**
Shiner surfperch	7 (137)	115	**0.09**
Jacksmelt	7 (35)	265	**0.07**

[7] In this species, length is measured from the tip of the snout to the end of the anal fin.

Table 2: Summary of Results on Methylmercury and Mercury in Red Rock Crabs from Tomales Bay

Species	Number of Composite Samples (Total Number of Crabs)	Mean Length (mm)	Mean Methylmercury (ppm)	Mean Mercury (ppm)
Red rock crab				
1999	3 (9)	129	**0.16**[8]	0.17
2001	3 (9)	130	**0.12**	0.14
Years combined	6 (18)	130	**0.14**[9]	0.15

Table 3: Summary of Results on Mercury and Methylmercury in Clams from Tomales Bay

Species	Number of Composite Samples (Total Number of Clams)	Mean Length of Composite Samples (mm)	Overall Mean Methylmercury (ppm)	Overall Mean Mercury (ppm)
Clams[10]				
Hamlet	6 (30)	40	**0.06**	0.39
Other four locations	4 (81)	40[11]	**0.03**	0.05

[8] Estimated for samples from 1999 based on the mean percentage of methylmercury (90%) measured in 2001.

[9] Using estimated methylmercury for samples collected in 1999.

[10] Sampled in 1999 only.

[11] Minimum legal size is 38 mm. Some clams in these composites were less than legal size.

Figure 1: Tomales Bay

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APPENDIX I: INTERIM PUBLIC HEALTH ADVISORY FOR SPORT FISH FROM TOMALES BAY

MARIN COUNTY DEPARTMENT OF HEALTH AND HUMAN SERVICES
MARIN COUNTY COMMUNITY DEVELOPMENT AGENCY,
ENVIRONMENTAL HEALTH SERVICES DIVISION

November 2000

Elevated levels of mercury have been found in fish from Tomales Bay. The County of Marin Department of Health and Human Services and Community Development Agency/Environmental Health Services Division, in cooperation with the state Office of Environmental Health Hazard Assessment (OEHHA), is issuing the following recommendations for limiting consumption of sport fish caught in Tomales Bay:

- **DO NOT EAT** LEOPARD SHARKS OR BROWN SMOOTHHOUND SHARKS.
- **LIMIT** CONSUMPTION OF THE FOLLOWING FISH TO **NO MORE THAN**:
    - **ONE MEAL PER WEEK** OF SURFPERCH (SHINER, REDTAIL SURFPERCH) ***OR***
    - **TWO MEALS PER MONTH** OF CALIFORNIA HALIBUT ***OR*** PACIFIC ANGEL SHARKS ***OR***
    - **ONE MEAL PER MONTH** OF BAT RAYS
- THIS ADVISORY DOES **NOT** APPLY TO COMMERCIALLY GROWN TOMALES BAY OYSTERS, CLAMS, AND MUSSELS, WHICH DO NOT CONTAIN HIGH LEVELS OF MERCURY.

It is especially important that women who are pregnant or may become pregnant within a year, nursing mothers, and children under age six follow these guidelines. The nervous systems of the developing fetus and young children are especially sensitive to the toxic effects of methylmercury, the form of mercury that is found in fish.

APPENDIX II: METHYLMERCURY IN SPORT FISH: INFORMATION FOR FISH CONSUMERS

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

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

WHERE DOES METHYLMERCURY IN FISH COME FROM?

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

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

HOW MIGHT I BE EXPOSED TO METHYLMERCURY?

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

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

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

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

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

HOW DOES METHYLMERCURY AFFECT HEALTH?

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

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

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

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

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

CAN MERCURY POISONING OCCUR FROM EATING SPORT FISH IN CALIFORNIA?

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

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

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

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

IS THERE A MEDICAL TEST TO DETERMINE EXPOSURE TO METHYLMERCURY?

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

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

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

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

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

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

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

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

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

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

WHERE CAN I GET MORE INFORMATION?

