Technical Background for the 2008 Update to the New Hampshire Statewide Mercury Fish Consumption Advisory

New Hampshire Department of Environmental Services
Environmental Health Program
Air Resources Division

April 2008

NEW HAMPSHIRE DEPARTMENT OF Environmental Services

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R-ARD-08-1

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April 2008

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Acknowledgements

For their thoughtful review and valuable input to this document, appreciation is given to the staff of the New Hampshire Department of Environmental Services Environmental Health Program; Bob Estabrook, DES chief aquatic biologist; Jody Connor, limnologist and director of the Volunteer Lakes Assessment Program; Stephanie D'Agostino, Supervisor, Pollution Prevention Section; John Dreisig, toxicologist, NH Department of Health and Human Services; Michael Racine, NH Department of Fish and Game; Eric Frohmberg, toxicologist, Maine Bureau of Health; and Susannah King, New England Interstate Water Pollution Control Commission. Special thanks given to Kally Abrams for the cover photograph of Quinn Abrams with a smallmouth bass at Lake Umbagog, 2007.

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Abbreviations

BW - Body weight
CR - Consumption rate
DES – Department of Environmental Services
EPA - United States Environmental Protection Agency
kg - Kilogram
mg - Milligram
oz - Ounce
RBCL - Risk-based consumption limit
RfD - Reference dose
UCL - Upper confidence limit

1. Executive Summary

The New Hampshire statewide freshwater fish consumption advisory for mercury was established in 1994 and revised in 2001. Extensive sampling efforts have greatly increased the number of samples in the New Hampshire Fish Mercury Database. This document summarizes an analysis of the current database with regard to the fish consumption advisory for mercury and provides recommendations based on that analysis.

Summary data is presented for mercury concentrations in various species and size categories of consumable fish. Risk-based consumption limits (RBCL) are calculated to evaluate health risk in relation to fish tissue mercury levels. Mercury concentrations in consumable fish in New Hampshire are generally well below those used for the statewide advisory.

The consumption advisory update of 2001 established a restriction for consumption of bass and Eastern chain pickerel over 12 inches in length. In this update, the possible need for additional species-specific length restrictions was examined. It is now recommended that yellow perch and white perch be included with bass and pickerel for restricted consumption based on length.

In 2001 specific consumption advisories were issued for several waterbodies that had fish tissue mercury concentrations higher than the level used to establish the statewide consumption advisory. The current database was evaluated to determine the need for additional specific advisories. This analysis resulted in the recommendation of new waterbody specific advisories for Jackman Reservoir in Hillsboro, Tower Hill Pond in Candia, Dubes Pond in Hooksett and Mascoma Lake in Enfield.

In addition, this document presents an analysis of mercury concentrations in New Hampshire stocked trout. The mercury concentration of New Hampshire stocked trout is far lower than that of non-stocked species, and therefore it is recommended that stocked trout be exempt from the statewide fish consumption advisory.

2. Introduction to Fish Consumption Limit Calculations

The current statewide fish advisory recommends limiting New Hampshire freshwater fish consumption to one meal per month for sensitive populations (pregnant women and children under seven) and four meals per month for all others.

The New Hampshire freshwater fish consumption advisory is based on RBCLs, calculated according to U.S. Environmental Protection Agency guidance (EPA 2000). RBCLs are determined 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.

Evaluation of potential health risk from mercury exposure requires comparison of the exposure level with a toxicological reference dose (RfD). A RfD is an estimate of a daily oral exposure that is likely to be without any appreciable risk of adverse health effects. The EPA RfD for methylmercury was derived to be protective for the developing nervous system of the fetus and young child. The EPA RfD for methylmercury (0.0001 mg/kg-day) was used to calculate the RBCL for sensitive populations: women who are or may become pregnant, nursing women and children under age seven. A RfD of 0.0003 mg/kg-day was used to calculate RBCL for older children and other adults. This alternative RfD was accepted for use by EPA in 1985, and is based on neurological impairment in adults (EPA 2001). These RfDs are considered to be health protective with a considerable margin of safety and reflect the best available science.

