Health Effects of Methylmercury and North Carolina's Advice on Eating Fish

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Benefits of Eating Fish With Low Methylmercury Levels

Fish is a low fat, high protein food and contains beneficial fatty acids such as omega-3 fatty acids. Omega-3 fatty acids are important for optimal brain and nervous system development in fetuses and infants. Therefore, maternal consumption of fish low in methylmercury during pregnancy and while breast feeding can provide health benefits to the fetus and infant (Neuringer, M, Reisbick, S, and Janowsky, J 1994. The role of omega-3 fatty acids in visual and cognitive development: current evidence and methods of assessment. *J. Pediatr*. 125:S39-47; Toxicology Excellence for Risk Assessment (TERA), 1999. Comparative Dietary Risks: Balancing the Risks and Benefits of Fish Consumption. Results of a Cooperative Agreement between US. Environmental Protection Agency and Toxicology Excellence for Risk Assessment). Additionally, fish consumption has been associated with a decreased risk of heart attack and coronary artery disease in adults by reducing cholesterol and triglyceride levels as well as inhibiting platelet aggregation (Toxicology Excellence for Risk Assessment (TERA), 1999. Comparative Dietary Risks: Balancing the Risks and Benefits of Fish Consumption. Results of a Cooperative Agreement between US. Environmental Protection Agency and Toxicology Excellence for Risk Assessment). Therefore, general public consumption of fish low in methylmercury can provide some cardiovascular benefits.

Because of these health benefits, the North Carolina Division of Public Health recommends that women of childbearing age and children less than 15 years of age eat up to two meals a week of fish low in methylmercury. Fish low in methylmercury include fish that may have on average methylmercury levels between 0.1 to 0.3 (milligram per kilogram) mg/kg (see Appendix A "North Carolina's Advice on Eating Fish Fact Sheet" and Appendix C "Ocean and Freshwater fish with Low Methylmercury Levels mg/kg". The two meals per week recommendation is consistent with the US EPA and FDA advice for women of childbearing age and children (USEPA and FDA, 2004 "EPA and FDA Advice for Women Who Might Become Pregnant, Women Who Are Pregnant, Nursing Mothers, Young Children – What You Need to Know About Mercury in Fish and Shellfish" http:www.cfsan.fda.gov). The 0.3 mg/kg level is the health-protective level as defined by US EPA in their January 2001 Final *Water Quality Criterion for the Protection of Human Health : Methylmercury Report* that was prepared by the Office of Water Office of Science and Technology. As shown in the Appendix B "Methylmercury in Fish Risk Assessment" Table 1, women of childbearing age (15 to 44 years) can safely consume approximately one, two and three meals a week when the average methylmercury

levels are 0.1, 0.2 and 0.3 mg/kg, respectively. Even if women of childbearing age were to consume two meals per week when the average methylmercury levels are 0.3 mg/kg, the risk of the infant having neuropsychological effects is less than 5%. In order for the developing child to have a 5% incremental risk (above background) of having neuropsychological effects, women of childbearing age would have to consume approximately 10 meals per week of seafood with average methylmercury levels of 0.3 mg/kg. Therefore, the two meals per week recommended consumption rate is considered a safe consumption rate for women of childbearing age for when the average methylmercury levels are 0.1 to 0.3 mg/kg. In addition, North Carolina Division of Public Health also recommends that the general public eat four meals a week of fish low in methylmercury. As shown in the Appendix B "Methylmercury in Fish Risk Assessment" Table 2, the general public can safely consume approximately three to nine meals a week when the average methylmercury levels are 0.1 to 0.3 mg/kg. The four meals per week recommended consumption rate is considered a safe consumption rate for the general public when the average methylmercury levels are 0.1 to 0.3 mg/kg.

Health Effects of Eating Fish With High Methylmercury Levels

Methylmercury, an environmental pollutant, can accumulate to harmful concentrations in predatory fish (Environmental Protection Agency EPA, 1997. Summary. Vol. 1. In: Environmental Protection Agency (US). Mercury Study Report to Congress. Washington: EPA. Pub. No.EPA-452/R-97-001). Several epidemiology studies of fishing villages have been conducted to assess the impact of methylmercury exposure on the neurodevelopment of children. Results show that the developing human nervous system is particularly sensitive to methylmercury. The Seychelles Islands and Faroes Islands fishing village epidemiology studies of the 1980s and 1990s assessed the neurodevelopment of children from birth to several years old following maternal consumption of fish and/or whale meat on a routine basis during pregnancy. The Seychelles Islands study was conducted by the University of Rochester School of Medicine and Dentistry and the Faroes Islands study was conducted by the Harvard School of Public Health (NRC National Research Council. 2000. Toxicological effects of Methylmercury. Committee on the Toxicological Effects of Methylmercury, Board on environmental Studies and Toxicology, Commission on Life Sciences, National Research Council. Washington, DC: National Academy Press). The Seychelles Islands are located in the Indian Ocean near Africa and the Faroes Islands are located in the north Atlantic Ocean between Scotland and Iceland.

The Seychelles Islands study evaluated approximately 740 mother-infant pairs where the mothers consumed 12 meals per week of fish with low average levels of methylmercury of less than 0.3 mg/kg which is less than the North Carolina's fish advisory action level of 0.4 mg/kg. The mercury levels in the mothers' hair during pregnancy was on average 6.8 mg/kg (range 0.5 – 27 mg/kg). A broad range of cognitive-behavioral tests were administered to the children at approximately 6 months, 1 ½ years, 2 ½ years, 5 ½ years and 9 years. No effects were detected among the children tested at 6 months, 1 ½ years, 2 ½ years, 5 ½ years and 9 years following prenatal exposure (NRC National Research Council. 2000. Toxicological effects of Methylmercury. Committee on the Toxicological Effects of Methylmercury, Board on environmental Studies and Toxicology, Commission on Life Sciences, National Research Council. Washington, DC: National Academy Press; Myers G et al., 2003. Prenatal Methylmercury Exposure From Ocean Fish Consumption in the Seychelles Child Development Study. *The Lancet* 361, pp 1686-1692).