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

APPENDIX III: GENERAL ADVICE ON FISH CONSUMPTION

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

Fishing Practices

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

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

Consumption Guidelines

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

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

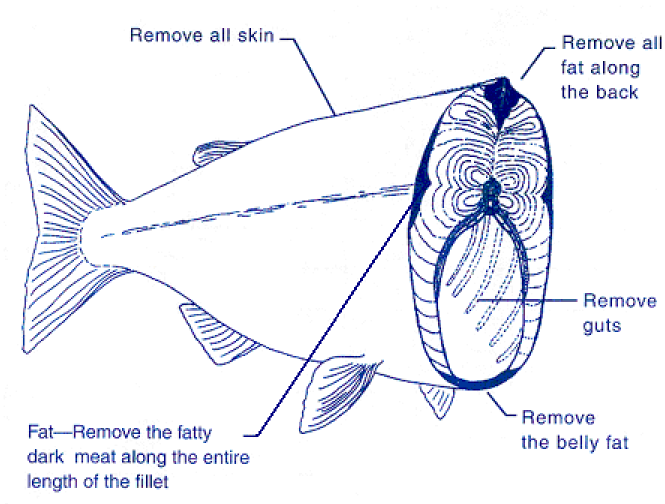
Fish Preparation and Consumption

• Eat only the fillet portions. Do not eat the guts and liver because chemicals usually concentrate in those parts. Also, avoid frequent consumption of any reproductive parts such as eggs or roe.

• Many chemicals are stored in the fat. To reduce the levels of these chemicals, skin the fish when possible and trim any visible fat.

• Use a cooking method such as baking, broiling, grilling, or steaming that allows the juices to drain away from the fish. The juices will contain chemicals in the fat and should be thrown away. Preparing and cooking fish in this way can remove 30 to 50 percent of the chemicals stored in fat. If you make stews or chowders, use fillet parts.

• Raw fish may be infested by parasites. Cook fish thoroughly to destroy the parasites.



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

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

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

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

National advice for women and children on mercury in fish is available from the U.S. Environmental Protection Agency at http://www.epa.gov/ost/fishadvice/advice.html and the U.S. Food and Drug Administration at http://www.cfsan.fda.gov/~frf/sea-mehg.html.

APPENDIX IV: COASTAL FISH CONTAMINATION PROGRAM (CFCP) DATA ON MERCURY, METHYLMERCURY, ARSENIC, AND INORGANIC ARSENIC IN FISH AND SHELLFISH FROM TOMALES BAY

Species	Sample Size			Length (mm)				Mercury (ppm wet weight)				Methylmercury (ppm wet weight)			
	Number of Composite Samples	Number of Individual Samples	Total N	Mean	SD	Min	Max	Mean	SD	Min	Max	Mean	SD	Min	Max
Brown smoothhound shark	3	9	18	878	41	790	924	1.39	.30	.66	1.84	NA			
Leopard shark	0	18	18	1013	107	900	1215	.98	.24	.65	1.44	NA			
Pacific angel shark	0	18	18	1032	40	930	1090	.47	.15	.22	.79	NA			
Bat ray	3	9	18	736	265	350	1156	.52	.21	.27	.91	NA			
California halibut	3	9	18	664	80	559	876	.20	.05	.12	.28	NA			
Shiner surfperch	7	0	137	115	8	102	132	.09	.02	.07	.12	NA			
Redtail surfperch	3	0	9	299	2	297	300	.15	.05	.11	.21	NA			
Pile surfperch	1	0	5	326	0	326	326	.11	.00	.11	.11	NA			
Jacksmelt	7	0	35	265	16	232	286	.07	.02	.05	.09	NA			
Red rock crab	6	0	18	130	7	119	141	.15	.06	.07	.22	.12	.05	.06	.19
Clams	10	0	111	40	3	32	42	.14	.16	.04	.56	.04	.02	.02	.11

Species	Sample Size			Arsenic (ppm wet weight)				Inorganic Arsenic* (ppm wet weight)
	Number of Composite Samples	Number of Individual Samples	Total N	Mean	SD	Min	Max	
Brown Smoothound Shark	3	9	18	5.12	1.75	2.47	8.16	ND
Leopard Shark	0	18	18	7.25	2.72	2.69	14.70	ND
Pacific Angel Shark	0	18	18	10.56	3.94	4.95	18.14	ND
Bat Ray	3	9	18	3.80	2.51	1.79	12.67	ND
California Halibut	3	9	18	.77	.20	.57	1.29	
Shiner Surfperch	7	0	137	.74	.23	.49	1.17	
Redtail Surfperch	3	0	9	.94	.08	.84	1.02	
Pile Surfperch	1	0	5	.96	.00	.96	.96	
Jack Smelt	7	0	35	.42	.08	.32	.53	
Red Rock Crab	6	0	18	4.25	1.90	1.90	6.52	
Clams	10	0	111	1.66	.32	1.25	2.41	

* reported for species with Total As > SV (1ppm)
NA – not analyzed
ND – non-detect