Consumption limit calculations used an adult portion size of eight ounces (0.227 kg, uncooked weight). Although the RBCL for sensitive populations is calculated using the adult portion size and female body weight, it is considered to be protective for the child using a child portion size of three ounces.

The mercury consumption advisories presented in this document are established to allow for fish consumption at a rate that EPA is confident will prevent the development of adverse health effects from exposure to mercury. If an individual chooses to consume fish in excess of the recommended consumption limits, it is possible that they could consume enough mercury for adverse health effects to develop. The most sensitive adverse health effect from mercury exposure that we are aware of is on the nervous system. It is not possible to predict how much mercury consumption in excess of the RfD will result in the development of symptoms in any individual.

3. Calculation of Risk-Based Consumption Limits used for the Statewide Advisory

The statewide consumption advisory is formulated using RBCLs as presented below.

A. General Population

$$CR = RfD \times BW \div C_{fish}$$

Using the following parameters:

CR =	Maximum Allowable Consumption Rate (kg/day)
RfD =	0.0003 mg/kg-day (RfD for children over 7 years old and other adults)
BW =	70 kg Body Weight (average of adult males and females in the US population)
C_{fish}	0.70 mg/kg Concentration of mercury in fish

$$CR = 0.0003 \text{ mg mercury/kg BW-day} \times 70 \text{ kg BW} \div 0.70 \text{ mg mercury/kg fish}$$

$$CR = 0.030 \text{ kg fish/day}$$

The RBCL is the CR expressed as meals per month:

$$RBCL = CR \times \text{days per month} \div \text{portion size}$$

$$RBCL = 0.030 \text{ kg fish/day} \times 30.4 \text{ days/month} \div 0.227 \text{ kg/meal} = 4.0 \text{ meals per month.}$$

B. Sensitive Population (women of childbearing age and children)

$$CR = RfD \times BW \div C_{fish}$$

Using the following parameters:

CR =	Maximum Allowable Consumption Rate (kg/day)
RfD =	0.0001 mg/kg-day (RfD for women of childbearing age & children under 7 years old)
BW =	61 kg Body Weight (average of adult females in the US population)
C_{fish}	0.70 mg/kg Concentration of mercury in fish

$$CR = 0.0001 \text{ mg mercury/kg BW-day} \times 61 \text{ kg BW} \div 0.70 \text{ mg mercury/kg fish}$$

$$CR = 0.009 \text{ kg fish/day}$$

The RBCL is the CR expressed as meals per month:

$$RBCL = CR \times \text{days per month} \div \text{portion size}$$

$$RBCL = 0.009 \text{ kg fish/day} \times 30.4 \text{ days/month} \div 0.227 \text{ kg/meal} = 1.17 \text{ meals per month.}$$

4. New Hampshire Statewide Mercury Fish Consumption Advisory

When established in 1994, the statewide mercury fish consumption advisory was based on a limited dataset of freshwater fish caught in New Hampshire (100 samples of mixed size and species). In 1994, the average fish tissue mercury concentration was 0.28 mg/kg and the 95th percentile of the distribution of samples was 0.61 mg/kg (Dreisig and Dupee, 1994). This corresponds to 1.3 meals per month for sensitive individuals and 4.6 meals per month for other adults. For ease of communication these numbers were rounded to one meal per month for sensitive individuals and four meals per month for others. Therefore, as shown in Section 3, using the statewide recommended number of meals per month to back-calculate the corresponding fish tissue mercury concentration, the result is 0.70 mg/kg.

New Hampshire uses the 95th percentile upper confidence limit (UCL) of the arithmetic mean mercury concentration for calculation of RBCLs. Use of the 95th percentile UCL, defined as a value that equals or exceeds the true mean 95 percent of the time, provides reasonable confidence that the true average will not be underestimated. Calculation of UCLs was accomplished using the EPA statistical software program ProUCL version 4.0 (EPA 2007).

