Statewide Bass Advisory

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Introduction

The Washington State Department of Health (DOH) has issued a statewide bass advisory. The bass advisory report provides recommended guidelines for consumption of largemouth bass and smallmouth bass in Washington State. These guidelines were developed by DOH in response to findings of elevated levels of mercury in bass tested across the state. The aim of the guidance is to protect the public against possible adverse health effects that may result from consumption of mercury-contaminated bass. This report provides background information and a description of the data and criteria used to develop these recommendations.

In 2002, the Washington State Department of Ecology (Ecology) conducted a screening-level survey for mercury in largemouth bass (*Micropterus salmoides)* and smallmouth bass (*Micropterus dolomieu*) from selected waterbodies across Washington State. The Ecology study, entitled *Mercury in Edible Fish Tissues and Sediment from Selected Lakes and Rivers of Washington State* (Fischnaller et al., 2003) was conducted in support of the *Washington State Mercury Chemical Action Plan* (Peele, 2003). Results of this and other previous studies (Johnson et al., 1989) (Serdar et al., 2001) were used by the Washington State Department of Health (DOH) to assess risks to human health associated with fish consumption.

Background

In recent years, several federal agencies have presented data indicating that women of childbearing age who consume fish may be over exposed to mercury. In 1999, the U.S. Congress requested the National Academy of Sciences (NAS), National Research Council (NRC) to develop appropriate exposure limits for methylmercury (NRC 2000). The NAS report concluded that children of women who consume large amounts of fish and seafood during pregnancy might be at risk for neurological problems. The report estimated that each year about 7% of women in the U.S. exceed the U.S. Environmental Protection Agency's (EPA) recommended limit for methylmercury exposure (0.1 microgram per kilogram per day). If that estimate is extrapolated to newborn infants, an estimated 60,000 babies born each year are at risk for toxic exposure. Potential effects might result in neurological damage that could lead to poor school performance due to children's exposure to methylmercury in utero.

Two more recent studies evaluated mercury levels in people and the need to reduce exposure. Researchers at the Center for Disease Control and Prevention (CDC) analyzed blood mercury levels from the 1999-2000 National Health and Nutrition Examination Survey (NHANES). They concluded that approximately 8% of women of childbearing age had concentrations higher than the EPA's recommended reference dose (RfD) of 0.1 µg/kg body weight per day. This corresponds to a whole blood level of 5.0 µg/l (Schober et al., 2003).

A second study conducted by researchers in San Francisco looked at mercury levels in the blood and hair of patients who consume fish. The findings indicated that 89% of the patients tested exceeded the RfD for mercury. Blood mercury levels were correlated with the amount of fish consumed. Women tested in this survey had mean mercury levels ten times higher than those reported in the CDC survey; some children had levels that were more than 40 times the national mean (Hightower and Moore, 2003). This research indicates that segments of the population consuming high amounts of fish are at increased risk for health effects associated with exposure to methylmercury. This is of particular importance in pregnant women and young children, due to the key neurological development that occurs early in the life of a fetus and child.

Mercury in the Environment

Mercury is widespread in the environment as a result of both natural and anthropogenic releases. People are exposed to three different forms of mercury; elemental, inorganic, and organic. Most of the mercury in the atmosphere is elemental mercury vapor and inorganic mercury. Most mercury occurring in water, soil, plants, and animals is organic, primarily methylmercury, and inorganic (EPA 1999).

Mercury is released into surface waters from the natural weathering of rocks and soils that contain and then release mercury, from volcanic activity, and from human sources that include: industrial activities, burning of fossil fuel, and the disposal of certain consumer products. Global cycling of mercury via air deposition occurs when mercury evaporates from soils and surface waters to the atmosphere, and is then redistributed on land and surface water, and absorbed by soil or sediments. Once released into the environment, bacteria convert inorganic mercury into organic mercury, the primary form that accumulates in fish and shellfish (EPA 1999, ATSDR 1999).

Methylmercury, the most common form of organic mercury, quickly enters the aquatic food chain. Methylmercury biomagnifies up the food chain as it is passed from a lower food chain level to a subsequently higher food chain level through consumption of prey organisms. Fish at the top of the aquatic food chain, such as largemouth and smallmouth bass, biomagnify methylmercury 10,000 to 100,000 times greater than concentrations dissolved in the surrounding waters. Nearly all of the mercury found in fish is in the methylmercury form (ATSDR 1999). In this document, methylmercury contained in fish will be referred to as mercury.

Nationwide Fish Advisories for Mercury

Numerous studies conducted across North America have characterized the range and extent of mercury contamination in a variety of fish species as seen in Table 1 (page 20). In 1987, EPA conducted the National Study of Chemical Residues in Fish (NSCRF 1992). The highest mercury tissue concentrations were found in largemouth bass, smallmouth bass, and walleye with mean concentrations of 460, 340, and 520 parts per billion (ppb), respectively. A similar study was conducted in the northeast states and eastern Canadian provinces that investigated mercury concentrations in a variety of freshwater sport fish collected from the late 1980s to 1996. This study also showed that predatory fish exhibited the highest mercury concentrations with mean levels of 510, 530 and 770 ppb in largemouth bass, smallmouth bass and walleye, respectively (NESCAUM 1998). A national dataset compiled by EPA from 43 states also showed elevated mercury concentrations in these same predatory species with largemouth bass, smallmouth bass, and walleye at 520, 320, and 430 ppb, respectively (U.S. EPA 2001a). National regulatory guidelines for mercury in fish are discussed in Appendix B (page 24).