APPENDIX V: TOMALES BAY CASE SUMMARIES BY SPECIES

Tomales Bay Case Summaries by Species for Mercury (ppm), Arsenic (ppm) and Length (mm)

Species	Running Count by Species	Collection Date	Station Name	Number per sample	Mercury (ppm)	Arsenic (ppm)	Length (mm)
Bat Ray	1	05-MAY-1999	Tomales Bay/Mid Bay	3	.404	4.760	350.0
	2	11-AUG-1998	Tomales Bay/Mid Bay	3	.480	4.310	490.0
	3	05-MAY-1999	Tomales Bay/Mid Bay	3	.912	1.890	683.3
	4	30-MAY-2001	Tomales/Mid Bay	1	.484	4.623	815.0
	5	30-MAY-2001	Tomales/Mid Bay	1	.393	2.578	881.0
	6	31-MAY-2001	Tomales/Mid Bay	1	.274	1.864	914.0
	7	31-MAY-2001	Tomales/Mid Bay	1	.405	2.492	915.0
	8	31-MAY-2001	Tomales/Mid Bay	1	.374	12.668	930.0
	9	29-MAY-2001	Tomales/Mid Bay	1	.806	3.280	990.0
	10	31-MAY-2001	Tomales/Mid Bay	1	.276	2.419	1030.0
	11	30-MAY-2001	Tomales/Mid Bay	1	.504	3.803	1050.0
	12	31-MAY-2001	Tomales/Mid Bay	1	.392	1.785	1156.0
Brown Smoothhound	1	30-MAY-2001	Tomales/Mid Bay	1	.663	7.332	790.0
	2	30-MAY-2001	Tomales/Mid Bay	1	.951	6.588	807.0
	3	30-MAY-2001	Tomales/Mid Bay	1	1.483	4.567	836.0
	4	30-MAY-2001	Tomales/Mid Bay	1	1.169	2.921	841.0
	5	11-AUG-1998	Tomales Bay/Mid Bay	3	1.270	6.180	860.0
	6	30-MAY-2001	Tomales/Mid Bay	1	1.170	4.341	861.0
	7	30-MAY-2001	Tomales/Mid Bay	1	1.300	4.980	882.0
	8	30-MAY-2001	Tomales/Mid Bay	1	1.844	8.157	889.0
	9	04-MAY-1999	Tomales Bay/Mid Bay	3	1.705	7.453	910.0
	10	30-MAY-2001	Tomales/Mid Bay	1	1.342	4.910	910.0
	11	11-AUG-1998	Tomales Bay/Mid Bay	3	1.515	2.470	920.0
	12	30-MAY-2001	Tomales/Mid Bay	1	1.683	5.102	924.0
California Halibut	1	17-JUL-2001	Tomales/Mid Bay	1	.145	1.292	559.0
	2	29-MAY-2001	Tomales/Mid Bay	1	.119	.894	566.0
	3	28-JUN-2001	Tomales/Mid Bay	1	.158	1.107	578.0
	4	31-MAY-2001	Tomales/Mid Bay	1	.128	.802	599.0
	5	26-AUG-1998	Tomales Bay/Outer Bay	3	.227	.789	623.3
	6	01-JUN-2001	Tomales/Mid Bay	1	.181	.669	641.0
	7	07-JUL-2001	Tomales/Mid Bay	1	.175	.650	648.0
	8	17-JUL-2001	Tomales/Mid Bay	1	.208	.603	654.0
	9	04-MAY-1999	Tomales Bay/Outer Bay	3	.199	.567	680.0
	10	01-SEP-1998	Tomales Bay/Outer Bay	3	.282	.683	706.7
	11	31-JUL-2001	Tomales/Mid Bay	1	.211	1.024	800.0
	12	15-JUN-2001	Tomales/Mid Bay	1	.161	.633	876.0
Clams	1	11-MAY-1999	Tomales Bay/S. Millerton Ramp	16	.068	2.410	32.2
	2	29-JUL-1999	Tomales Bay/Hamlet 1	5	.298	1.520	39.4
	3	29-JUL-1999	Tomales Bay/Hamlet 3	5	.561	1.250	39.4
	4	29-JUL-1999	Tomales Bay/Hamlet 1	5	.339	1.470	39.4
	5	29-JUL-1999	Tomales Bay/Hamlet 2	5	.304	1.330	39.8
	6	10-MAY-1999	Tomales Bay/Millerton Park	23	.056	1.530	40.6
	7	29-JUL-1999	Tomales Bay/Hamlet 3	5	.399	1.630	41.0
	8	11-MAY-1999	Tomales Bay/McDonald	22	.036	1.610	41.8
	9	29-JUL-1999	Tomales Bay/Hamlet 2	5	.428	1.550	42.0
	10	10-MAY-1999	Tomales Bay/Blake's Landing	20	.047	1.600	42.0
Jacksmelt	1	11-AUG-1998	Tomales Bay/Mid Bay	5	.048	.453	232.0
	2	04-MAY-1999	Tomales Bay/Mid Bay	5	.057	.323	262.0
	3	04-MAY-1999	Tomales Bay/Mid Bay	5	.054	.530	265.0
	4	04-MAY-1999	Tomales Bay/Mid Bay	5	.075	.521	267.0
	5	04-MAY-1999	Tomales Bay/Outer Bay	5	.092	.359	271.0
	6	04-MAY-1999	Tomales Bay/Outer Bay	5	.074	.364	274.0
	7	04-MAY-1999	Tomales Bay/Outer Bay	5	.081	.408	286.0
Leopard Shark	1	04-MAY-1999	Tomales Bay/Mid Bay	1	.666	9.690	900.0
	2	05-MAY-1999	Tomales Bay/Mid Bay	1	.744	5.440	900.0
	3	30-MAY-2001	Tomales/Mid Bay	1	1.408	14.704	900.0

