

# Health Consultation

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Evaluation of Mercury Concentrations in Fish Collected From  
Turee Pond in Bow

BOW, MERRIMACK COUNTY, NEW HAMPSHIRE

**Prepared by the  
New Hampshire Department of Environmental Services**

March 3, 2010

Prepared under a Cooperative Agreement with the  
U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES  
Agency for Toxic Substances and Disease Registry  
Division of Health Assessment and Consultation  
Atlanta, Georgia 30333

## **Health Consultation: A Note of Explanation**

A health consultation is a verbal or written response from ATSDR or ATSDR's Cooperative Agreement Partners to a specific request for information about health risks related to a specific site, a chemical release, or the presence of hazardous material. In order to prevent or mitigate exposures, a consultation may lead to specific actions, such as restricting use of or replacing water supplies; intensifying environmental sampling; restricting site access; or removing the contaminated material.

In addition, consultations may recommend additional public health actions, such as conducting health surveillance activities to evaluate exposure or trends in adverse health outcomes; conducting biological indicators of exposure studies to assess exposure; and providing health education for health care providers and community members. This concludes the health consultation process for this site, unless additional information is obtained by ATSDR or ATSDR's Cooperative Agreement Partner which, in the Agency's opinion, indicates a need to revise or append the conclusions previously issued.

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HEALTH CONSULTATION

Evaluation of Mercury Concentrations in Fish Collected  
From Turee Pond in Bow

BOW, MERRIMACK COUNTY, NEW HAMPSHIRE

Prepared By:

New Hampshire Department of Environmental Services  
Environmental Health Program  
Under Cooperative Agreement with the  
Agency for Toxic Substances and Disease Registry

## Summary

<b>INTRODUCTION:</b>	The New Hampshire Department of Environmental Services (DES), Air Resources Division, Environmental Health Program (EHP) has completed this environmental data evaluation of mercury concentrations in fish collected from Turee Pond located in Bow, New Hampshire. In the State of New Hampshire, it is DES's responsibility to provide recreational fishermen with the best information available to safeguard their health and the health of their families from the potential health risks posed by mercury exposure.
<b>CONCLUSIONS &amp; BASIS FOR DECISION:</b>	<p>DES reached two conclusions about eating fish caught from Turee Pond:</p> <p>Eating largemouth bass from Turee Pond could potentially harm the health of young children (ages 1-6). Although this conclusion is based on an evaluation of fish tissue data from largemouth bass in excess of 14-inches in length, a public health hazard has been identified. Please note that the statewide mercury fish consumption advisory recommends that bass, perch and pickerel greater than 12 inches in length not be consumed. Mercury concentrations in bass from Turee Pond are also within the normal range for fish of this size (1). Specific details regarding this conclusion are outlined in the "Conclusions" Section.</p> <p>Risk Based Consumption Limits (RBCLs) were calculated for people who eat recreationally-caught yellow perch and largemouth bass from Turee Pond. If the RBCLs are followed, harmful health effects from exposure to mercury are not expected. If an individual chooses to eat these species of fish in excess of the recommended RBCL, it is possible that they could consume enough mercury for adverse health effects to develop. Residents should follow the recommendations in the statewide fish consumption advisory before consuming the Turee Pond fish species not analyzed in this document (e.g., black crappie, sunfish and brown bullhead). The statewide fish consumption advisory provides general safe eating guidelines for freshwater fish in New Hampshire with specific limits on certain fish types and sizes (2).</p>
<b>NEXT STEPS:</b>	DES will review additional fish tissue data as it becomes available and provide documents, including follow-up health consultations, if appropriate.
<b>FOR MORE INFORMATION:</b>	If you have concerns about your health, you should contact your healthcare provider. You may also call DES at 603-271-1370 to request further information regarding this health consultation or about the health effects associated with exposure to mercury from eating New Hampshire freshwater fish.

## Background

The general population is most commonly exposed to mercury from eating fish containing methylmercury in their tissues. In 2009, the DES Environmental Health Program was contacted by a concerned citizen regarding mercury exposure from fish caught in Turee Pond located in Bow, New Hampshire. To address this concern, DES assembled and analyzed the available fish samples collected from Turee Pond during the summer of 2000 and 2001. This health consultation (HC) presents a water body-specific evaluation of fish tissue samples and the related potential public health implications for local residents who may consume these fish. This scientific evaluation employs health-based benchmarks developed by the US Environmental Protection Agency (EPA).