The Faroes Islands study evaluated approximately 700 mother-infant pairs where the mothers consumed 1-3 meals per week of fish with low average levels of methymercury of less than 0.3 mg/kg and 1 meal a month of pilot whale meat containing high average levels of methylmercury of 1 mg/kg and greater which is higher than the North Carolina's action level of 0.4 mg/kg. The average hair levels of the Faroes mothers during pregnancy was 4.3 mg/kg (range 0.2 – 39 mg/kg) which is similar to Seychelles. When children were evaluated at 7 years of age, researchers detected deficits in attention, language, and memory. A maternal hair level of 10 mg/kg, a cord blood of 58 ug/L (micrograms per liter), and a daily dose of 1 microgram per kilogram per day were found to be associated with a 10% risk of abnormalities in language, attention, and memory in children. Based on this study, monthly bolus dosing from maternal consumption of seafood with high average methylmercury levels may be associated with an increased risk to the developing child (NRC National Research Council 2000. Toxicological effects of Methylmercury. Committee on the Toxicological Effects of Methylmercury, Board on environmental Studies and Toxicology, Commission on Life Sciences, National Research Council. Washington, DC: National Academy Press). Based on the Seychelles study, the Faroes Islands study, and National Academy of Sciences review, the North Carolina Division of Public Health conservatively considers average methylmercury levels in fish tissue of 0.4 mg/kg as potentially unsafe for women of childbearing age and children.

According to the American Academy of Pediatrics, the differences in the neurological test results for the children in these studies may be due to the bolus or short-term high doses that the Faroes Islands fetuses received from maternal consumption of pilot whale meat monthly versus the chronic low doses that the Seychelles Islands fetuses received from maternal consumption of fish weekly. Additional studies are needed to further evaluate the issue of whether the bolus or high doses of methylmercury received over a short period of time by the Faroes Islands fetuses during the sensitive time periods of development are more likely to cause neurodevelopmental damage than the low doses received cumulatively by the Seychelles Islands fetuses over a period of several months. The average maternal hair levels and range of maternal hair levels for these two studies were similar but the doses were delivered differently (Goldman, L, Shanon M. 2001. Technical Report: Mercury in the Environment: Implications for Pediatricians. American Academy of Pediatrics. *Pediatrics* 108:1, pp 197-205).

In 2000 the National Academy of Sciences reviewed these studies and found the Faroes Islands study to be the study of choice to assess the 95% confidence limit of risk from consumption of fish containing methylmercury. A benchmark dose was determined to be 85 ppb methylmercury in cord blood which corresponds to a maternal methylmercury hair level of 15 mg/kg. At these blood and hair levels, there is an estimated 5% incremental risk above background of having abnormal neuropsychological test scores above background (background associated with 5% risk) or an estimated total risk of 10%. EPA determined the 95% confidence interval or the range of doses that would be expected to be associated with a total 10% risk of having abnormal scores or 5% incremental risk above background. The lowest dose of this interval was 58 ug/L in cord blood or 10 mg/kg in maternal hair and is designated as the Benchmark Dose Limit (BMDL) (NRC National Research Council 2000. Toxicological effects of Methylmercury. Committee on the Toxicological Effects of Methylmercury, Board on environmental Studies and Toxicology, Commission on Life Sciences, National Research Council. Washington, DC: National Academy Press). In 2004, US EPA determined that a fetal cord blood level of 58 ppb (ug/L) may correlate with a maternal blood level of 35 ug/L (January 2004 Update on Recent Epidemiological Mercury Studies, Dr. Kate Mahaffey, US EPA toxicologist, Presented at the 2004 EPA National Forum on Contaminants in Fish, San Diego, California). This corresponds to a maternal intake of 1.081 ug/kg-day. An uncertainty factor of 10 was applied to the 1.081 ug/kg-day to account for variability in susceptibility within the study cohort, variability in pharmacokinetic parameters for methylmercury, and lack of data on long term sequelae of in utero exposure. The resulting reference dose is 0.1 ug/kg-day or 0.0001 mg/kg-day maternal daily intake corresponding to a maternal hair level of 1.0 mg/kg, maternal blood level of 3.5 ug/L, and a fetal blood level of 5.8 ug/L.

Based on studies conducted in the Faroes Islands, researchers conclude that the deficits observed in the exposed children can be considered predictive of problems in cognitive and academic performance associated with methylmercury exposure. These deficits may reflect the way the children think, learn, and problem solve. These studies have shown the developing fetus to be at least three times more sensitive to methylmercury than adults. The 10% neurodevelopmental fetal effect maternal dose is 1.0 ug/kg-day where as the 5% neurological adult effect dose is 3 ug/kg-day. At this dose, adults would be at a 5% incremental risk above background of experiencing blurred vision as well as numbness of lips, tongue, fingers, and toes (NRC National Research Council 2000. Toxicological effects of Methylmercury. Committee on the Toxicological Effects of Methylmercury, Board on environmental Studies and Toxicology, Commission on Life Sciences, National Research Council. Washington, DC: National Academy Press).

Using the data generated from the Faroes Islands study and US EPA standardized equations and recommended doses, the North Carolina Occupational and Environmental Epidemiology Branch determined the action level for issuing fish advisories in North Carolina to be 0.4 mg/kg which is just above US EPA's recommended health-protective concentration of 0.3 mg/kg (US EPA January 2001 Final *Water Quality Criterion for the Protection of Human Health: Methylmercury* Report that was prepared by the Office of Water Office of Science and Technology). If the average methylmercury level for a given species at a given location is 0.4 mg/kg or higher then no consumption is recommended for women of childbearing age and children less than 15 years of age and no more than 1 meal a week for the general public. As shown in Appendix B Table 1, maternal consumption during pregnancy of 7 meals per week of fish containing on average 0.4 mg/kg would correlate to a 10% risk to the developing child of having neurological effects (determined by multiplying the recommended fish meals per month by safety factor of 10 used to calculate the recommended daily intake).

This type of exposure to the developing child may result in problems with the way they may think, learn, and problem solve later in life. To minimize the risks to the developing children, North Carolina Division of Pubic Health recommends that women of childbearing age and children under 15 years avoid fish with average methylmercury levels of 0.4 mg/kg and higher. The list of fish that have been reported to have high average methylmercury levels or that should be avoided by women of childbearing age and limited for the general public (other women not of childbearing age, men, and children 15 years and older) are provided in Appendix A "North Carolina's Advice on Eating Fish Fact Sheet" and Appendix D "Ocean and Freshwater fish with High Methylmercury Levels mg/kg." The average levels in these fish range from 0.4 to greater than 1 mg/kg which are similar to the levels found in the pilot whale meat of 1.0 mg/kg and greater than the Faroes women consumed on a monthly basis (NRC National Research Council. 2000. Toxicological effects of Methylmercury. Committee on the Toxicological Effects of Methylmercury, Board on environmental Studies and Toxicology, Commission on Life Sciences, National Research Council. Washington, DC: National Academy Press). As shown in the calculations in Appendix B "Methylmercury in Fish Risk Assessment" Table 2, the general public can safely consume 1 to 2 meals a week when the average methylmercury levels are 0.4 to 1 mg/kg. Based on these calculations, the recommended meal limit for the general public when the average methylmercury levels are 0.4 to 1 mg/kg is one meal per week.