Tomales Bay Case Summaries by Species for Mercury (ppm), Arsenic (ppm) and Length (mm)							
Species	**Running Count by Species**	**Collection Date**	**Station Name**	**Number per sample**	**Mercury (ppm)**	**Arsenic (ppm)**	**Length (mm)**
	4	30-MAY-2001	Tomales/Mid Bay	1	.947	7.382	905.0
	5	30-MAY-2001	Tomales/Mid Bay	1	.759	7.464	913.0
	6	30-MAY-2001	Tomales/Mid Bay	1	.650	5.445	915.0
	7	30-MAY-2001	Tomales/Mid Bay	1	.860	4.457	946.0
	8	04-MAY-1999	Tomales Bay/Mid Bay	1	.943	10.900	970.0
	9	04-MAY-1999	Tomales Bay/Mid Bay	1	.845	6.220	980.0
	10	04-MAY-1999	Tomales Bay/Mid Bay	1	1.095	6.240	1010.0
	11	05-MAY-1999	Tomales Bay/Mid Bay	1	1.245	6.100	1010.0
	12	30-MAY-2001	Tomales/Mid Bay	1	.982	6.943	1036.0
	13	30-MAY-2001	Tomales/Mid Bay	1	.837	5.675	1051.0
	14	30-MAY-2001	Tomales/Mid Bay	1	1.011	8.501	1085.0
	15	05-MAY-1999	Tomales Bay/Mid Bay	1	.931	9.870	1140.0
	16	04-MAY-1999	Tomales Bay/Mid Bay	1	1.310	6.440	1150.0
	17	06-MAY-1999	Tomales Bay/Mid Bay	1	1.001	2.690	1200.0
	18	30-MAY-2001	Tomales/Mid Bay	1	1.439	6.292	1215.0
Pacific Angel Shark	1	04-MAY-1999	Tomales Bay/Mid Bay	1	.224	5.280	930.0
	2	05-MAY-1999	Tomales Bay/Mid Bay	1	.279	4.990	980.0
	3	30-MAY-2001	Tomales/Mid Bay	1	.410	9.848	990.0
	4	30-MAY-2001	Tomales/Mid Bay	1	.475	9.785	1011.0
	5	30-MAY-2001	Tomales/Mid Bay	1	.707	13.399	1012.0
	6	29-MAY-2001	Tomales/Mid Bay	1	.369	6.928	1021.0
	7	29-MAY-2001	Tomales/Mid Bay	1	.399	8.327	1024.0
	8	04-MAY-1999	Tomales Bay/Mid Bay	1	.463	9.240	1030.0
	9	30-MAY-2001	Tomales/Mid Bay	1	.627	12.586	1030.0
	10	30-MAY-2001	Tomales/Mid Bay	1	.347	4.949	1035.0
	11	30-MAY-2001	Tomales/Mid Bay	1	.792	17.622	1035.0
	12	05-MAY-1999	Tomales Bay/Mid Bay	1	.470	10.500	1050.0
	13	04-MAY-1999	Tomales Bay/Mid Bay	1	.326	9.530	1060.0
	14	05-MAY-1999	Tomales Bay/Mid Bay	1	.483	16.100	1060.0
	15	29-MAY-2001	Tomales/Mid Bay	1	.481	18.143	1065.0
	16	05-MAY-1999	Tomales Bay/Mid Bay	1	.606	11.700	1070.0
	17	05-MAY-1999	Tomales Bay/Mid Bay	1	.621	10.800	1090.0
	18	05-MAY-1999	Tomales Bay/Mid Bay	1	.421	10.300	1090.0
Pile Surfperch	1	30-MAY-2001	Tomales/Mid Bay	5	.112	.959	326.2
Red Rock Crab	1	31-MAY-2001	Tomales/Outer Bay	3	.211	6.520	118.7
	2	03-MAY-1999	Tomales Bay/Outer Bay	3	.101	1.900	127.0
	3	03-MAY-1999	Tomales Bay/Outer Bay	3	.215	6.220	128.0
	4	29-MAY-2001	Tomales/Outer Bay	3	.071	2.791	131.3
	5	03-MAY-1999	Tomales Bay/Outer Bay	3	.206	3.830	133.0
	6	31-MAY-2001	Tomales/Outer Bay	3	.126	NA	140.7
Redtail Surfperch	1	06-MAY-1999	Tomales Bay/Mid Bay	3	.135	.838	296.7
	2	06-MAY-1999	Tomales Bay/Mid Bay	3	.108	1.020	300.0
	3	06-MAY-1999	Tomales Bay/Mid Bay	3	.209	.976	300.0
Shiner Surfperch	1	10-OCT-1998	Tomales Bay/Mid Bay	19	.085	.493	102.4
	2	10-OCT-1998	Tomales Bay/Mid Bay	20	.110	.536	106.9
	3	04-MAY-1999	Tomales Bay/Mid Bay	20	.087	.716	113.5
	4	04-MAY-1999	Tomales Bay/Mid Bay	20	.119	.622	115.0
	5	04-MAY-1999	Tomales Bay/Mid Bay	20	.078	.678	115.0
	6	29-MAY-2001	Tomales/Mid Bay	20	.067	1.031	119.4
	7	30-MAY-2001	Tomales/Mid Bay	18	.094	1.167	131.6