## Pathways of Exposure

Environmental contamination cannot affect a person’s health unless there is a “completed exposure pathway.” A completed exposure pathway exists when all of the following five elements are present: 1) a source of contamination; 2) transport through an environmental medium; 3) a point of exposure; 4) a route of human exposure; and 5) a receptor population. These five elements do not define exposure; rather they contribute to determining the probability of exposure (3).

The only completed exposure pathway in this HC is the ingestion of fish contaminated with mercury. All water bodies throughout the northeastern United States are subject to mercury pollution from local, regional, and distant sources of contamination. Mercury is transported through ambient air and deposited into water bodies including Turee Pond (transport). This mercury becomes incorporated into the aquatic food chain and is ingested by fish that may be caught and consumed by people who recreationally fish (point of exposure, route of human exposure & receptor population). This is the pathway by which mercury becomes a potential human health risk (3).

People who eat recreationally-caught fish may have been exposed and may be currently exposed to the mercury from those fish. The potential for future exposures also exists. This completed exposure pathway is illustrated below.

## Pathway Analysis

Source	Environmental Transport And Media	Exposure Point	Exposure Route	Exposed Population	Time Frame	Status
Food (Fish)	Air Emissions to Turee Pond to Fish	Dinner Table	Ingestion	Recreational Fishermen	Past	Completed
					Present	Completed
					Future	Completed

## **Fish Sampling**

Turee Pond is located in the northern area of Bow, approximately 3 miles south-south-west of Concord, New Hampshire. A map showing the location of the Bow-Concord area is available in Appendix A (4).

In August 2000, DES worked in partnership with the New Hampshire Fish and Game Department (NH F&G) to collect fish samples from Turee Pond for subsequent mercury analysis. This initial fish collection effort sought to generally assess mercury levels in New Hampshire water bodies. NH F&G collected legal-sized fish mainly using electro-fishing techniques. Nine total fish samples were collected including species of eastern chain pickerel, largemouth bass, and yellow perch. All samples were subsequently analyzed by the New Hampshire Department of Health and Human Services (DHHS) Public Health Laboratory (5, 6).

A second fish collection effort was conducted in July 2001. This endeavor was part of a more focused collaboration between DES, the United States Fish and Wildlife Service (USFWS), and NH F&G to study the impact of mercury emissions near the Merrimack Station Power Plant located in Bow, NH. This 2001 initiative was prompted by modeling projections presented in the Northeast States/Canadian Provinces Mercury Study as well as research conducted by the BioDiversity Research Institute documenting levels of mercury in Loon blood and eggs. This 2001 study collected eastern chain pickerel, largemouth bass, and yellow perch tissue samples. Five of the eleven total fish samples collected in 2001 were analyzed at the USFWS contract lab (Trace Elements Research Laboratory –TERL) located at Texas A&M University. The remaining six samples were analyzed by the DHHS Public Health Laboratory (5, 6).

The mercury concentrations in the thirteen yellow perch and largemouth bass samples collected during 2000-01 were evaluated by EHP. These species were chosen because they are commonly caught and consumed by recreational anglers. Eastern chain pickerel are edible, but require a careful, specialized filleting technique to remove their many small bones. As a result, they are normally not consumed and were therefore eliminated from this analysis.

## **Fish-Specific Information**

This section provides a brief overview of the fish species that were used for RBCL calculations.

The yellow perch (*perca flavescens*) is a game fish that prefers relatively shallow waters near shore. They travel in schools and remain active during the winter; hence they are a popular target for ice fisherman. Adult perch (4-10 inches) primarily eat immature insects, larger invertebrates such as crayfish, other small fish and fish eggs (7).

The largemouth bass (*Micropterus salmoides*) is a predator game fish species that lives in warm, shallow water habitats, among reeds, waterlilies, and other vegetation. Like smallmouth bass, the species is a good indicator of persistent pollutants. Young largemouth bass feed on microscopic animals, small crustaceans such as crayfish, insects, and smaller fishes such as minnows. Adult largemouth bass will eat any available fish (including their own), crayfish, frogs, salamanders, snakes, mice, turtles and birds (8).