Determination of Methylmercury Levels in Fish

States generally use and are encouraged by US EPA to use average methylmercury levels to represent the methylmercury level for a given species. The average methylmercury level of exposure for a given species is then converted to an average daily intake. This average daily intake can then be compared to the US EPA recommended average daily intake for risk assessment purposes. The average or mean methylmercury levels as opposed to the median or 50^{th} percentile levels are used because the average levels are influenced by the magnitude of the observations in the entire distribution, and is susceptible to being influenced by outlying observations in the distribution. The median, on the other hand, is the midpoint of the distribution and is not influenced by the magnitude of the observations in the upper and lower half of the distribution. The average or

mean reflects the most likely exposure outcome in a population. With repeated sampling, there is generally a regression to the mean and not the median. From a practical standpoint, if there is a population of fish of a given species in a waterbody, and a person samples (catches) those fish repeatedly over time, their exposure over time will be equivalent to eating a fish with the mean concentration of the contaminant in question.

North Carolina average methylmercury fish tissue levels for ocean fish and freshwater fish were used if available to determine the safety of eating these fish. Florida Atlantic, FDA, and other state methylmercury fish sampling data were evaluated to determine the safety of consuming fish for which adequate data were not available in North Carolina due to limited resources. This is a sound approach for certain fish that are considered migratory because they swim between Florida Atlantic and North Carolina Atlantic. These fish include Almaco Jack, Banded Rudderfish, Butterfish, Cobia, Crevalle Jack, Greater Amberjack, Grouper, Ladyfish, Little Tunny, Marlin, Pompano, Skate, Tripletail, Tuna (fresh/frozen), and White Grunt. According to the Division of Marine Fisheries, the average methylmercury levels for the migratory fish sampled in Florida would be expected to be similar to the average methylmercury levels for the same species sampled in North Carolina (Daniel, L 2005. Personal communication with the North Carolina Department of Environment and Natural Resources, Division of Marine Fisheries; NOAA Marine Recreational Statistics Survey website showing geographic range for ocean species http://www.st.nmfs.gov/st1/recreational/survey/ranges.html). According to the North Carolina Department of Agriculture and Consumer Services and the North Carolina Division of Marine Fisheries, North Carolina restaurants, processing plants, and markets receive ocean fish from several states, including Florida, through seafood dealers. In other words, commercial fish brought in North Carolina could have originated in other states (Woody, M 2005. Personal communication with the North Carolina Department of Agriculture and Consumer Services Food and Drug Protection Division; Orama H 2005. Personal communication with the North Carolina Division of Marine Fisheries Marine Control). According to the Florida Department of Agriculture and Consumer Services, there is no tracking system for determining the percent of Florida exports that are distributed to North Carolina and other states (2005 Personal communication with the Florida Department of Agriculture and Consumer Services).

What fish are safe to eat?

North Carolina's Advice on Eating Fish
Report Prepared by the North Carolina Division of Public Health

Most fish are good to eat and good for you—high in protein and other nutrients, and low in fat. But some kinds of fish contain high amounts of mercury, which can cause health problems in people, especially children. People should use caution in eating those fish. To help you make the healthiest choices, North Carolina offers the following advice:

	Fish Low in Mercury	Fish High in Mercury
Women of childbearing age, pregnant women, nursing mothers, and children under age 15	**Eat up to 2 meals per week**	**Do not eat**
All other people	**Eat up to 4 meals per week**	**Only 1 meal per week**

Avoid fish that are high in mercury:

Ocean fish
Almaco jack
Banded rudderfish
Canned white tuna (albacore tuna)
Cobia
Crevalle jack
Greater amberjack
South Atlantic grouper (gag, scamp, red and snowy)
King Mackerel
Ladyfish
Little tunny
Marlin
Orange roughy
Shark
Spanish mackerel
Swordfish
Tilefish
Tuna (fresh or frozen)**

Freshwater fish
Blackfish (bowfin)*
Catfish (caught wild)*
Jack fish (chain pickerel)*
Largemouth bass (statewide)
Warmouth*

Eat fish that are low in mercury:

Ocean fish
Black drum
Canned light tuna
Cod
Crab
Croaker
Flounder

Haddock
Halibut
Herring
Jacksmelt
Lobster
Mahi-mahi
Ocean perch
Oysters
Pollock
Pompano
Red drum
Salmon (canned, fresh or frozen)
Scallops
Sheepshead
Shrimp
Skate
Southern kingfish (sea mullet)
Spot
Speckled trout (spotted sea trout)
Tripletail
Whitefish
White grunt

Freshwater fish
Bluegill Sunfish
Farm-raised catfish
Farm-raised trout
Farm-raised crayfish
Tilapia
Trout

***High mercury levels have been found in Blackfish (bowfin), catfish, Jack fish (chain pickerel), and Warmouth caught south and east of Interstate 85.**

**Different species from canned tuna

For more information, contact N.C. Division of Public Health at 919.707.5900 or see www.epi.state.nc.us/epi/fish.

Appendix B. Methylmercury in Fish Risk Assessment, Prepared by Medical Evaluation and Risk Assessment Unit, Occupational and Environmental Epidemiology Branch, North Carolina Department of Health and Human Services

1. Calculated Fish Meals Per Month and Week for Women of Childbearing Age (15 to 44 years) and Children (less than 15 years)

$$CR_{mm} = \frac{CR_{lim} \times T_{ap}}{MS}$$

(Equation obtained from USEPA Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories, Volume 2, EPA 823-B-00-008 November 2000)

CR_{mm} = maximum allowable fish consumption rate (meals/month)

CR_{lim} = maximum allowable fish consumption rate (kg/day)

$$CR_{lim} = \frac{RFD \times BW}{C_m}$$

RFD = 0.0001 mg/kg-day reference dose for developing fetus and women of childbearing age

(Reference dose obtained from US EPA Water Quality Criterion for the Protection of Human Health: Methylmercury, Final. Office of Science and Technology, Office of Water, Washington, DC. EPA-823-R-01-001. January 2001.