NA – not analyzed

Tomales Bay Case Summaries for Inorganic Arsenic (ppm) and Length (mm)						
Species	Running Count	Collection Date	Station Name	Number per sample	Inorganic Arsenic (ppm) ND=0.015	Length (mm)
Bat Ray	1	30-MAY-2001	Tomales/Mid Bay	1	.0150	815.0
	2	30-MAY-2001	Tomales/Mid Bay	1	.0150	881.0
	3	31-MAY-2001	Tomales/Mid Bay	1	.0150	914.0
	4	31-MAY-2001	Tomales/Mid Bay	1	.0150	915.0
	5	31-MAY-2001	Tomales/Mid Bay	1	.0150	930.0
	6	29-MAY-2001	Tomales/Mid Bay	1	.0150	990.0
	7	31-MAY-2001	Tomales/Mid Bay	1	.0150	1030.0
	8	30-MAY-2001	Tomales/Mid Bay	1	.0150	1050.0
	9	31-MAY-2001	Tomales/Mid Bay	1	.0150	1156.0
Brown Smoothhound	1	30-MAY-2001	Tomales/Mid Bay	1	.0150	790.0
	2	30-MAY-2001	Tomales/Mid Bay	1	.0150	807.0
	3	30-MAY-2001	Tomales/Mid Bay	1	.0150	836.0
	4	30-MAY-2001	Tomales/Mid Bay	1	.0150	841.0
	5	30-MAY-2001	Tomales/Mid Bay	1	.0150	861.0
	6	30-MAY-2001	Tomales/Mid Bay	1	.0150	882.0
	7	30-MAY-2001	Tomales/Mid Bay	1	.0150	889.0
	8	30-MAY-2001	Tomales/Mid Bay	1	.0150	910.0
	9	30-MAY-2001	Tomales/Mid Bay	1	.0150	924.0
California Halibut	1	17-JUL-2001	Tomales/Mid Bay	1	.0668	559.0
	2	29-MAY-2001	Tomales/Mid Bay	1	.0150	566.0
	3	28-JUN-2001	Tomales/Mid Bay	1	.0867	578.0
	4	31-MAY-2001	Tomales/Mid Bay	1	.0762	599.0
	5	01-JUN-2001	Tomales/Mid Bay	1	.0150	641.0
	6	07-JUL-2001	Tomales/Mid Bay	1	.0625	648.0
	7	17-JUL-2001	Tomales/Mid Bay	1	.0697	654.0
	8	31-JUL-2001	Tomales/Mid Bay	1	.0683	800.0
	9	15-JUN-2001	Tomales/Mid Bay	1	.0987	876.0
Leopard Shark	1	30-MAY-2001	Tomales/Mid Bay	1	.0150	900.0
	2	30-MAY-2001	Tomales/Mid Bay	1	.0150	905.0
	3	30-MAY-2001	Tomales/Mid Bay	1	.0150	913.0
	4	30-MAY-2001	Tomales/Mid Bay	1	.0150	915.0
	5	30-MAY-2001	Tomales/Mid Bay	1	.0150	946.0
	6	30-MAY-2001	Tomales/Mid Bay	1	.0150	1036.0
	7	30-MAY-2001	Tomales/Mid Bay	1	.0150	1051.0
	8	30-MAY-2001	Tomales/Mid Bay	1	.0150	1085.0
	9	30-MAY-2001	Tomales/Mid Bay	1	.0150	1215.0
Pacific Angel Shark	1	30-MAY-2001	Tomales/Mid Bay	1	.0150	990.0
	2	30-MAY-2001	Tomales/Mid Bay	1	.0150	1011.0
	3	30-MAY-2001	Tomales/Mid Bay	1	.0150	1012.0
	4	29-MAY-2001	Tomales/Mid Bay	1	.0150	1021.0
	5	29-MAY-2001	Tomales/Mid Bay	1	.0150	1024.0
	6	30-MAY-2001	Tomales/Mid Bay	1	.0150	1030.0
	7	30-MAY-2001	Tomales/Mid Bay	1	.0150	1035.0