## **Laboratory Sample Preparation and Analyses**

The Conference of New England Governors and Eastern Canadian Premiers report *Fish Tissue Sampling and Analysis Practices in the New England States and Eastern Canadian Provincial* outlines the procedure for fish tissue preparation and analysis at the New Hampshire Department of Health and Human Services (DHHS) Public Health Laboratory. Upon submittal to the DHHS Public Health Laboratory, fish samples were identified by species, weighed and measured. Samples of skinless portions from the right side of each upper-back fillet were then digested in a Teflon vessel using nitric acid and hydrogen peroxide. Digested samples were then analyzed using a Perkin Elmer, FIMS Mercury Analyzer to measure the total mercury levels (wet weight). Fish tissue samples were analyzed in groups of ten. For each group, a method blank, a blank spike, and a sample spike were analyzed for Quality Assurance/Quality Control (QA/QC) purposes (6).

Five fish samples were collected as part of the 2001 DES, USFWS, and NH F&G initiative studying mercury emission deposition southeast of the Merrimack Station Power Plant. Each sample was analyzed by Trace Elements Research Laboratory (TERL) located at Texas A&M University. Four samples were skinless fillets, while the fifth consisted of tissue remaining on the fish after the fillets were removed (referred to as "offal"). All samples were freeze dried, homogenized to a fine powder, and then digested with a mixture of nitric acid, sulfuric acid, potassium permanganate, and potassium persulfate. Digested samples were then analyzed for mercury by cold-vapor atomic absorption. Quality control samples included method blanks, certified reference materials as well as laboratory control, duplicate, and spiked samples (9).

## **Summary of Analytical Results**

Table 1 summarizes the species, sample year, length, weight, and mercury level of the thirteen fish collected from Turee Pond including six largemouth bass and seven yellow perch. Analytical results indicated concentrations of total mercury ranging from 0.176 parts-per-million (ppm) found in a yellow perch fillet, to 0.884 ppm found in a largemouth bass fillet. Levels of mercury were generally higher in largemouth bass than in yellow perch, which most likely reflects both their larger size and the greater proportion of their diet that consists of smaller fish (5).

**Table 1. Turee Pond fish tissue sampling results (5).**

<b>Species</b>	<b>Sample Year</b>	<b>Length (inches)</b>	<b>Weight (grams)</b>	<b>Total Mercury (*ppm)</b>
Largemouth bass	2000	12.8	482	0.699 <sub>(1)</sub>
Largemouth bass	2000	13.4	482	0.862 <sub>(1)</sub>
Largemouth bass	2000	13.2	540	0.560 <sub>(1)</sub>
Largemouth bass	2001	15.2	835	0.884 <sub>(1)</sub>
Largemouth bass	2001	15.4	943	0.867 <sub>(1)</sub>
Largemouth bass	2001	15.8	992	0.797 <sub>(1)</sub>
Yellow perch	2000	9.5	162	0.287 <sub>(1)</sub>
Yellow perch	2000	9.8	180	0.659 <sub>(1)</sub>
Yellow perch	2000	9.8	174	0.646 <sub>(1)</sub>
Yellow perch	2001	8.8	143	0.217 <sub>(2)</sub>
Yellow perch	2001	8.5	132	0.176 <sub>(2)</sub>
Yellow perch	2001	9.1	143	0.381 <sub>(2)</sub>
Yellow perch	2001	8.5	127	0.275 <sub>(2)</sub>

(\*) - parts per million (ppm)

(1) - Lab analysis by the NH DHHS Public Health Laboratory

(2) - Lab analysis by Trace Elements Research Laboratory (TERL) - Texas A&M University

## Health Risk Assessment Methods

Mercury was found in the tissue of thirteen fish caught in Turee Pond. Fish plays a vital role in maintaining a healthy, well-balanced diet and is a valuable source of omega-3 fatty acids. People who eat mercury containing fish, are exposed to varying amounts of mercury (based on species, amount eaten, and the water body where the fish was caught). Using EPA methodology and protective estimates for methylmercury toxicity, DES has determined water body and species-specific eating guidelines whereby residents can safely enjoy the benefits of eating fish from Turee Pond, while protecting against the harmful effects of mercury exposure (5, 10).

The primary effect of methylmercury exposure in humans is neurotoxicity (affects the nerve cells within the brain and spinal cord). RBCLs are determined using an estimate of mercury intake from eating fish, as well as an estimate of mercury intake that may present an increased risk of adverse health effects (EPA Reference Dose or RfD). Several safety factors are incorporated into EPA RfDs to account for variability and uncertainty (1, 10, 11).