A fish consumption advisory is generally issued by a state or local government to protect people from possible risks of eating contaminated fish. Consumption advisories may recommend that people limit or avoid eating certain fish species caught from certain lakes, rivers, or coastal waters. Statewide advisories are issued when sufficient evidence suggests that contamination is widespread and not localized to specific water bodies. Based on the above information, numerous states have issued fish statewide advisories for bass and walleye.

As of 2002, 2,800 fish advisories have been issued by states for specific waterbodies due to various contaminants. Almost 75 % of the advisories have been issued in part because of mercury contamination. In 2002, 19 states (Connecticut, Florida, Illinois, Indiana, Kentucky, Maine, Maryland, Massachusetts, Michigan, Minnesota, Missouri, New Hampshire, New Jersey, North Dakota, Ohio, Pennsylvania, Rhode Island, Vermont, and Wisconsin) issued statewide advisories for mercury in freshwater lakes and/or rivers. Another 11 states issued statewide advisories for mercury in their coastal waters. In addition, two tribal advisories have been issued for mercury in freshwater and marine fish by the Micmac tribe in Maine (EPA 2001a). The number of states that have issued mercury advisories has risen from 27 in 1993 to 45 in 2002. The increase in the number of advisories is not necessarily a function of increased pollution but rather an increase in fish tissue monitoring by states for this and other contaminants, as well as new evidence of developmental effects from several recently conducted large scale studies.

Mercury Based Fish Consumption Advisories in Washington State

Washington State, as of May 2003, has two fish advisories for freshwater fish species based solely on mercury levels. The advisories include walleye from Lake Roosevelt and smallmouth bass and yellow perch from Lake Whatcom. The 1997 U.S. Geological Survey (USGS 1997) study of Lake Roosevelt found a mean mercury level in 34 walleye of approximately 300 ppb. The state's first fish consumption advisory due to mercury was issued for walleye based on this information. Analysis of a limited number of smallmouth bass collected during this same sampling event detected 280 ppb mercury with an upper range exceeding 600 ppb. This sample, however, was deemed too small for a consumption advisory on bass from Lake Roosevelt.

In Whatcom County, human health concerns were raised due to elevated levels of mercury in smallmouth bass collected in a screening level survey conducted on Lake Whatcom fish in 1999 (Serdar et al., 1999). A follow up study conducted in 2001 confirmed those concerns (Serdar et al., 2001). Mercury concentrations for smallmouth bass were similar to those found nationally with a mean concentration of 490 ppb. Subsequently, DOH, working with the Whatcom County Department of Health and

Social Services (WCDHHS), issued a fish consumption advisory for Lake Whatcom (DOH 2001a). At that time, a statewide mercury advisory was also issued for several commercially available fish species including shark, swordfish, king mackerel, tilefish, and large tuna. This advisory recommended that women of childbearing age and children under six not consume these species. Additionally, recommendations on the amount of canned tuna were also provided to this sensitive population (DOH 2001b).

In 2001, the FDA and EPA issued national advice on limiting consumption of both freshwater and marine fish due to methylmercury contamination. EPA's national advisory was aimed at risks associated with mercury in freshwater fish caught by friends and family and recommended that women who are, or may become pregnant, nursing mothers, and young children limit consumption to one meal per week (EPA 2001b). The FDA advisory also warned of the hazards of consuming certain kinds of marine fish that may contain high levels of methylmercury. The FDA advises pregnant women and women of childbearing age who may become pregnant not to eat shark, swordfish, king mackerel, and tilefish (FDA 2001). FDA also advised women who eat an average of 12 ounces of fish from stores and restaurants, not to eat fish caught by their family or friends that week.

2003 Washington State Department of Ecology Mercury in Bass Study

Until recently, data on the levels of mercury in largemouth bass and smallmouth bass were lacking for other waterbodies in Washington State. Due to the concern within Washington, as well as known mercury levels in bass throughout the U.S. and Canada, Ecology conducted a screening survey for mercury concentrations in bass from selected lakes and rivers across Washington State. Largemouth bass and smallmouth bass were targeted due to their wide distribution, predatory nature, and known tendency to bioaccumulate mercury in its tissue. Waterbodies were selected based on spatial distribution across the state, known use by recreational fishers, availability of either largemouth or smallmouth bass, availability of public access, and ability to obtain required permits. There were 20 lakes and rivers selected for participation in the Ecology study. Locations of the selected waterbodies are listed in Table 2 (page 21).