	8	30-MAY-2001	Tomales/Mid Bay	1	.0150	1035.0
	9	29-MAY-2001	Tomales/Mid Bay	1	.0150	1065.0

Tomales Bay Case Summaries for Methylmercury (ppm) and Length (mm)

Species	Running Count by Species	Collection Date	Station Name	Number per sample	Methylmercury (ppm)	Length (mm)
Clams	1	11-MAY-1999	Tomales Bay/S. Millerton Ramp	16	.0318	32.2
	2	29-JUL-1999	Tomales Bay/Hamlet 1	5	.0404	39.4
	3	29-JUL-1999	Tomales Bay/Hamlet 1	5	.0465	39.4
	4	29-JUL-1999	Tomales Bay/Hamlet 3	5	.0859	39.4
	5	29-JUL-1999	Tomales Bay/Hamlet 2	5	.0476	39.8
	6	10-MAY-1999	Tomales Bay/Millerton Park	23	.0364	40.6
	7	29-JUL-1999	Tomales Bay/Hamlet 3	5	.1050	41.0
	8	11-MAY-1999	Tomales Bay/McDonald	22	.0168	41.8
	9	10-MAY-1999	Tomales Bay/Blake's Landing	20	.0241	42.0
	10	29-JUL-1999	Tomales Bay/Hamlet 2	5	.0595	42.0
Red Rock Crab	1	31-MAY-2001	Tomales/Outer Bay	3	.1880	118.7
	2	29-MAY-2001	Tomales/Outer Bay	3	.0636	131.3
	3	31-MAY-2001	Tomales/Outer Bay	3	.1130	140.7

APPENDIX VI: GUIDANCE TISSUE LEVELS (GTLs) AND CORRESPONDING CONSUMPTION GUIDANCE FOR TWO POPULATION GROUPS

Guidance Tissue Levels (GTLs) (ppm Total Mercury or Methylmercury*, wet weight) for Two Population Groups		**Meals/month:**				
		30	**12**	**4**	**1**	**0**
Population group	**Reference Dose (RfD)**	**Tissue concentration (ppm)**				
Women of child-bearing age and children aged 17 years and younger	**1 x 10^{-4} mg/kg/day**	**≤ 0.03**	**> 0.03 - ≤ 0.08**	**> 0.08 - ≤ 0.23**	**> 0.23 - ≤ 0.93**	**> 0.93**
Women beyond childbearing age and men	**3 x 10^{-4} mg/kg/day**	**≤ 0.09**	**> 0.09 - ≤ 0.23**	**> 0.23 - ≤ 0.70**	**> 0.70 - ≤ 2.80**	**> 2.80**

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

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

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

where,

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

For example: $\frac{(1 \times 10^{-4}\text{ mg/kg-day})(70\text{ kg body weight})(1)}{0.030\text{ kg/day}} = 0.23\text{ mg/kg tissue}$

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

Meal Sizes used in this table: Although people eat different meal sizes, their typical portion size is related to their individual body weight in a fairly consistent manner (see Table 1). 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.