In 2001, the New Hampshire Fish Mercury Database contained approximately 1000 samples. Several waterbodies were identified as having fish with higher than average mercury concentrations in select species (Dreisig 2001). Specific advisories were issued for any waterbody with at least eight samples and a 95th percentile UCL fish tissue mercury concentration above the statewide advisory criteria. In addition, the 2001 report established an advisory to restrict consumption of bass and pickerel over 12 inches in length.

The New Hampshire Fish Mercury Database now contains over 1500 mercury determinations from more than 150 water bodies. The mercury concentration data for specific species of consumable fish are shown in Table 1. Consumable fish are only non-stocked freshwater fish that, if of specific length restricted species, are between 8 and 12 inches in length.

The statewide advisory is not species specific, however in some species mercury concentration increases with fish size. The data used to establish size-based consumption advice for specific species is presented in Section 5. For these species, only specimens between 8 and twelve inches were included for estimating consumable fish mercury concentration, as noted with an asterisk in Table 1.

Table 1. Mercury Concentration by Species (1992-2007)

Species	Number of samples	Average Length (inches)	Average Mercury (mg/kg)	95th% UCL Mercury (mg/kg)
White perch (8-12”) *	64	9	0.51	0.57
Eastern chain pickerel (8-12”) *	29	11	0.32	0.49
Smallmouth bass (8-12”) *	89	10	0.43	0.48
Black crappie	42	10	0.40	0.48
Yellow perch (8-12”) *	466	9	0.42	0.47
Cusk	22	24	0.35	0.42
Largemouth bass (8-12”) *	131	10	0.38	0.41
Rock bass	12	8	0.32	0.39
Fallfish	24	9	0.33	0.38
Bluegill	13	7	0.30	0.38
Lake trout	18	21	0.30	0.36
White sucker	55	16	0.31	0.35
Pumpkinseed	15	7	0.27	0.33
Brown bullhead	65	10	0.23	0.27
Yellow bullhead	7	9	0.54	NA
Northern pike	4	31	0.50	NA
Walleye	5	14	0.48	NA
Sunfish	5	8	0.27	NA
Alewife	3	11	0.20	NA

Notes:

* - Restricted species: because these species are higher in mercury, only fish between 8 and 12” are included in this dataset. Data obtained from the New Hampshire Fish Mercury Database, New Hampshire Department of Environmental Services Water Division, Biology Bureau. Prepared May 2007.

As can be seen in Table 1, the 95th percentile UCL mercury concentrations in consumable fish ranged from 0.27 to 0.57 mg/kg. No species of consumable fish exceeded the mercury concentration used to establish the advisory (0.70 mg/kg). Although these estimates of fish tissue mercury concentrations are lower than those used to set the advisory, the advisory will not be revised at this time for several reasons described below.

Fish tissue mercury concentrations vary in different New Hampshire waterbodies and many waterbodies have not been sampled. As described in the sections that follow, the consumption advisories that restrict fish length and place additional limits on consumption of fish from specific waterbodies, are based on a maximum allowable fish tissue mercury concentration of 0.70 mg/kg. Changing the statewide consumption limit to reflect lower fish tissue mercury concentrations would necessitate additional length restrictions and waterbody specific advisories and possibly create confusion for fish consumers. Individuals who wish to assess their own potential exposure from eating freshwater fish caught in New Hampshire are encouraged to contact DES for waterbody specific information.

5. Species Specific Mercury and Fish Length Analysis

As mentioned above, the 2001 analysis of New Hampshire fish established a length restriction for bass and Eastern chain pickerel over 12 inches in length (Dreisig 2001). The May 2007 New Hampshire Fish Mercury Database contained samples for 14 non-stocked freshwater fish species greater than 12 inches in length. Table 2 presents the summary statistics for these fish.

As can be seen in Table 2, the concentrations of mercury in yellow and white perch are similar to those in bass and pickerel, and therefore DES recommends that perch be included in the size limitation for fish greater than 12 inches.