Mercury concentrations were measured in edible tissue from 185 bass, collected from 18 lakes and two rivers across the State of Washington as described by Ecology (Fischnaller et al., 2003). Sampling was conducted over a 16-month period, from June 2001 to November 2002. The goal was to collect ten individual fish from either species of largemouth bass or smallmouth bass of at least ten inches in length or greater. Tissue samples from individual fish were analyzed to obtain estimates of the variance and an overall mean for each species at a given location. Sample collection, preparation, and analysis are described in detail by Ecology (Fischnaller et al., 2003).

The mean fish length in the study was approximately 14 inches while the average weight was 31 ounces. The mean mercury tissue level was 217 ppb, with a standard deviation of $\pm$ 179, with a range from 22 to 1280 ppb. Mercury concentrations from individual fish were highly influenced by size and age of fish, and with few exceptions, strongly correlated with increasing fish age, weight, and length. The highest mean for a given waterbody was 451 ppb. This value is similar to results collected from Lake Whatcom in 2001 (Serdar et al., 2001), where the mean concentration of mercury in smallmouth bass was 490 ppb, a level that mirrors the mercury concentrations in bass seen across North America. A detailed summary of mercury concentrations from specific waterbodies is listed in Table 2 (page 21). A summary of the overall fish length, weight, and mercury concentration are listed in Table 3 (page 22).

Discussion

Health Effects and Toxicology of Methylmercury

Human exposure to methylmercury through the consumption of contaminated fish is a global concern. Exposure through diet has increased the body burden of methylmercury in animal and human populations. A spectrum of adverse health effects has been observed following methylmercury exposure. The severity of effects depends largely on the magnitude of exposure.

Human health effects from exposure to methylmercury have been evaluated in several poisoning episodes that occurred from acute high-dose exposures in the 1950's, 1960's, and early 1970's (NRC 2000, Agency of Toxic Substances and Disease Registry [ATSDR] 1999). The first of these occurred in Japan, where fish were contaminated with very high levels of methylmercury due to mercury-containing factory waste being discharged into Minamata Bay. The consumption of these fish and the resulting poisoning outbreak indicated that the prenatal period was a very sensitive period for exposure to methylmercury. Severely brain damaged infants were born to mothers who hardly showed ill effects (Harada 1995). This episode provided the first evidence that methylmercury was bioaccumulating and biomagnifying in locally caught fish. The second key exposure occurred due to a poisoning incident involving seed grain treated with methylmercury fungicide that occurred in Iraq in the 1970s (Marsh et al., 1987). In this incident the grain was mistakenly used to make bread. Consumers developed permanent brain damage as a result of methylmercury exposure.

In each of these poisoning episodes, many people experienced severe adverse health effects. Deaths were seen in both adults and children. Until recently the more subtle effects from low-dose exposure to methylmercury had to be extrapolated from the data from acute, high-dose poisonings incidents. It is important to note that the amounts of mercury ingested in these episodes were much higher than levels commonly consumed in the U.S.

Methylmercury is known to cross the placental barrier following adult exposure, resulting in prenatal exposures that can lead to developmental effects. These effects were borne out by further studies on these communities that documented neurotoxic effects in children. An important finding recognized that infants of women exposed during pregnancy, showed nervous system damage to the baby, even when mothers were only slightly affected or showed no signs of toxicity. Infants exposed during fetal development displayed blindness, deafness, impaired motor functions, abnormal reflexes, seizures, deficiencies in memory, learning, and psychological parameters. Effects on the developing nervous system are considered to be the most sensitive endpoint from methylmercury exposure. The available data clearly indicate that the populations of greatest concern consist of women of childbearing age, and children under the age of six (NRC 2000, ATSDR 1999).

More recently, three major scientific studies were conducted in the Seychelles, Faroe Island, and New Zealand. Their purpose was to address potential health effects from exposure to methylmercury at the low levels that typically occur from consumption of seafood. Each of these studies was well designed and carefully conducted, and each examined prenatal methylmercury exposures within the range that the general U.S. population is exposed. The Seychelles Islands study investigated the effects of prenatal exposure to methylmercury through maternal fish consumption, by testing for fetal neurodevelopmental effects during infancy and childhood (Davidson et al., 1995, 1998). Similarly, the New Zealand study (Kjellstrom et al., 1986, 1989) used a research design and exposure pattern similar to that of the Seychelles study but examined an ethnically mixed population. The Faroe Islands study looked at the effects of prenatal exposure to methylmercury through maternal consumption of fish and whale (Grandjean et al., 1997).

No observable adverse neurodevelopmental effects were seen in the Seychelle's children, nor were abnormalities observed based on clinical examinations of children in the Faroe Islands and New Zealand studies. However, the Faroe and New Zealand studies showed that methylmercury exposure was associated with poor neurodevelopment functional outcomes, such as dysfunctions in language, attention and memory. Currently, it is not known whether these effects from low-level exposure to methylmercury are transient or chronic in nature. EPA, NRC, Agency of Toxic Substances and Disease Registry (ATSDR), and DOH Office of Environmental Health Assessment (OEHA) each reviewed the results of the Seychelles, Faroe Islands, and New Zealand studies to derive a safe intake level. OEHA has adopted the EPA RfD 0.1 microgram per kilogram of body weight per day.