APPENDIX VII: RESPONSES TO COMMENTS AND QUESTIONS RECEIVED AT THE PUBLIC WORKSHOP MAY 17, 2004

Q1: What are the concentrations of mercury in oysters? Is it safe to eat them?

A1: The San Francisco Bay Regional Water Quality Control Board (SFBRWQCB) tested samples of commercial oysters, clams, and mussels and found that the mercury concentrations were very low. The measured concentrations were below a level of health concern indicating they were safe to eat. The advisory for Tomales Bay does not include commercial shellfish. Oysters, clams, and mussels are filter feeders and are low on the food chain and low in mercury. If you have collected them yourself (as opposed to purchasing them from local commercial growers) check for information on mussel and bivalve quarantines at 1-800-553-4133 before eating.

Q2: Where were the fish collected in Tomales Bay? Are the concentrations of mercury in fish associated with the proximity of the samples to Walker Creek? Were there differences in concentrations between years?

A2: Fish were collected at several locations in Tomales Bay, but OEHHA does not consider the locations where fish were collected to necessarily indicate where they are all the time because fish move around. Therefore, the advisory for fish from Tomales Bay applies to the whole bay (and also includes the same species that are caught near but outside the bay). However, for non-mobile shellfish such as clams, one can look at the influence of location on mercury concentration. Clams were collected from several different areas. The samples closest to Walker Creek had the highest concentration of total mercury, and mercury concentrations decreased as the distance from Walker Creek increased. However, we also analyzed the clam samples for methylmercury because, unlike fish, the proportion of methylmercury in shellfish is often lower and more variable than it is in fish. The results showed that the concentrations of methylmercury in clams were very low regardless of where they were sampled. Therefore, even though the ones collected closest to Walker Creek had a lot more total mercury, only a tiny amount was methylmercury. This amount of methylmercury was similar to that in samples from other sites. The concentrations of mercury in fish were very similar between sampling years.

Q3: When reports in the newspaper (and other places) indicate that there are "elevated levels" of mercury in Tomales Bay, it makes it sound as if Tomales Bay is worse than other places. But aren't mercury levels about the same in all halibut regardless of where they were collected? Is it possible to make comparisons among different locations using the Coastal Fish Contamination Program (CFCP) data? Shouldn't there be an advisory for halibut for the whole coast? And what about the halibut that is sold in the market at Inverness?

A3: OEHHA recognizes that communicating risks to the public can be challenging and is interested in finding ways to improve the messages so that people can make informed decisions about eating fish wisely. We have added a message to the advisory tables in all our new advisories that states, "Many other water bodies are known or suspected to have elevated mercury levels." In addition, the text under this heading explains that for water bodies where no advice is available, women of childbearing age and children should eat no more than one meal of sport fish caught at that location per week, and not eat any fish the same week from any other source.

As the commenter suggested, the concentrations of mercury that have been measured in halibut from Tomales Bay are similar to the average concentration reported by federal agencies for halibut collected elsewhere in the U.S. The U.S. Food and Drug Administration (FDA) reported an average mercury concentration for halibut of 0.26 parts per million (ppm), but noted that the sample size for this species was limited (32 samples). Unlike the data for halibut from Tomales Bay, however, in which mercury concentrations in all samples were similar, the concentrations in halibut from other locations in the U.S. ranged from "non-detect" to 1.52 ppm mercury. The national data also do not indicate which species of halibut were tested, and the samples may have included species other than California halibut.

At present, OEHHA has only received data from the first two years of the CFCP and the only samples for halibut came form Tomales Bay, so it is not possible to make comparisons of California halibut from different locations along the California coast or to issue advice for halibut for other regions. As was noted at the public workshop by Dyan Whyte from the SFBRWQCB, size can also be a factor in the mercury concentration of individuals within a species with a large size range. However, because halibut from Tomales Bay were analyzed as composites (including fish of different sizes), it is not possible to calculate the relationship between length and mercury concentration in these samples.