Species-specific RBCLs for three receptor groups were calculated using an estimate of mercury intake from fish consumption and an estimate of the level of mercury intake that may present an increased risk of adverse health effects. The 95<sup>th</sup> percentile upper confidence limit (UCL) of the arithmetic mean mercury concentration is defined as a value that equals or exceeds the true mean 95% of the time, and provides reasonable confidence that the true mean will not be underestimated. Calculation of UCLs was accomplished using the EPA statistical software program ProUCL version 4.0.04 (12).

Using UCL values for both largemouth bass and yellow perch, mercury-specific RBCLs for three receptor groups; women of child-bearing age, young children (ages 1-6), and other adults and children were then calculated according to EPA guidance (13). Parameters used for the RBCL calculations are described in the *Technical Background for the 2008 Update to the New Hampshire Statewide Mercury Fish Consumption Advisory*, and included an adult fish portion size of eight ounces and a child portion of three ounces (uncooked weight). These parameters are illustrated in the Appendix B calculations. For clarity, RBCLs were rounded to the closest whole meal per month (1).

The RBCLs presented in this health consultation allow for fish consumption at a rate that is expected to prevent the development of adverse health effects from exposure to mercury. If an individual chooses to eat fish in excess of the recommended RBCL, it is possible that they could consume enough mercury for adverse health effects to develop. It is not possible to predict how much mercury consumption in excess of the EPA RfD will result in the development of symptoms in any individual (1).

## Results

Analysis of the Turee Pond fish tissue data revealed that yellow perch could safely be eaten at least one time per month by all receptor groups (Table 2) (5). Largemouth bass could also be safely eaten at least one time per month by women of childbearing age and older children and adults. **DES, however, recommends that young children (ages 1-6) not consume any largemouth bass from Turee Pond.** This recommendation is based on the analysis of six largemouth bass (14+ inches in length) with a 95% UCL mercury concentration of 0.882 ppm.

According to the DES *Technical Background for the 2008 Update to the New Hampshire Statewide Mercury Fish Consumption Advisory* document, mercury concentrations in largemouth bass generally increase with length. This is because largemouth bass are a long-lived species and accumulate mercury over time from the prey they consume. For example, New Hampshire largemouth bass averaging 14-inches in length have a mean mercury level nearly twice that of fish in the 8-12 inch size range. Because DES does not have data to represent 8-12 inch largemouth bass from Turee Pond, DES is unable to definitively state whether smaller-sized largemouth bass from Turee Pond could be safely eaten by young children (1, 8).

**Table 2. Average Length , Mercury Concentration and Recommended Risk-Based Consumption Limits (RBCLs) for Turee Pond Fish (5).**

Water Body	Fish Species	Average Fish Length (inches)	95 <sup>th</sup> Percentile UCL Mercury Concentration (ppm)	Human Receptor	RBCL (meals/month)
Turee Pond	Yellow Perch	9.1	0.497 (n=7)	Women	2
				Young Children	1
				Other	6
	Largemouth Bass	14.3	0.882 (n=6)	Women	1
				Young Children	None
				Other	3

“Women” - Women of child-bearing age

n - Number of samples

“Young Children” - Children 1 to 6 years of age

“Other” – Older children and other adults

NOTE: For clarity, the calculated “Risk-Based Consumption Limits” were rounded to the nearest whole meal per month

### Limitations

This health consultation was conducted using a limited amount of largemouth bass fish tissue data. The 95<sup>th</sup> percentile UCL was, calculated using six samples instead of the minimum of eight recommended by the DES document *Technical Background for the 2008 Update to the New Hampshire statewide Mercury Fish Consumption Advisory*. The largemouth bass UCL value was higher than the calculated mean concentration (0.882 ppm vs. 0.778 ppm). Likewise, the limited number of samples for yellow perch may have lead to an overly conservative estimate. Use of the 95<sup>th</sup>% UCL value provides a protective estimate of fish tissue concentration for assessing fish consumption risk for recreational fishermen who eat the fish they catch (1, 5).

DES was unable to calculate RBCLs for some of the edible fish species available in Turee Pond (e.g., black crappie, sunfish and brown bullhead) but not represented in the data. Consequently, the risk associated with eating these species of fish remains unknown. Given these circumstances, DES suggests that anglers follow the protective recommendations outlined in the existing *New Hampshire Fish Consumption Guidelines 2009* available at:

<http://des.nh.gov/organization/commissioner/pip/factsheets/ard/documents/ard-ehp-25.pdf> (2).