In addition to neurologic effects, other health effects from exposure to methylmercury have been shown in studies involving humans and animals. A variety of immune system effects have been demonstrated in animal studies (NRC 2000). These studies show that the immune systems of certain animals are sensitive to methylmercury. Occupational studies of mercury compounds other than methylmercury show an association with decreased immune response in workers. A variety of human reproductive effects including increased incidence of spontaneous abortions, decreased fertility and reproductive success have been linked to metallic or elemental mercury. No studies have been identified that evaluate human reproductive success and methylmercury exposure. However, numerous animal reproductive studies show a variety of toxic effects from methylmercury exposure including abnormal sperm production, fetal malformations, and more commonly, increased rates of spontaneous abortion and decreased litter size.

Human epidemiological studies have not shown an association with mercury exposure and increases in overall cancer rates (NRC 2000). However two studies involving small population numbers cited an association with exposure to mercury and acute leukemia. A limitation of these studies was the inability to control for other risk factors. In animal studies, chronic high-level exposure to methylmercury increased the incidence of renal tumors in mice. This effect was believed to be secondary to the cell damage and repair caused by the high dose. Based on human and animal data, the International Agency for Research on Cancer (IARC) and EPA has classified methylmercury as a “possible” human carcinogen. Evidence of human exposure causing genetic damage is inconclusive.

Occupational exposure to mercury vapor is associated with adverse effects on the kidney but is rarely documented following human exposure to organic forms of mercury. The kidney is the target organ for inorganic mercury, as well as methylmercury induced renal toxicity, in animals.

While numerous studies have shown that fish consumption has protective effects against cardiovascular disease and is generally considered beneficial, the consumption of fish contaminated with methylmercury has been associated with adverse cardiovascular effects. Mercury accumulates in the heart, and exposures to organic and inorganic forms of mercury have been associated with blood-pressure alterations and abnormal cardiac function. These effects have also been observed in animal studies and two recent epidemiological studies conducted in Finland (Salonen et al., 1995; Sorensen et al., 1999). Further research is needed before conclusions can be made regarding cardiovascular effects.

Although mercury can produce adverse effects on other organs systems, it is generally thought that the central nervous system is the most sensitive target. Protecting populations from the most sensitive endpoint will ultimately protect individuals from other possible adverse effects that occur at higher exposures. For further information regarding the toxicological effects of methylmercury, please refer to the NRC report (NRC 2000), ATSDR’s toxicological profile for methylmercury (ATSDR 1999), EPA’s report to Congress (EPA 1997) or DOH’s Evaluation of Evidence Related to the Development of a Tolerable Daily Intake for Methylmercury (DOH 1999).

Exposure Estimates and the RfD

Public health officials are often asked how much a person can safely eat, regardless of the current consumption pattern. By using the known concentration of mercury in a fish species, it is possible to calculate an allowable amount that can be consumed for that species without exceeding the RfD. In this approach, the RfD is used to back-calculate the quantity of fish that a person can safely consume.

Appendix C provides the exposure assumptions and calculations used to determine the level of fish consumption that would result in a dose equivalent to the RfD. In determining this consumption rate, an average meal size of eight-ounces was used based on results of average consumption rates from Washington State (DOH 2001c). EPA also uses this value in averaging the weight of a fish meal portion. In addition, consumption rates for a four-ounce meal size are presented with the understanding that individuals who weigh less, such as children, are likely to consume smaller portion sizes. Individuals who consume smallmouth and largemouth bass above these rates are likely to exceed the RfD.

As depicted in Figure 1 (page 23), the recommended consumption rate for a 125-pound woman is approximately two eight-ounce meal per month or three and a half four-ounce meals per month. A woman weighing twice as much may safely consume twice the amount. Recommendations for a 50 pound child is to limit consumption to less than one eight-ounce meal per month or slightly greater than one four-ounce meal.

It is important to note that the calculated number of meals that an individual could consume and remain below the RfD is based solely on the consumption of that species. For example, a 125-pound person could consume approximately two meals per week of bass and remain below the RfD provided that this was his or her only source of methylmercury. This does not take into consideration other fish species consumed.

It is known that methylmercury can affect adults at levels much higher than those found to be detrimental in children. In Minamata, Japan, a well-documented exposure to mercury in fish did show some limited toxicity in adults, although these effects paled in comparison to the severe neurological and developmental effects in children exposed in the womb. The levels in this incident were several times higher than mercury levels in fish from Washington State. More recent research from human and animal studies suggests that possible adverse health effects on cardiovascular or reproductive systems may occur in the general population due to mercury exposure at concentrations similar to those causing problems in children. More research is required to determine if low-level effects occur in the general population and if so, what that exposure level might be. Following the same guidelines for women of childbearing age and children can provide a fair margin of safety.

Benefits of Fish Consumption

Fish are an excellent source of protein that is low in saturated fats, rich in vitamin D and omega-3 fatty acids as well as other nutrients. The health benefits of eating fish are well documented and linked to the reduction of cardiovascular disease, osteoporosis, and partial reduction of certain types of cancer. These are major chronic diseases that afflict much of the U.S. population. It is, therefore, important to consider the very real health benefits of fish consumption when considering advisories that would impose limits on fish consumption. Replacing fish in the diet with other sources of protein such as red meat brings other considerations such as the link between saturated fat intake and cardiovascular disease and the presence of contaminants. Advisories can still be effective in the face of this uncertainty by decreasing the consumption of fish known to have high methylmercury concentrations in favor of fish that are lower in methylmercury and other contaminants.