The recommended advisory for size restricted species is for all populations to limit consumption to fish 12 inches or less in length. Using risk-based calculations and the 95th percentile mercury concentration for the species with the highest mercury concentration in fish greater than 12 inches in length (yellow perch 1.25 mg/kg), the general population could consume two meals per month. However, as will be discussed in Section 6., large specimens of fish from several New Hampshire waterbodies have been shown to have a greater than average mercury concentration. Because we do not have sufficient data to assess the large fish in every waterbody, to be health protective, it is recommended that the statewide advisory restrict all consumption of perch, bass and pickerel over 12 inches in length. Individuals are encouraged to call DES for waterbody specific information.

The data in Table 2 show that mercury concentrations were lowest in lake trout and landlocked salmon, even though these were some of the largest specimens. This has been demonstrated in other studies, and supports the theory that salmonid fish species (landlocked salmon, brook trout, lake trout) generally have lower mercury concentrations than non-salmonid species (Bank et al., 2007).

Table 2. Mercury Concentrations in Fish Greater Than 12 Inches Long (1992-2007)

Species	Number of samples	Average length (inches)	Average mercury (mg/kg)	95th% UCL mercury (mg/kg)
Yellow perch	36	13.7	0.986	1.25
Smallmouth bass	118	14.6	0.980	1.06
Largemouth bass	263	14.2	0.730	0.84
Eastern chain pickerel	147	16.7	0.670	0.73
White perch	24	14.4	0.627	0.70
Northern pike	4	30.6	0.496	NA
Walleye	5	13.7	0.480	NA
Black crappie	5	12.9	0.392	NA
Brown bullhead	12	12.9	0.362	0.45
Cusk	22	24.1	0.354	0.42
White sucker	53	16.8	0.314	0.36
Lake trout	18	21.5	0.298	0.36

Note: NA was entered for the 95th% UCL if there were less than 8 samples in the dataset. Data obtained from the New Hampshire Fish Mercury Database, New Hampshire Department of Environmental Services Water Division, Biology Bureau. Prepared May 2007.

6. Waterbody Specific Advisories

The statewide consumption advisory is issued to be protective of the sport-caught fish consumer's health throughout the state. Sufficient data has now been collected for many waterbodies to predict fish tissue concentrations within an acceptable level of certainty. DES considers a minimum of eight samples adequate to make a statistically valid estimate for fish tissue mercury in a particular water body. In order to be health protective for all potential fish consumers, only high mercury containing species were considered for this analysis. These species include black crappie, Eastern chain pickerel, largemouth bass, Northern pike, smallmouth bass, walleye, white perch, and yellow perch.

The New Hampshire Fish Mercury Database contains fish samples from 152 waterbodies, of these 149 had data for high mercury containing species between six and 12 inches. Only 36 had at least eight samples of high mercury containing species between eight and 12 inches, when fish greater than six inches were included 62 waterbodies had at least eight samples. Therefore to be comprehensive, if a waterbody did not have at least eight specimens greater than eight inches long, specimens greater than six inches were included in the calculations. Waterbodies with less than eight samples have been targeted for additional sampling.

The average mercury concentration in the high mercury containing species between eight and 12 inches was 0.42 mg/kg. Of the 62 waterbodies with at least eight samples of high mercury containing species, 20 had an average mercury concentration higher 0.42 mg/kg. Summary statistics were generated for all waterbodies with sufficient data and a higher than average mercury concentration. These data are show in Table 3. If the 95th percentile UCL for mercury concentration for consumable fish exceeds the statewide criterion of 0.70 mg/kg, a waterbody specific advisory is warranted.

Waterbody specific consumption advisories have been previously issued for bass and pickerel collected from May Pond and Ashuelot Pond in Washington, and Crystal Lake in Gilmanton. In addition, consumption advisories were established for all species collected in the Comerford and Moore Reservoirs on the Connecticut River. To normalize the consumption advice for the state, it is recommended that all species be included in all waterbody specific consumption advisories.