OEHHA does not have authority over commercial fish such as halibut sold at local markets. However, OEHHA's advisories include advice provided by U.S. EPA and FDA in their joint Federal Advisory for Mercury in Fish. The federal advice suggests, for example, that pregnant women or women who can become pregnant, nursing mothers, and young children eat up to 12 ounces (two average meals) a week of a variety of fish lower in mercury, which could include halibut as well as other types of fish.

Q4: How is the new advisory different from the 2000 advisory?

A4: Since the interim advisory was issued in 2000 by the Marin County Department of Health and Human Services in consultation with OEHHA, more data were collected and analyzed from Tomales Bay. These data were used in addition to the previous results to develop the new advisory. The combined data representing more samples for California halibut from Tomales Bay showed that they could be eaten somewhat more frequently than was recommended in the interim advisory. Additionally, OEHHA has made a few changes in the way we provide consumption guidelines. First, OEHHA has expanded the definition of the "sensitive population" to include all women of childbearing age and children aged 17 years and younger to be more protective of the population most at risk from exposure to methylmercury. Second, we have simplified the number of advice categories to the following four categories:

No consumption
Once a month
Once a week
Three times a week

Furthermore, two fish species from Tomales Bay (jacksmelt and shiner surfperch) had low enough concentrations of mercury that the "general population" (women beyond childbearing age and men) can eat them daily without exceeding the reference dose. Therefore, we added a special advice category of "unlimited consumption" for women beyond childbearing age and men for these two species in the Tomales Bay advisory.

Q5: How can I determine the health risks of commercial fish consumption for an elderly man? I only let him eat halibut two times a month and no farmed salmon.

A5: The advisory for commercial fish issued by the U.S. EPA and FDA in 2004 in their joint Federal Advice for Mercury in Fish is targeted to pregnant and nursing women, and children, and therefore does not address what is best for the elderly. The elderly population should consider both the health benefits of fish consumption, especially since fish oils offer cardiovascular benefits, and the risks of exposure to too much mercury. Although an elderly man is not considered part of the population most at risk, it is still better to choose fish lower in mercury to avoid any potential health risks and so that, overall, more fish can be eaten. Shrimp, king crab, scallops, farmed catfish, wild salmon, oysters, tilapia, flounder, and sole generally contain some of the lowest mercury levels. Wild-caught salmon is a good choice for consumers in California as it is low in contaminants and high in omega fatty acids, and is fairly readily available. Using either the average concentration measured in halibut from Tomales Bay or the average reported for halibut by FDA, women beyond childbearing age and men can eat halibut up to three times a week (if no other fish with mercury are eaten that week) without exceeding the reference dose for methylmercury. Therefore, halibut can be part of a healthy diet.

Q6: Is there any problem with E. coli in fish from Tomales Bay?

A6: No, and to make sure that parasites do not cause a problem, OEHHA recommends that people cook fish thoroughly.

Q7: What is the long-term prognosis for mercury? How long will it take for the levels to decrease?

A7: Dyan Whyte from the SFBRWQCB pointed out during the public workshop that a few studies have shown that reducing mercury loads can lead to decreases in mercury tissue concentrations. But, there have not been any studies done in areas impacted by mercury mines. Meanwhile, because concentrations change slowly, it is important for people to follow OEHHA's consumption guidelines to protect their health.

Q8: For local areas with high concentrations of mercury, would it help to dredge them?

A8: Dyan Whyte from the SFBRWQCB noted that there are pros and cons of dredging contaminated sediments. One concern is the possible re-suspension and redistribution of mercury from the sediments during dredging activities. Dredging could also have other negative effects on ecosystems including disturbance to benthic communities (organisms living in the sediments). On the other hand, if concentrations are localized, this can be an effective way of reducing impacts. Thus, dredging is an option that will need to be carefully considered.

Q9: What is the future of the CFCP?

A9: Although the legislature mandated that the coastal monitoring program be implemented by state agencies, funds are not currently available to support it. OEHHA does not know if or how this will change in the future. OEHHA is expecting, however, to get the results from the samples that were collected in the third and fourth years of the CFCP, before funding was cut, and will evaluate these additional data.

Q10: Local fishers would be willing to supply samples of coastal halibut if you are interested and able to get more analyses done.

A10: The CFCP did include data in the past from fish samples collected by local fishers at Tomales Bay. OEHHA may follow up with this offer in the future, if monitoring is reinstated and funds are available for analyses.