Conclusions

Based on data from numerous waterbodies in Washington State, methylmercury levels in largemouth and smallmouth bass have been shown to exceed a level of health concern for some consumers. This information, coupled with the known toxicity of methylmercury was used to develop a state wide advisory for bass. The goal of this advisory is to prevent mercury body burdens of women of childbearing age to become elevated to a point where harm may occur to a developing fetus and to prevent overexposure of mercury to young children. Limiting exposure of these target populations will reduce the likelihood of any adverse heath effects resulting from the consumption of bass caught in Washington State waters.

Recommended Consumption Guidelines for Smallmouth and Largemouth Bass in Washington State

The following specific recommendations were developed for women of childbearing age, infants, and children that consume smallmouth and largemouth bass from Washington waters.

Women of childbearing age, infants and children

Women of childbearing age and children six years of age or younger should eat no more than 2 meals per month of smallmouth and largemouth bass caught in Washington State freshwater. Specific consumption rates are provided in Figure 1 (page 23) based on an individuals body weight and should be followed by women of childbearing age, infants, and children under six years old.

General Population

The recommendations for consumption of smallmouth and largemouth bass from Washington waters are aimed at protecting the most sensitive population: women of childbearing age and children under the age of six. Limited scientific information from human and animal studies suggests that mercury contained in fish may cause possible adverse health effects involving the cardiovascular or reproductive system in the general population at levels similar to those resulting in effects in the sensitive population. Currently, it is not known if or at what level these effects might occur. More research is required to determine if effects occur to the general population and at what exposure level. For those individuals who are concerned about their exposure to mercury, following the same guidelines for women of childbearing age and children will likely provide a fair margin of safety.

Glossary

Acute short-term exposure to a chemical, i.e. one dose or multiple doses occurring for a limited duration (usually less than 14 days); the effects form such an exposure

Anthropogenic deriving from a human source

Bioaccumulation net accumulation of a chemical by an organism as a result of uptake form all routes of exposure (e.g. food, water, dermal absorption)

Biomagnification accumulation of a chemical to higher concentrations at higher levels in the food web through dietary accumulation

Carcinogen an agent capable of inducing a cancer response

C*hronic* multiple exposures occurring over an extended period of time, or a significant fraction of the organism's life-time; effects from chronic exposure, or long-term effects from high short-term exposures

Developmental toxicity adverse effects on the developing organism (including death, structural abnormality, altered growth, or functional deficiency) that may result from exposure prior to conception (in either parent), during prenatal development, or postnatally up to the time of sexual maturation, and which may be detected at any point in the life span of the organism

Dose-response the relationship between the amount or magnitude of exposure (dose) and the biological response or toxic injury produced by the chemical

Endpoint an observable or measurable biological or chemical event used as an index of the effect of a chemical on a cell, tissue, organ, or organism

Epidemiology the study of the distribution and determinants of disease and injuries in human populations.

Half-life the period required for a chemical to decrease in concentration to one-half of the original concentration

Neurotoxicity adverse effects in the nervous system caused by chemicals, pathogens, or trauma

Noncarcinogen a chemical or substance that causes noncancer health effects

ppb parts per billion (μg/kg or microgram per kilogram) = (0.000001g/1000g)

ppm parts per million (mg/kg or milligram per kilogram) = (0.001g/1000g)

Reference dose (RfD) an estimate (with uncertainty spanning perhaps and order of magnitude) of a daily exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime

Sensitivity the condition whereby adverse health effects that occur from exposure to a chemical contaminant are determined by quantitative differences; a chemical can produce the same effect in infants, children, or adults, but the magnitude of effect differs

Susceptibility the condition whereby adverse health effects from exposure to a chemical contaminant are due to qualitative differences; such as, unique processes of growth and development in the exposed organism, particularly in young, not fully matured individuals, changes due to aging, state of health, nutritional status, or genetic predisposition to harm.

Tolerable Daily Intake (TDI) a daily intake level for a chemical that is unlikely to result in adverse health effects

Toxicology the study of the nature and mechanism of adverse effects of substances on living organisms or biologic systems.