(Reference dose of 0.0001 mg/kg-day supported by the National Academy of Sciences as referenced in the Toxicological Effects of Methylmercury, National Research Council, National Academy Press, Washington, DC 2000.)

Methylmercury, an environmental pollutant, can accumulate to harmful concentrations in predatory fish (Environmental Protection Agency EPA, 1997. Summary. Vol. 1. In: Environmental Protection Agency (US). Mercury Study Report to Congress. Washington: EPA. Pub. No.EPA-452/R-97-001). Several epidemiology studies of fishing villages have been conducted to assess the impact of methylmercury exposure on the neurodevelopment of children. Results show that the developing human nervous system is particularly sensitive to methylmercury. The Seychelles Islands and Faroes Islands fishing village epidemiology studies of the 1980s and 1990s assessed the neurodevelopment of children from birth to several years old following maternal consumption of fish and/or whale meat on a routine basis during pregnancy. The Seychelles Islands study was conducted by the University of Rochester School of Medicine and Dentistry and the Faroes Islands study was conducted by the Harvard School of Public Health (NRC National Research Council. 2000. Toxicological effects of Methylmercury. Committee on the Toxicological Effects of Methylmercury, Board on environmental Studies and Toxicology, Commission on Life Sciences, National Research Council. Washington, DC: National Academy Press). The Seychelles Islands are located in the Indian Ocean near Africa and the Faroes Islands are located in the north Atlantic Ocean between Scotland and Iceland.

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The Faroes Islands study evaluated approximately 700 mother-infant pairs where the mothers consumed 1-3 meals per week of fish with low average levels of methymercury of less than 0.3 mg/kg and 1 meal a month of pilot whale meat containing high average levels of methylmercury of 1 mg/kg and greater which is higher than the North Carolina's action level of 0.4 mg/kg. The average hair levels of the Faroes mothers during pregnancy was 4.3 mg/kg (range 0.2 – 39 mg/kg) which is similar to Seychelles. When children were evaluated at 7 years of age, researchers detected deficits in attention, language, and memory. A maternal hair level of 10 mg/kg, a cord blood of 58 ug/L (micrograms per liter), and a daily dose of 1 microgram per kilogram per day were found to be associated with a 10% risk of abnormalities in language, attention, and memory in children. Based on this study, monthly bolus dosing from maternal consumption of seafood with high average methylmercury levels may be associated with an increased risk to the developing child (NRC National Research Council 2000. Toxicological effects of Methylmercury. Committee on the Toxicological Effects of Methylmercury, Board on environmental Studies and Toxicology, Commission on Life Sciences, National Research Council. Washington, DC: National Academy Press). Based on the Seychelles study, the Faroes Islands study, and National Academy of Sciences review, the North Carolina Division of Public Health conservatively considers average methylmercury levels in fish tissue of 0.4 mg/kg as potentially unsafe for women of childbearing age and children.

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Based on studies conducted in the Faroes Islands, researchers conclude that the deficits observed in the exposed children can be considered predictive of problems in cognitive and academic performance associated with methylmercury exposure. These deficits may reflect the way the children think, learn, and problem solve. These studies have shown the developing fetus to be at least three times more sensitive to methylmercury than adults. The 10% neurodevelopmental fetal effect maternal dose is 1.0 ug/kg-day where as the 5% neurological adult effect dose is 3 ug/kg-day. At this dose, adults would be at a 5% incremental risk above background of experiencing blurred vision as well as numbness of lips, tongue, fingers, and toes (NRC National Research Council 2000. Toxicological effects of Methylmercury. Committee on the Toxicological Effects of Methylmercury, Board on environmental Studies and Toxicology, Commission on Life Sciences, National Research Council. Washington, DC: National Academy Press).

BW = consumer body weight of 67 kg for women 15 to 44 years

(Body weight obtained from USEPA Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories, Volume 2, EPA 823-B-00-008 November 2000)

C_m = average measured Methyl methylmercury (MHg) concentration of chemical contaminant *m* in a given species of fish (mg/kg)

T_{ap} = time average period (365.25 days/12 months = 30.44 days/month)

(Obtained from USEPA Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories, Volume 2, EPA 823-B-00-008 November 2000)

MS = meal size 0.170 kilograms fish/meal or 6 ounce meal size – where 6 oz x 28.35 grams (avoirdupois unit) / 1 oz = 170 g

(Obtained from USEPA Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories, Volume 2, EPA 823-B-00-008 November 2000)
(USEPA and FDA, 2004 "EPA and FDA Advice for Women Who Might Become Pregnant, Women Who Are Pregnant, Nursing Mothers, Young Children – What You Need to Know About Mercury in Fish and Shellfish" http:www.cfsan.fda.gov).

Table 1. Fish Meals Per Month and Week for Women of Childbearing Age (15 to 44 years) and Children (less than 15 years)