The 95th UCLs mercury concentrations shown in Table 3 suggest that new water body specific advisories are warranted for Jackman Reservoir in Hillsboro, Tower Hill Pond in Candia, Dubes Pond in Hooksett and Mascoma Lake in Enfield.

A perch specific advisory that allows a greater consumption than the statewide advisory was issued for the McIndoes Reservoir of the Connecticut River in 2001, to be consistent with the fish consumption advisory issued by the state of Vermont. New Hampshire does not have the resources to issue advisories on every waterbody that has below average mercury concentrations for particular fish species. Therefore, to be consistent with the rest of the state, it is recommended that the perch specific advisory for the McIndoes Reservoir be rescinded.

Table 3. Waterbody Specific Mercury Concentrations in High Mercury Consumable Fish (1992-2007)

Waterbody	Number of Samples	Average Mercury (mg/kg)	Size Category (inches)	95th % UCL Mercury (mg/kg)	Waterbody Specific Advisory?
Jackman Reservoir	11	0.85	6-12	0.99	recommended
Tower Hill Pond	9	0.79	6-12	1.01	recommended
Comerford & Moore Reservoirs (Connecticut River 15 Miles Chain)	58	0.76	8-12	0.83	established
Mascoma Lake	11	0.76	8-12	0.84	recommended
Dubes Pond	9	0.70	6-12	0.81	recommended
Ashuelot Pond	10	0.63	8-12	0.74	established
May Pond	13	0.62	8-12	0.75	established
Flints Pond	10	0.59	8-12	0.70	established
Otternick Pond	10	0.58	8-12	0.71	No
Turtle Pond	12	0.54	8-12	0.70	No
Gorham Pond	14	0.52	8-12	0.61	No
Robb Reservoir	10	0.51	6-12	0.60	No
Great Pond	11	0.49	8-12	1.28	No*
Lake Monomonac	10	0.48	8-12	0.56	No
Bearcamp Pond	8	0.44	6-12	0.58	No
Pine River Pond	10	0.44	6-12	0.51	No
Crooked Pond	8	0.44	6-12	0.64	No
Halfmoon Pond	11	0.44	8-12	0.52	No
Lakins Pond	9	0.43	6-12	0.49	No
Bellamy Reservoir	22	0.42	8-12	0.46	No

* An exception was made for Great Pond because one sample of yellow perch was unusually high in mercury concentration (2.2 mg/kg), when that sample was eliminated the 95th%UCL was 0.359.

Note: Data obtained from the NH Fish Mercury Database, New Hampshire Department of Environmental Services Water Division, Biology Bureau. Prepared May 2007

The consumption advice for waterbody specific advisories is for sensitive populations to avoid all consumption, and the general population to limit consumption to two meals per month. This is based on calculations made using the 95th percentile mercury concentration for fish from Tower Hill Pond (1.01 mg/kg), the waterbody with the highest measured mercury concentration in consumable fish.

An additional analysis explored the waterbody specific mercury concentrations in fish specimens of the length-restricted fish species (bass, pickerel and perch) that were greater than 12 inches long. Twelve waterbodies had average fish tissue mercury concentrations in these large fish specimens greater than the RBCL cut-off (0.70 mg/kg) and enough samples to conduct a statistical analysis. A summary of these 12 waterbodies is shown in Table 5. All waterbodies with specific advisories in the 2001 update to the statewide fish advisory are represented in this subset of the New Hampshire Fish Mercury Database. Although the species length and waterbody specific restrictions in the statewide advisory are protective for consumers of fish from these waters, the data demonstrate that large fish from these waterbodies have the highest fish tissue mercury concentrations measured in the state.