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Appendix A: Figures and Tables

Table 1. NATIONAL DATA ON MERCURY LEVELS IN BASS

Study/Date	Smallmouth Bass Mean Concentration (ppm)	Smallmouth Bass Minium-Maximum Range (ppm)	Largemouth Bass Mean Concentration (ppm)	Largemouth Bass Minium-Maximum Range (ppm)
NSCRF 1987	0.34	NR	0.46	NR
NESCAUM 1998	0.53	0.08 - 5.0	0.51	0.0 - 8.94
NLFWA 2000	0.32	0.005 - 3.34	0.52	0.0005 - 8.94

NR: not reported
NSCRF 1987 - EPA National Study of Chemical Residue in Fish
NESCAUM 1998 - Northeast States for Coordinated Air Use Management
NLFWA 2000 - EPA National Listing of Fish and Wildlife Advisories

Table 2. Waterbodies Sampled by Region

Waterbody	County	Species	Sample Size	Mean Length (mm)	Mean Hg Concentration (ppb)	Standard Deviation
Northwest Region						
Lake Terrell	Whatcom	LMBS	10	351	159	82
Fazon Lake	Whatcom	LMBS	10	439	447	204
Lake Samish	Whatcom	LMBS	10	377	331	347
Kitsap Lake	Kitsap	LMBS	10	380	313	193
Lake Meridian	King	LMBS	8	362	272	160
Southwest Region						
American Lake	Pierce	LMBS	4	429	404	185
Black Lake	Thurston	LMBS	10	322	254	247
Offut Lake	Thurston	LMBS	10	221	80	17
Duck Lake	Grays Harbor	LMBS	10	367	247	190
Loomis Lake	Pacific	LMBS	10	354	311	78
Vancouver Lake	Clark	LMBS	10	306	160	185
Central Region						
Palmer Lake	Okanogan	LMBS	10	307	133	44
Bonaparte Lake	Okanogan	LMBS	3	454	451	30
Okanogan River	Okanogan	SMBS	10	324	151	65
Banks Lake	Grant	LMBS	10	351	114	38
Eastern Region						
Newman Lake	Spokane	LMBS	10	276	118	105
Moses Lake	Grant	LMBS	10	447	86	48
Deer Lake	Stevens	LMBS	10	384	331	75
Walla Walla River	Walla Walla	SMBS	10	341	179	69
Upper Long Lake	Spokane	LMBS	10	395	89	53

LMBS = Largemouth Bass

SMBS = Smallmouth Bass

source - Mercury in Edible Fish Tissue from Selected Lakes and Rivers of Washington State. June 2003. Washington State Department of Ecology

Table 3. Overall Fish Size and Tissue Mercury Concentration

	Fish Length mm (inches)	Fish Weight gms (oz.)	Hg Tissue Concentration ug/kg ww
Mean	353 (13.9)	889 (31)	217
Range	191 - 575 (7.5 - 22.6)	86 - 3747 (3 - 132)	22 - 1280
Standard Deviation	79 (3.1)	708 (25)	179

ug/kg = parts per billion (ppb)

ww = wet weight
source - Mercury in Edible Fish Tissue and Sediment from Selected Lakes and Rivers of Washington State.

June 2003. Washington State Department of Ecology

Table 4. Monthly Fish Consumption Recommendations for Methylmercury

Consumption Recommendations Fish Meals/month	oz./day	Fish Tissue Hg Concentrations* (ppb ww)
Unrestricted (>16)	>4.21	0 - 50
16	4.21	50
12	3.15	70
8	2.10	100
4	1.05	200
3	0.79	270
2	0.53	400
1	0.26	810
0.5	0.13	1620
None	-	> 1620

ppb = parts per billion (ug/kg)
ww = wet weight
* fish tissue conc. = (RfD X BW)/CR
meal size = 8 oz. (0.227 kg)
RfD for mercury 0.1 (ug/kg-day)
body weight of 132 pounds (60 kg)

Figure 1. Recommended Monthly Consumption Rates of Smallmouth and Largemouth Bass for Women of Childbearing Age and Children Under Six