The data used for this health consultation were collected a number of years ago (2000-01) (5). It is unknown whether mercury levels in Turee Pond fish have fluctuated over time, or have remained relatively static. This older data, nevertheless, represent a foundation whereby additional fish tissue samples could be added in the future. Additional samples would enable DES to more accurately ascertain risks associated with eating fish from Turee Pond, and could also facilitate analysis of size thresholds for consumption (e.g., smaller-sized largemouth bass).

## **Public Health Implications**

Fish are an excellent source of protein, minerals, and vitamins, and plays an important role in maintaining a healthy, well-balanced diet. Fish are also a valuable source of omega-3 fatty acids, which are essential for proper fetal development (14). Conversely, the general population is most commonly exposed to mercury from eating fish tissue containing methylmercury (10).

After inorganic mercury compounds are released into the environment and deposited in water and sediment (washed out of the air by precipitation & discharged to the water), microorganisms such as bacteria and fungi convert inorganic mercury to methylmercury. In aquatic environments, methylmercury subsequently accumulates in fish to levels that are many times greater than levels found in the surrounding water (10).

The primary effect of methylmercury exposure in humans is neurotoxicity (affects the nerve cells within the brain and spinal cord). Methylmercury can cause adverse effects in young children because it can interfere with critical processes in the developing brain. Methylmercury can accumulate in an unborn baby's blood, at concentrations higher than in the mother, and can be passed from a mother's breast milk to a nursing infant. Over time, the bodies of children and adults can also build-up harmful levels of methylmercury (10).

DES accounted for these sensitive populations (prospective mothers and young children) when calculating risk-based consumption limits (RBCLs). Specifically, it is considered to be protective to use the EPA RfD, or amount that is thought to be without risk of adverse health effects for risk based calculations. EPA derived its RfD from epidemiological studies of: 1) mother-infant pairs from fish-eating populations; and 2) children of mothers with higher mercury levels matched with children whose mothers had lower mercury levels. This focus was deemed as the appropriate strategy for protecting public health (11).

## **Conclusions**

DES reached two important conclusions about eating fish caught from Turee Pond:

1. The RBCLs presented in Table 2 support that residents who eat recreationally-caught fish from Turee Pond should observe the statewide fish consumption advisory. Although site specific RBCLs were calculated in this analysis, due to the limited dataset, people consuming fish from these waters should continue to follow the recommendations in the statewide fish consumption advisory. If fish are eaten within the recommended limits, harmful health effects from exposure to mercury are not expected. If an individual chooses to eat fish in excess of the recommended RBCL, it is possible that they could consume enough mercury for adverse health effects to develop.

2. DES concludes that eating **largemouth bass caught in Turee Pond** could harm the health of young children (ages 1-6). This is a public health hazard. This DES public health conclusion is based on fish tissue data from largemouth bass in excess of 14-inches in length. The statewide mercury fish consumption advisory restricts consumption of bass to fish less than 12 inches in length. Data from other New Hampshire locations show that mercury levels are typically lower in smaller-sized largemouth bass (8-10 inches in length). Therefore, it is possible that smaller largemouth bass caught in Turee Pond may be safe for limited consumption. In the absence of additional fish tissue data, however, DES is unable to make this determination.

### **Recommendations**

1. Residents can minimize their exposure while obtaining the health benefits associated with fish consumption by reducing serving sizes, the frequency of fish consumption, eating smaller-sized fish, and substituting lower mercury-containing species (e.g., panfish).
2. Tentative arrangements are underway to have local volunteer fishers collect, for DES analysis, a minimum of eight sufficiently-sized fish tissue samples from each edible species in Turee Pond. Such data will facilitate a more up-to-date, statistically-sound, and comprehensive review of the mercury levels in Turee Pond fish. As part of this effort, DES also recommends that the largemouth bass tissue samples be collected from smaller-sized fish (< 12-inches) in order to ascertain whether they may be consumed on a limited basis.

### **Public Health Action Plan**

The purpose of the Public Health Action Plan is to ensure that the current document not only identifies exposure potentials and possible health risks, but also provides a plan of action to mitigate and prevent adverse human health effects resulting from exposures to mercury in fish tissue. The first section of the Public Health Action Plan contains a description of completed and ongoing actions taken to collect fish tissue samples for subsequent mercury analysis. The second section presents a list of public health actions planned for the future.