Table 4. Waterbody Specific Fish Mercury Concentrations in Large Specimens of Length Restricted Species (1992-2007)

Waterbody	Town	Number of samples	Average Length (inches)	Average Mercury (mg/kg)	95th% UCL
May Pond	Washington	8	16.0	1.49	1.88
Tower Hill Pond	Candia	8	15.5	1.42	1.82
Ashuelot Pond	Washington	17	16.0	1.26	1.43
Comerford & Moore Reservoirs (Connecticut River 15 Miles Chain)	Littleton/Monroe	69	15.1	0.81	1.08
Goose Pond	Canaan	19	19.6	1.14	1.3
Crystal Lake	Gilmanton	14	17.0	1.12	1.29
Pine River Pond	Wakefield	14	14.8	1.02	1.24
Highland Lake	Stoddard	11	14.9	0.82	1.35
Woodward Pond	Roxbury	11	16.0	0.80	1.21
Mcindoes Reservoir	Monroe	10	14.5	0.78	0.898
Cass Pond	Richmond	9	13.7	0.78	0.93
Long Pond	Northwood	10	14.3	0.77	0.955

Note: Data obtained from the NH Fish Mercury Database, New Hampshire Department of Environmental Services Water Division, Biology Bureau. Prepared May 2007

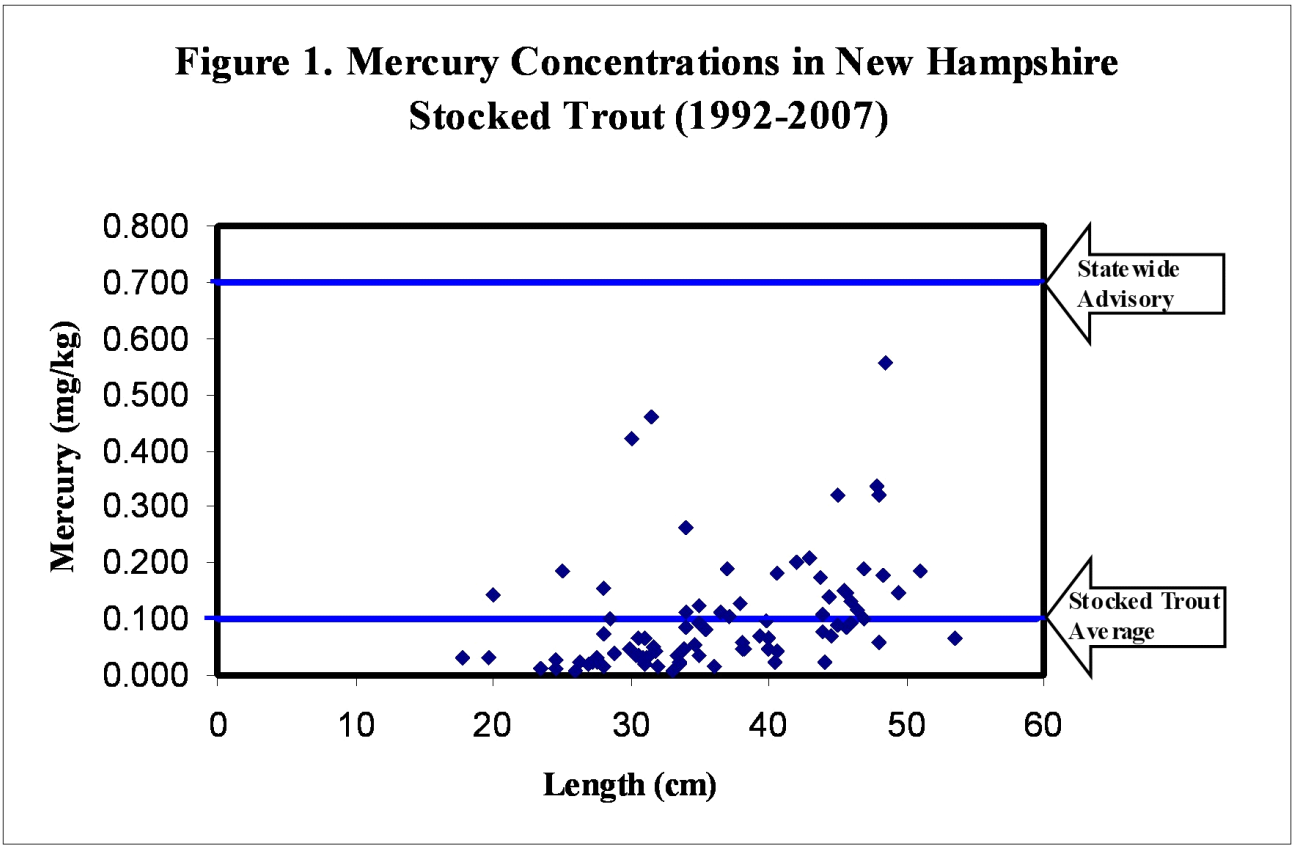
7. Stocked Trout Consumption Limits

The NH Fish and Game Department stocking program contributes over a million trout to New Hampshire waters each year. Currently, rainbow trout, brown trout and Eastern brook trout are stocked, but lake trout are not. Lake trout and Eastern brook trout are native species. Although lake trout are not stocked, brook trout could be of either stocked or native origin.

The New Hampshire Fish Mercury Database contains mercury concentration data for 88 non-native (stocked) trout samples (77 rainbow and 11 brown trout). The average mercury concentration for these two species is 0.100 mg/kg and the 95th percentile UCL is 0.118 mg/kg, far below the criteria used to set the statewide consumption advisory 0.70 mg/kg (See Figure 1).

Because the concentration of mercury in stocked trout is low, it is now recommended that stocked rainbow and brown trout can be safely consumed more frequently than the statewide advisory. As shown by the calculations in Section 8, women of childbearing age and children can safely eat up to six meals of stocked trout each month, others can eat as much as six meals per week.