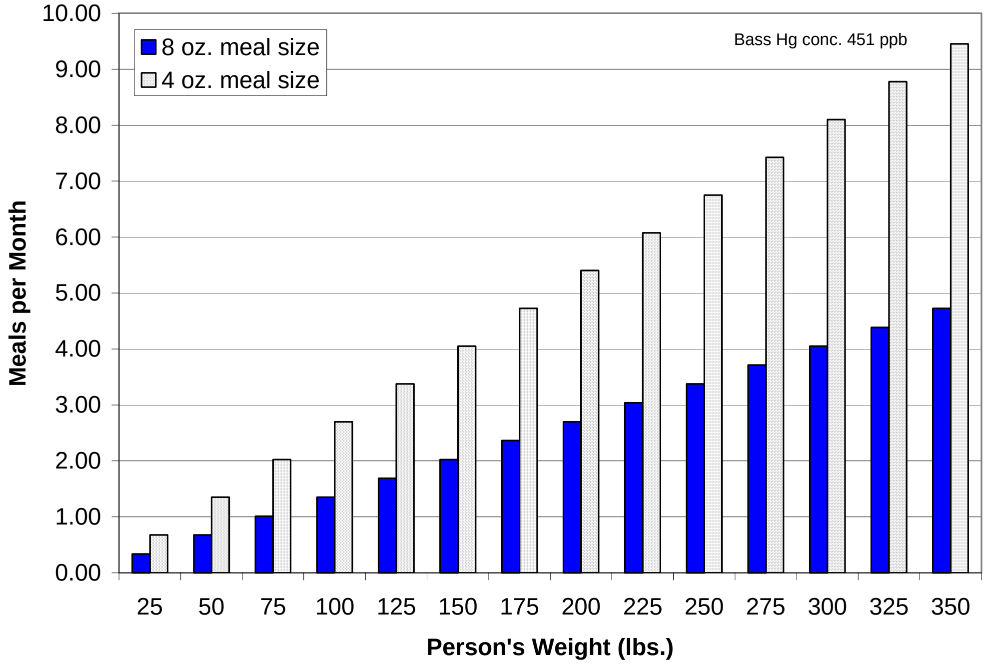
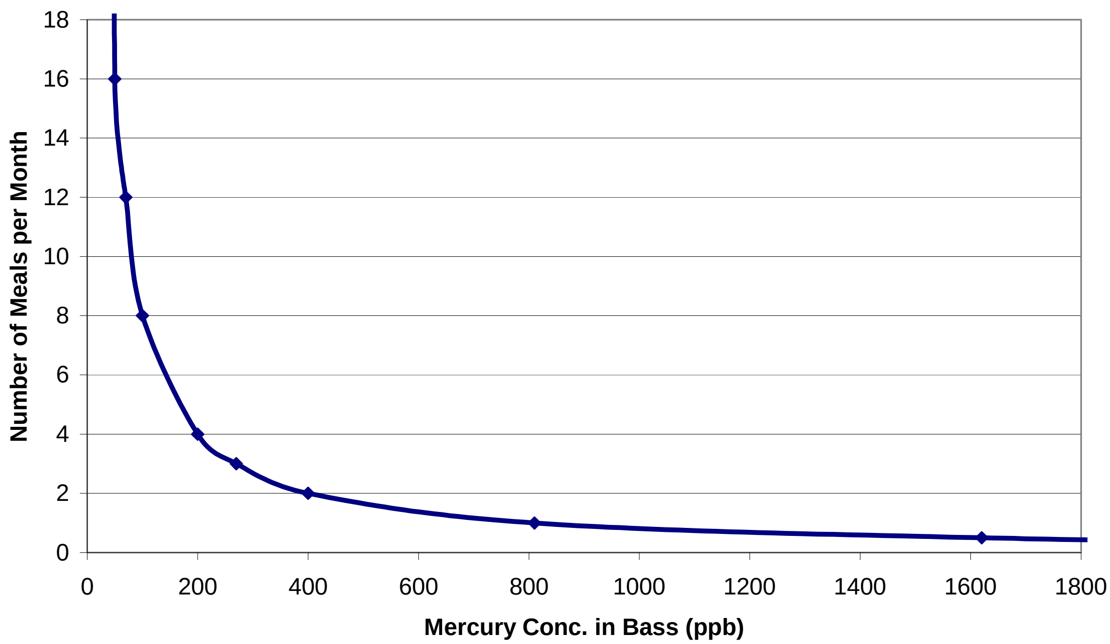


Figure 2. Monthly Consumption Recommendations for a 60 kg (132 lb) woman Based on Mercury Concentrations in Bass



Appendix B: National Regulatory Guidelines/Recommendations

The U.S. Food and Drug Administration (FDA) has established an action level of 1 ppm (1000 ppb) for mercury in fish and shellfish sold and bought in interstate commerce. This value is based on assumptions about national fish consumption habits and levels of contamination in commercial seafood products. In setting this level, FDA assumes a consumption rate of 7 ounces of seafood per week, which translates to approximately 28 grams per day. Using this consumption rate, it is possible to calculate a mercury intake level for comparison with allowable daily mercury intake levels set by other agencies. FDA's calculated mercury intake level becomes 0.47 μg/kg per day. FDA's value is nearly five times higher than that recommended by EPA fish consumption advisory guidelines.

EPA does not support application of the FDA's standard to sport fish since the risks may be greater to fishers who consume large amounts of fish from local water bodies. While the FDA uses 1ppm as the limit (action level) for methylmercury concentration for commercially sold fish, DOH does not recognize this value as being protective of sensitive populations. EPA encourages states and tribes, whose responsibility is to assess and manage risks from contaminated sport fish, to use a risk-based approach in evaluating human health risks and issuing advisories.

When local information is lacking, EPA has issued national advice on mercury in freshwater fish for women who are or may become pregnant, nursing mothers, and young children (EPA 2003). This advice applies to all freshwater fish species. This generic recommendation states that freshwater fish caught by family and friends should be limited to one meal per week.

For various program and regulatory requirements, EPA has set different criteria for mercury concentration in fish tissue. These include the National Toxics Rule (NTR) of 825 ppb and the Fish Tissue Residual Criterion (TRC) for methylmercury of 300 ppb. While both of these criteria are based on the current RfD, they utilize different consumption rates as required by law. EPA has also provided guidelines to states on determining allowable monthly fish consumption based on ranges of methylmercury in consumed fish tissue. (REF)

Appendix C: Determining Allowable Consumption Rates

In conducting a mercury health assessment, DOH uses an approach similar to EPA's risk-based approach to characterize and evaluate risks from exposure to chemicals (EPA 2000). This approach calculates an allowable monthly consumption rate based on the toxicity of a contaminant utilizing EPA's reference dose (RfD) for noncancer endpoints, the body weight of an individual, and the known contaminant concentration in fish. For noncancer health effects, EPA defines the RfD as a threshold of exposure exists below which health effects are unlikely. Currently, EPA's RfD for methylmercury is 0.1 μg/kg-day based on information from the Faroe Island study. The use of this value is consistent with recommendations of the NRC.