### **Actions Completed**

1. In 2000 and 2001, DES, the United States Fish and Wildlife Service (USFWS), and NH Fish & Game Department worked collaboratively to collect fish samples from Turee Pond for subsequent mercury analysis.

### **Actions Planned**

1. DES will continue to provide health outreach and education to the community as needed. This includes disseminating this health consultation and the existing DES fish consumption advisory to the local community members and elected officials.

2. DES will review additional fish tissue data as it becomes available and provide documents, including follow-up health consultations, if appropriate.

### **Preparers of the Report**

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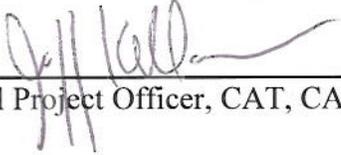
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## Certification

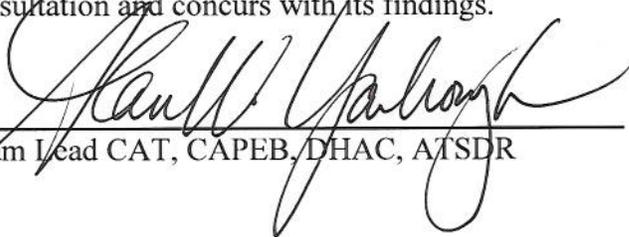
The Health Consultation evaluating fish samples from Turee Pond in Bow, New Hampshire was prepared by the New Hampshire Department of Environmental Services, Environmental Health Program, under a cooperative agreement with the federal Agency for Toxic Substances and Disease Registry (ATSDR). It is in accordance with approved methodologies and procedures existing at the time this health consultation was initiated. Editorial review was completed by the cooperative agreement partner.



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Technical Project Officer, CAT, CAPEB, DHAC, ATSDR

The Division of Health Assessment and Consultation (DHAC), ATSDR, has reviewed this health consultation and concurs with its findings.



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Team Lead CAT, CAPEB, DHAC, ATSDR

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# Appendix A



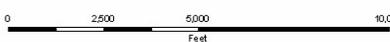
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**LEGEND**

- Town Boundaries



### Vicinity of Turee Pond Bow, New Hampshire



New Hampshire State Plane Coordinate System  
North American Datum 1983 (feet)



New Hampshire Department of Environmental Services  
Air Resources Division  
29 Hazen Drive  
P.O. Box 95  
Concord, NH 03302-0095

The coverages presented are under constant revision as new sites or facilities are added, and may not contain all potential or existing sites or facilities. NHDES is not responsible for the use or interpretation of this information by third parties. Not intended for legal purposes.

DATE PRODUCED: 12/29/2009

## APPENDIX B - Sample RBCL Calculations

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*Yellow Perch Example:*

### Other Adults & Older Children

Parameter	Abbreviation	Value	Units	Source
Toxicity Reference Dose	RfD	3.00E-04	mg/kg-day	USEPA
Body Weight	BW	70	kg	USEPA
Portion Size	PS	0.227	kg	(8 oz) - professional judgement
Concentration in Fish	C <sub>fish</sub>	0.497	mg/kg	95% UCL USEPA ProUCL output
Conversion Factor		30.42	days/month	
Maximum Allowable Consumption F	CR <sub>(limit)</sub>	0.042	kg/day	= (RfD * BW) / (C <sub>fish</sub> )
		1.28	kg/month	UCL
<b># Meals/month (UCL)</b>	<b>5.66</b>			= CR <sub>limit</sub> * (days/month) / PS

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*Largemouth Bass Example:*

### Women of Childbearing Age & Young Children (ages 1-6)

Parameter	Abbreviation	Value	Units	Source
Toxicity Reference Dose	RfD	0.0001	mg/kg-day	*USEPA
Body Weight	BW	16.6	kg	61 woman & 16.6 Child (1-6 yrs)
Portion Size	PS	0.111	kg	8 oz (0.227kg) woman & 3 oz (0.111kg) child of 1-6 yrs
Concentration in Fish	C <sub>fish</sub>	0.882	mg/kg	95% UCL USEPA ProUCL output
Conversion Factor		30.42	days/month	
Maximum Allowable Consumption F	CR <sub>(limit)</sub>	0.001882	kg/day	= (RfD * BW) / (C <sub>fish</sub> )
		0.057253	kg/month	
<b># Meals/month (UCL)</b>	<b>0.52</b>			= CR <sub>limit</sub> * (days/month) / PS

\* RfD is based on three epidemiological studies of mother-infant pairs (sensitive groups).