Fish MHg Levels (mg/kg)	Equations	**Fish Meals per month (Meals per week)**
0.1	$\frac{\text{0.0001mg/kg-day x 67 kg}}{\text{0.1 mg/kg}}$ **x 30.44 d/mos x** $\frac{\text{1 meal}}{\text{0.170 kg fish}}$	**11.99 (or 2.99 per week)**
0.2	$\frac{\text{0.0001mg/kg-day x 67 kg}}{\text{0.2 mg/kg}}$ **x 30.44 d/mos x** $\frac{\text{1 meal}}{\text{0.170 kg fish}}$	**5.99 (or 1.49 per week)**
0.3	$\frac{\text{0.0001mg/kg-day x 67 kg}}{\text{0.3 mg/kg}}$ **x 30.44 d/mos x** $\frac{\text{1 meal}}{\text{0.170 kg fish}}$	**3.99 (or 0.99 per week)**
0.4	$\frac{\text{0.0001mg/kg-day x 67 kg}}{\text{0.4 mg/kg}}$ **x 30.44 d/mos x** $\frac{\text{1 meal}}{\text{0.170 kg fish}}$	**2.99 (or 0.74 per week)**
0.5	$\frac{\text{0.0001mg/kg-day x 67 kg}}{\text{0.5 mg/kg}}$ **x 30.44 d/mos x** $\frac{\text{1 meal}}{\text{0.170 kg fish}}$	**2.39 (or 0.59 per week)**
0.6	$\frac{\text{0.0001mg/kg-day x 67 kg}}{\text{0.6 mg/kg}}$ **x 30.44 d/mos x** $\frac{\text{1 meal}}{\text{0.170 kg fish}}$	**1.99 (or 0.49 per week)**
0.7	$\frac{\text{0.0001mg/kg-day x 67 kg}}{\text{0.7 mg/kg}}$ **x 30.44 d/mos x** $\frac{\text{1 meal}}{\text{0.170 kg fish}}$	**1.71 (or 0.43 per week)**
0.8	$\frac{\text{0.0001mg/kg-day x 67 kg}}{\text{0.8 mg/kg}}$ **x 30.44 d/mos x** $\frac{\text{1 meal}}{\text{0.170 kg fish}}$	**1.49 (or 0.37 per week)**
0.9	$\frac{\text{0.0001mg/kg-day x 67 kg}}{\text{0.9 mg/kg}}$ **x 30.44 d/mos x** $\frac{\text{1 meal}}{\text{0.170 kg fish}}$	**1.33 (or 0.33 per week)**
1.0	$\frac{\text{0.0001mg/kg-day x 67 kg}}{\text{1.0 mg/kg}}$ **x 30.44 d/mos x** $\frac{\text{1 meal}}{\text{0.170 kg fish}}$	**1.19 (or 0.29 per week)**
1.5	$\frac{\text{0.0001mg/kg-day x 67 kg}}{\text{1.5 mg/kg}}$ **x 30.44 d/mos x** $\frac{\text{1 meal}}{\text{0.170 kg fish}}$	**0.79 (or 0.19 per week)**
2.0	$\frac{\text{0.0001mg/kg-day x 67 kg}}{\text{2.0 mg/kg}}$ **x 30.44 d/mos x** $\frac{\text{1 meal}}{\text{0.170 kg fish}}$	**0.59 (or 0.15 per week)**

2. Calculated Fish Meals per Month and Week for General Public (males 15 years and older and women greater than 44 years)

$$CR_{mm} = \frac{CR_{lim} \times T_{ap}}{MS}$$

(Equation obtained from USEPA Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories, Volume 2, EPA 823-B-00-008 November 2000)

CR_{mm} = maximum allowable fish consumption rate (meals/month)

CR_{lim} = maximum allowable fish consumption rate (kg/day)

$$CR_{lim} = \frac{RFD \times BW}{C_m}$$

RFD = 0.0003 mg/kg-day reference dose for general public

The reference dose of 0.0003 mg/kg-day was proposed by EPA in 1980 and is based on the methylmercury poisoning in Iraq in 1970s when seed grain was treated with methylmercury-containing fungicide and was ground into flour and consumed. According to the 1990 World Health Organization Methylmercury Criteria Document 101, 5% of adults with blood methylmercury levels of 200 ppb or 50 mg/kg hair level experienced ataxia and paresthesia. A hair level of 50 mg/kg and blood level of 200 ppb was calculated to correspond to a 5% Lowest Observed Adverse Effect Level of 0.003 mg/kg-day. An uncertainty factor of 10 was applied by EPA to adjust the Lowest Observed Adverse Effect Level of .003 mg/kg-day to what is expected to be a No Observed Adverse Effect Level of .0003 mg/kg-day. This information is referenced in the US EPA Water Quality Criterion for the Protection of Human Health: Methylmercury, Final. Office of Science and Technology, Office of Water, Washington, DC. EPA-823-R-01-001. January 2001)

The dose of 0.0003 mg/kg-day for the general public for use in fish consumption advisories is currently under review by EPA. According to the National Research Council in their latest document Toxicological Effects of Methylmercury, National Academy Press 2000 "Recent studies in adults suggest that hair Hg concentrations below 50 mg/kg are significantly associated with disturbances of the visual system (chromatic discrimination, contrast sensitivity, and peripheral fields) and with neuromotor deficits (tremor, dexterity, grip strength, complex-movement sequences, hand-eye coordination, and rapid alternating movement). Those findings suggest that the current reference dose for adults based on 50 mg/kg [mg/kg] in hair might not be sufficiently protective". Therefore, the dose used for the general public in this equation may change in the future resulting in a change in the fish meal recommendations.

BW = consumer body weight of 70 kg
(Body weight obtained from USEPA Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories, Volume 2, EPA 823-B-00-008 November 2000)

C_m = average measured Methyl methylmercury (MHg) concentration of chemical contaminant *m* in a given species of fish (mg/kg)

T_{ap} = time average period (365.25 days/12 months = 30.44 days/month)
(USEPA Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories, Volume 2, EPA 823-B-00-008 November 2000)

MS = meal size 0.170 kilograms fish/meal or 6 ounce meal size – where 6 oz x 28.35 grams (avoirdupois unit) / 1 oz = 170 g
(Obtained from USEPA Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories, Volume 2, EPA 823-B-00-008 November 2000)
(USEPA and FDA, 2004 "EPA and FDA Advice for Women Who Might Become Pregnant, Women Who Are Pregnant, Nursing Mothers, Young Children – What You Need to Know About Mercury in Fish and Shellfish" http:www.cfsan.fda.gov).

Table 2. Fish Meals per Month and Week for General Public (males 15 years and older and women greater than 44 years)