By using the known concentration of mercury in a fish species, it is possible to calculate an allowable amount that can be consumed for that species without exceeding the RfD. In this approach the RfD is used to back-calculate the quantity of fish a person of a given weight can safely consume, when the average contaminant concentration for a particular fish species is known. The equation used to calculate a safe consumption rate is from EPA's *Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories* (EPA 2000) is seen below:

$$\frac{grams\ of\ \ fish}{day} = \left(RfD \times Body\ Weight \times Unit\ Conversion\ Factor\right) \div \left(Conc.\ of\ \ Hg\ in\ Fish\right)$$

Hg is the elemental symbol of mercury.

Based on this equation, there are two variables that affect the amount of fish a person can consume and stay below the RfD. These variables include the concentration of mercury in fish and an individual's body weight. Both the RfD and the unit conversion factors are constant. Reducing the consumption rate will also reduce exposure. The consumption rate is expressed as grams of fish per day and later converted to allowable meals per month. The RfD is expressed on a microgram per kilogram per day basis. The concentration of mercury in fish is the highest mean concentration of mercury found in bass, as determined in Ecology's fish tissue analysis. Body weight is that of an average woman of weighing 60 kg (approximately 132 lbs.). This weight was chosen to ensure that the sensitive population (woman of child-bearing age) is factored into calculating the final consumption rate.

Applying the RfD (0.1 μg/kg-day) and using the highest lake mean concentration of mercury in bass, 451 ppb (451 μg Hg/kg) the equation to calculate a safe consumption rate for a 60 kg woman becomes:

$$\frac{grams_{fish}}{day} = \left(\frac{0.1\,\mu g\ Hg}{kg_{person}\ day}\right) \times \left(\frac{60\,kg_{person}}{1}\right) \times \left(\frac{1000\,gm_{fish}}{1\,kg_{fish}}\right) \div \left(\frac{451\,\mu g\ Hg}{Kg_{fish}}\right)$$

For a 132-pound (60 kg) woman of childbearing age, the safe consumption rate is 13.3 grams of bass per day. This is equivalent to approximately 0.47 ounces per day, or 14.3

ounces per month (16 ounces = 1 pound) or just slightly less than about 2 eight-ounce meals per month. Monthly fish consumption rates ranging corresponding to ½ a meal per month to greater than 16 meals per month were calculated based on a mercury concentration of 451 and assuming a 60 kg (132 pound) woman, are provided in Table 4. This information is also presented graphically in Figure 2.

The selection of the highest mean lake concentration (451 ppb) was chosen for use in determining allowable consumption rates across the state. This value is approximately equal to the 90^{th} %ile of the 185 individual samples analyzed. While typically the mean value is generally chosen for use in risk assessments in setting consumption limits, DOH based the decision to use this value after consultation with numerous local health jurisdictions. The use of the highest mean value was to ensure adequate public health protection to consumers of smallmouth and largemouth bass given the fact that the data collected from the 20 waterbodies is being used as a surrogate for the remainder of the state. The rational for the use of this value is supported by data collected throughout the US and Canada where bass have been analyzed for mercury. As shown in Table 1, the average of those levels reported is approximately 450 ppb. This applies to bass in areas considered pristine as well as those collected from more industrialized.

Given the limited amount of funding for fish tissue sampling, as well as the consistency of sample results collected from Washington waters showing similar with mercury levels in bass throughout North America, it is likely that bass in waterbodies that have not been analyzed for mercury would likely yield similar concentrations. Anglers, who fish for smallmouth and largemouth bass in Washington waters are likely, based on state and national data, to catch bass with similar mercury concentrations whether bass are located due to the propensity of these fish species to accumulate mercury at greater levels than other fish species. Issuing a fish consumption advisory for only those lakes where bass have been analyzed for mercury would likely have the unintended consequence of forcing anglers to fish in lakes where no data is available but are likely to have bass with similar mercury concentrations.

Uncertainty

It is important to note the uncertainty that goes along with the assumptions made in defining a safe level of exposure to mercury in fish. Sources of uncertainty include differences in frequency, duration and magnitude of exposure. For instance, parameters taken from the studies described above reflect average intake on a daily basis. It is possible, however, that adverse effects of methylmercury exposure are more directly related to the magnitude of peak exposure, such as could result from one or a few closely spaced meals of fish with high mercury concentration, rather than the average exposure level over a month or year. Unfortunately, the design of the studies for low-level methylmercury exposure makes it impossible to distinguish the influence of average versus peak exposure.

Other uncertainties that can change outcomes in protective level derivation are lack of knowledge about the variability within the different study populations. Some populations may differ in their sensitivity to toxic insult because of differences in genetic pre-disposition, age, gender, state of health and nutrition, or exposure to other contaminants. Another factor that may affect the toxicity of methylmercury is the simultaneous exposure to other contaminants such as polychlorinated biphenyls (PCBs) that have similar health endpoints.