FISH MHG LEVELS (MG/KG)	EQUATIONS	FISH MEALS PER MONTH (MEALS PER WEEK)
0.1	$\frac{0.0003 \text{mg/kg-day} \times 70 \text{ kg}}{0.1 \text{ mg/kg}} \times 30.44 \text{ d/mos} \times \frac{1 \text{ meal}}{0.170 \text{ kg fish}}$	37.60 (or 9.4 per week)
0.2	$\frac{0.0003 \text{mg/kg-day} \times 70 \text{ kg}}{0.2 \text{ mg/kg}} \times 30.44 \text{ d/mos} \times \frac{1 \text{ meal}}{0.170 \text{ kg fish}}$	18.80 (or 4.70 per week)
0.3	$\frac{0.0003 \text{mg/kg-day} \times 70 \text{ kg}}{0.3 \text{ mg/kg}} \times 30.44 \text{ d/mos} \times \frac{1 \text{ meal}}{0.170 \text{ kg fish}}$	12.53 (or 3.13 per week)
0.4	$\frac{0.0003 \text{mg/kg-day} \times 70 \text{ kg}}{0.4 \text{ mg/kg}} \times 30.44 \text{ d/mos} \times \frac{1 \text{ meal}}{0.170 \text{ kg fish}}$	9.40 (or 2.35 per week)
0.5	$\frac{0.0003 \text{mg/kg-day} \times 70 \text{ kg}}{0.5 \text{ mg/kg}} \times 30.44 \text{ d/mos} \times \frac{1 \text{ meal}}{0.170 \text{ kg fish}}$	7.52 (or 1.88 per week)
0.6	$\frac{0.0003 \text{mg/kg-day} \times 70 \text{ kg}}{0.6 \text{ mg/kg}} \times 30.44 \text{ d/mos} \times \frac{1 \text{ meal}}{0.170 \text{ kg fish}}$	6.27 (or 1.57 per week)
0.7	$\frac{0.0003 \text{mg/kg-day} \times 70 \text{ kg}}{0.7 \text{ mg/kg}} \times 30.44 \text{ d/mos} \times \frac{1 \text{ meal}}{0.170 \text{ kg fish}}$	5.37 (or 1.34 per week)
0.8	$\frac{0.0003 \text{mg/kg-day} \times 70 \text{ kg}}{0.8 \text{ mg/kg}} \times 30.44 \text{ d/mos} \times \frac{1 \text{ meal}}{0.170 \text{ kg fish}}$	4.7 (or 1.18 per week)
0.9	$\frac{0.0003 \text{mg/kg-day} \times 70 \text{ kg}}{0.9 \text{ mg/kg}} \times 30.44 \text{ d/mos} \times \frac{1 \text{ meal}}{0.170 \text{ kg fish}}$	4.18 (or 1.04 per week)
1.0	$\frac{0.0003 \text{mg/kg-day} \times 70 \text{ kg}}{1.0 \text{ mg/kg}} \times 30.44 \text{ d/mos} \times \frac{1 \text{ meal}}{0.170 \text{ kg fish}}$	3.76 (or 0.94 per week)
1.5	$\frac{0.0003 \text{mg/kg-day} \times 70 \text{ kg}}{1.5 \text{ mg/kg}} \times 30.44 \text{ d/mos} \times \frac{1 \text{ meal}}{0.170 \text{ kg fish}}$	2.51 (or .63 per week)
2.0	$\frac{0.0003 \text{mg/kg-day} \times 70 \text{ kg}}{2.0 \text{ mg/kg}} \times 30.44 \text{ d/mos} \times \frac{1 \text{ meal}}{0.170 \text{ kg fish}}$	1.88 (or 0.47 per week)

Appendix C.
Ocean and Freshwater Fish with Low Methylmercury Levels mg/kg
(Average Methylmercury Levels are Below NC's Action Level of 0.4 mg/kg)

Species	Source	Average Concentration mg/kg (Number of Samples)
Ocean Fish		
Black Drum – Florida Atlantic	Florida[a]	0.14 (36 samples)
Butterfish	NMFS[b]	0.06 (89 samples)
Canned Light Tuna (different species from fresh/frozen tuna)	FDA[b]	0.12 (131 samples)
	Washington State[c]	0.057 (159 cans)
Cod	FDA[b]	0.11 (20 samples)
Crab	FDA[b]	0.06 (59 samples)
Croaker - Atlantic	FDA[b]	0.05 (21 samples)
	North Carolina[d]	0.068 (10 composites 4 fish /composite)
	Florida[a]	0.06 (21 samples)
	Florida[a]	0.06 (23 samples)
Flounder	Florida[a]	0.04 (3 samples)
	Florida[a]	0.11 (17 samples)
Haddock	FDA[b]	0.03 (4 samples)
Halibut	FDA[b]	0.26 (32 samples)
Herring	FDA[b]	0.04 (38 samples)
Jacksmelt	FDA[b]	0.11 (16 samples)
Southern Kingfish (Sea Mullet)	North Carolina[d]	0.075 (10 composites 3 fish/composite)
Lobster (spiny)	FDA[b]	0.09 (9 samples)
Mahi-mahi	FDA[e]	0.17 (3 samples)
	FDA[e]	0.188 (13 samples)
	Florida[a]	0.11 (130 samples)
	Florida[a]	0.22 (2 samples)
	Florida[a]	0.13 (16 samples)
	Florida[a]	0.12 (24 samples)
	South Carolina[f]	0.20 (32 samples)
Ocean Perch	FDA[b]	Not detected (6 samples)
Oysters	FDA[b]	Not detected (34 samples)
Pollock	FDA[b]	0.06 (37 samples)
Pompano – Florida Atlantic	Florida[a]	0.10 (51 samples)

FDA = U.S. Food and Drug Administration
NMFS = National Marine Fisheries Service

[a]Florida Fish and Wildlife Conservation Commission in the Florida Marine Research Institute Technical Report Mercury Levels in Marine and Estuarine Fishes of Florida 1989-2001 by Douglas Adams, Robert McMichael, Jr., and George Henderson at http://www.floridamarine.org/engine/download_redirection_process.asp?file=fmri%5Ftr%5F9%5F2517%2Epdf&objid=43959&dltype=publication.

[b] Mercury Levels in Commercial Fish and Shellfish US. Department of health and Human Services and U.S. Environmental Protection Agency. Available at http://www.cfsan.fda.gov/~frf/sea-mehg.html

[c]White and Light Random Canned Tuna Sampling and Analyses by Washington State Department of Health 2003. http://www.epa.gov/waterscience/fish/forum/2004/presentations/monday/vandeslice-Hg-tuna.pdf

[d]October-November 2002 NC Methylmercury Marine Fish Tissue Sample Results of Spot, Croaker, Southern Kingfish (Sea Mullet), and Speckled Trout (Spotted Seatrout). Requested by Dr. Luanne K. Williams with the North Carolina Division of Public Health. Sampled by Dr. Louis Daniel and Mr. Randy Gregory with the North Carolina Division of Marine Fisheries. Analyzed by the North Carolina Division of Water Quality. Report prepared by Mr. Mark Hale with the North Carolina Division of Water Quality.

[e]FDA Mercury in Fish: FDA Monitoring Program 1990-2003 http://www.cfsan.fda.gov/~frf/seamehg2.html.

[f]Florida Fish and Wildlife Conservation Commission Red Drum Sampling Data 1990-2003 Excel File Submitted by Dr. George Henderson January 2005.

[g]Mercury Concentrations in NC Fish Tissue Summarized by County 1990-2003. Requested by Dr. Luanne K. Williams with the North Carolina Division of Public Health. Prepared by Mr. Mark Hale with the North Carolina Division of Water Quality.
[h]Santerre, CR, Bush PB, Xu, DH et al.,2001. "Metal Residues in Farm-Raised Channel Catfish, Rainbow Trout and Red Swamp Crayfish from the Southern U.S.", *Journal of Food Science-Food Chemistry and Toxicology* 66 (2) 2001 pp. 270-273.
[I]South Carolina Atlantic Ocean Mahi Mahi Methylmercury Fish Sampling Data. Personal communication with Ms. Tracy Shelley with the South Carolina Department of Health and Environmental Control.

Appendix C Continued.
Ocean and Freshwater Fish with Low Methylmercury Levels mg/kg
(Average Methylmercury Levels are Below NC's Action Level of 0.4 mg/kg)

Species	Source	Average Concentration mg/kg or mg/kg (Number of Samples)
Ocean Fish		
Red Drum- Florida Atlantic (18-27 inches total Length)	Florida [f]	0.162 (37 samples)
Salmon (canned)	FDA[b]	Not detected (23 samples)
Salmon (fresh/frozen)	FDA[b]	0.01 (34 samples)
Scallops	NMFS[b]	0.05 (66 samples)
Shrimp	FDA[b]	Not detected (24 samples)
Speckled Trout (or Spotted Seatrout)	North Carolina[d]	0.11 (26 samples)
Sheepshead	NMFS[b]	0.13 (59 samples)
	Florida [a]	0.16 (14 samples)
Skate	NMFS[a]	0.14 (56 samples)
Spot	North Carolina[d]	0.02 (25 samples)
	Florida [a]	0.12 (21 samples)
	Florida [a]	0.04 (9 samples)
Tripletail – Florida Atlantic	Florida[a]	0.13 (74 samples)
Whitefish	FDA[b]	0.07 (25 samples)
White Grunt – Florida Atlantic	Florida[a]	0.27 (15 samples)
Freshwater Fish		
Bluegill Sunfish	North Carolina[g]	0.03 – 0.3 (range of averages reported for 54 counties out of 100 counties in NC which included 341 samples)
Farm-Raised catfish	Purdue University[h]	0.008 (89 samples from Producers)
Farm-Raised catfish	Purdue University[h]	0.008 (67 samples from Processors)
Farm-Raised Rainbow Trout	Purdue University[h]	0.009 (34 samples)
Farm-Raised Red Swamp Crayfish	Purdue University[h]	0.025 (70 samples)
Tilapia	FDA[b]	0.01 (9 samples)
Trout	FDA[b]	0.03 (17 samples)

FDA = U.S. Food and Drug Administration
NMFS = National Marine Fisheries Service

[a]Florida Fish and Wildlife Conservation Commission in the Florida Marine Research Institute Technical Report Mercury Levels in Marine and Estuarine Fishes of Florida 1989-2001 by Douglas Adams, Robert McMichael, Jr., and George Henderson at http://www.floridamarine.org/engine/download_redirection_process.asp?file=fmri%5Ftr%5F9%5F2517%2Epdf&objid=43959&dltype=publication.

[b]Mercury Levels in Commercial Fish and Shellfish US. Department of health and Human Services and U.S. Environmental Protection Agency available at http://www.cfsan.fda.gov/~frf/sea-mehg.html .

[c]White and Light Random Canned Tuna Sampling and Analyses by Washington State Department of Health 2003. http://www.epa.gov/waterscience/fish/forum/2004/presentations/monday/vandeslice-Hg-tuna.pdf

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[e]FDA Mercury in Fish: FDA Monitoring Program 1990-2003 http://www.cfsan.fda.gov/~frf/seamehg2.html.

[f]Florida Fish and Wildlife Conservation Commission Red Drum Sampling Data 1990-2003 Excel File Submitted by Dr. George Henderson January 2005.

[g]Mercury Concentrations in NC Fish Tissue Summarized by County 1990-2003. Requested by Dr. Luanne K. Williams with the North Carolina Division of Public Health. Prepared by Mr. Mark Hale with the North Carolina Division of Water Quality.

[h]Santerre, CR, Bush PB, Xu, DH et al.,2001. "Metal Residues in Farm-Raised Channel Catfish, Rainbow Trout and Red Swamp Crayfish from the Southern U.S.", *Journal of Food Science-Food Chemistry and Toxicology* 66 (2) 2001 pp. 270-273.
[l]South Carolina Atlantic Ocean Mahi Mahi Methylmercury Fish Sampling Data. Personal communication with Ms. Tracy Shelley with the South Carolina Department of Health and Environmental Control.

Appendix D Continued.
Ocean and Freshwater Fish with High Methylmercury Levels mg/kg
(Average Methylmercury Levels are At or Above NC's Action Level of 0.4 mg/kg)

Species	Source	Average Concentration mg/kg (Number of Samples)
Ocean Fish		
Almaco Jack – Florida Atlantic	Florida [a]	0.56 (17 samples)
Banded Rudderfish – Florida Atlantic	Florida [a]	0.59 (10 samples)
Canned White Tuna (Albacore)	FDA[b]	0.358 (170 samples)
	Washington State[c]	0.215 (130 cans)
Cobia – Florida Atlantic	Florida [a]	0.57 (20 samples)
	Florida [a]	1.42 (3 samples)
	Florida [a]	0.41 (2 samples)
	Florida [a]	0.76 (1 sample)
Crevalle Jack – Florida Atlantic	Florida [a]	0.53 (55 samples)
Greater Amberjack – Florida Atlantic	Florida [a]	0.59 (7 samples)
	Florida [a]	0.51 (9 samples)
	Florida [a]	0.46 (41 samples)
South Atlantic Grouper (Snowy, Gag, Red, and Scamp)	Florida [a]	0.578 (107 samples including 29 Snowy, 67 Gag, 9 Red, and 2 Scamp)
King Mackerel (avg fork length 34 inches)	North Carolina [d]	0.94 (112 samples)
King Mackerel (avg fork length 40 inches)	Georgia [d]	1.06 (20 samples)
King Mackerel (avg fork length 43 inches)	South Carolina [d]	0.89 (28 samples)
Ladyfish – Florida Atlantic	Florida [a]	0.72 (30 samples)

FDA = U.S. Food and Drug Administration
NMFS = National Marine Fisheries Service

[a]Florida Fish and Wildlife Conservation Commission in the Florida Marine Research Institute Technical Report Mercury Levels in Marine and Estuarine Fishes of Florida 1989-2001 by Douglas Adams, Robert McMichael, Jr., and George Henderson at http://www.floridamarine.org/engine/download_redirection_process.asp?file=fmri%5Ftr%5F9%5F2517%2Epdf&objid=43959&dltype=publication.

[b]Mercury Levels in Commercial Fish and Shellfish US. Department of health and Human Services and U.S. Environmental Protection Agency available at http://www.cfsan.fda.gov/~frf/sea-mehg.html.

[c]White and Light Random Canned Tuna Sampling and Analyses by Washington State Department of Health 2003 http://www.epa.gov/waterscience/fish/forum/2004/presentations/monday/vandeslice-Hg-tuna.pdf.

[d]November 1998 spanish mackerel and king mackerel caught off North Carolina, Georgia, and South Carolina Atlantic Coast. Requested by Dr. Luanne K. Williams with the North Carolina Division of Public Health, Dr. Randy Manning with Georgia Department of Natural Resources, and Ms. Tracy Shelley with South Carolina Department of Health and Environmental Control. Analyzed by North Carolina Division of Water Quality, Georgia Department of Natural Resources, and South Carolina Department of Health and Environmental Control.

[e]1991-1994 Analyses of shark caught off North Carolina Carteret County coast and shark collected from ten processing plants in North Carolina. Requested by Dr. Luanne K. Williams with the North Carolina Division of Public Health. Sampled by North Carolina Division of Marine Fisheries. Analyzed by North Carolina Division of Water Quality.

[f]Mercury Concentrations in NC Fish Tissue Summarized by County 1990-2003. Requested by Dr. Luanne K. Williams with the North Carolina Division of Public Health. Prepared by Mr. Mark Hale with the North Carolina Division of Water Quality.

Appendix D Continued.
Ocean and Freshwater Fish with High Methylmercury Levels mg/kg
(Average Methyl Mercury Levels Are At or Above NC's Action Level of 0.4mg/kg)

Species	Source	Average Concentration mg/kg (Number of Samples)
Ocean Fish		
Little Tunny – Florida Atlantic	Florida [a]	2.15 (2 samples)
	Florida [a]	0.63 (2 samples)
	Florida [a]	0.79 (6 samples)
Marlin	FDA[b]	0.49 (16 samples)
Orange Roughy	FDA[b]	0.54 (26 samples)
Shark (Dusky Shark)	North Carolina[e]	2.32 (8 samples)
Shark (Sand Tiger Shark)	North Carolina[e]	2.95 (2 samples)
Shark (Sandbar Shark)	North Carolina[e]	0.92 (29 samples)
Shark (Blacktip Shark)	North Carolina[e]	0.862 (5 samples)
Shark (Dogfish Shark)	North Carolina[e]	0.67 (3 samples)
Shark (Hammerhead Shark)	North Carolina[e]	1.44 (4 samples)
Shark (Tiger Shark)	North Carolina[e]	1.00 (6 samples)
Spanish Mackerel – NC Atlantic (average fork length 17 inches)	NC[d]	0.35 (21 samples)
Spanish Mackerel – SC Atlantic (average fork length 14 inches)	South Carolina[d]	0.2 (73 samples)
Spanish Mackerel – Fla Atlantic (average fork length 14 inches)	Florida [a]	0.32 (98 samples)
Spanish Mackerel – Fla Atlantic (average fork length 19 inches)	Florida [a]	0.39 (20 samples)

FDA = U.S. Food and Drug Administration
NMFS = National Marine Fisheries Service

[a]Florida Fish and Wildlife Conservation Commission in the Florida Marine Research Institute Technical Report Mercury Levels in Marine and Estuarine Fishes of Florida 1989-2001 by Douglas Adams, Robert McMichael, Jr., and George Henderson at http://www.floridamarine.org/engine/download_redirection_process.asp?file=fmri%5Ftr%5F9%5F2517%2Epdf&objid=43959&dltype=publication.

[b]Mercury Levels in Commercial Fish and Shellfish US. Department of health and Human Services and U.S. Environmental Protection Agency available at http://www.cfsan.fda.gov/~frf/sea-mehg.html.

[c]White and Light Random Canned Tuna Sampling and Analyses by Washington State Department of Health 2003 http://www.epa.gov/waterscience/fish/forum/2004/presentations/monday/vandeslice-Hg-tuna.pdf.

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[f]Mercury Concentrations in NC Fish Tissue Summarized by County 1990-2003. Requested by Dr. Luanne K. Williams with the North Carolina Division of Public Health. Prepared by Mr. Mark Hale with the North Carolina Division of Water Quality.

Appendix D Continued.
Ocean and Freshwater Fish with High Methylmercury Levels mg/kg
(Average Methylmercury Levels Are At or Above NC's Action Level of 0.4 mg/kg)

Species	Source	Average Concentration mg/kg (Number of Samples)
Tilefish	FDA[b]	1.45 (60 samples)
Fresh/Frozen Tuna	FDA[b]	0.38 (131 samples)
Blackfin Tuna – Florida Atlantic	Florida [a]	1.16 (22 samples)
Yellowfin Tuna – Florida Atlantic	Florida [a]	0.30 (33 samples)
Freshwater Fish		
Blackfish (bowfin)	North Carolina [f]	0.36 – 1.29 (range of averages reported for 35 counties in NC south and east of Interstate 85 which included 501 samples)
Catfish	North Carolina [f]	0.35 –1.10 (range of averages reported for 11 counties sampled south and east of Interstate 85 which included 113 samples)
Chain Pickerel (Jackfish)	North Carolina [f]	0.35 – 1.162 (range of averages reported for 21 counties in NC south and east of Interstate 85 which included 244 samples)
Largemouth Bass	North Carolina [f]	0.35 – 1.4 (range of averages reported for 35 counties across NC which included 1,014 samples)
Warmouth	North Carolina [f]	0.35 – 0.62 (range of averages reported for 12 counties south and east of Interstate 85 which included 152 samples)

FDA = U.S. Food and Drug Administration
NMFS = National Marine Fisheries Service

[a]Florida Fish and Wildlife Conservation Commission in the Florida Marine Research Institute Technical Report Mercury Levels in Marine and Estuarine Fishes of Florida 1989-2001 by Douglas Adams, Robert McMichael, Jr., and George Henderson at http://www.floridamarine.org/engine/download_redirection_process.asp?file=fmri%5Ftr%5F9%5F2517%2Epdf&objid=43959&dltype=publication.

[b]Mercury Levels in Commercial Fish and Shellfish US. Department of health and Human Services and U.S. Environmental Protection Agency available at http://www.cfsan.fda.gov/~frf/sea-mehg.html.

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