As mentioned above, although some Eastern brook trout are stocked, they are a native species and have reproducing populations in some New Hampshire waters. Non-stocked brook trout may accumulate mercury similar to other non-stocked fish species. The New Hampshire Fish Mercury Database contains 29 eastern brook trout samples with a mean mercury concentration of 0.182 mg/kg and a 95th percentile UCL of 0.229 mg/kg, which is below the mean for non-stocked fish. However, DES recommends that brook trout be consumed at the rate of the general statewide advisory because it cannot be determined if any particular brook trout is of stocked or native origin.



Note: Data obtained from the NH Fish Mercury Database, New Hampshire Department of Environmental Services Water Division, Biology Bureau. Prepared May 2007.

8. Calculation of Risk-Based Consumption Limits used for Stocked Rainbow and Brown Trout

A. Sensitive Population (women of childbearing age and children)

$$CR = RfD \times BW \div C_{fish}$$

Using the following parameters:

CR=	Maximum Allowable Consumption Rate (kg/day)
RfD =	0.0001 mg/kg-day (RfD for women of childbearing age & children under 7 years old)
BW =	61 kg Body Weight (average of adult females in the US population)
C_{fish}	0.118 mg/kg Concentration in fish (95th% UCL of dataset)

CR = 0.0001 mg mercury/kg BW-day × 61 kg BW ÷ 0.118 mg mercury/kg fish

CR = 0.0.0517 kg fish/day

The maximum allowable consumption rate is expressed as meals per month by multiplying the number of days in a month (30.4) and dividing by portion size (0.227 kg).

CR = 0.0517 kg fish/day × 30.4 days/month ÷ 0.227 kg/meal = 6 meals per month.

B. General Population

$$CR = RfD * BW / C_{fish}$$

Using the following parameters:

CR =	Maximum Allowable Consumption Rate (kg/day)
RfD =	0.0003 mg/kg-day (RfD for children over 7 years old and other adults)
BW =	70 kg Body Weight (average of adult males and females in the US population)
C_{fish}	0.118 mg/kg Concentration in fish (95th% UCL of dataset)

CR = 0.0003 mg mercury / kg BW- day * 70 kg BW ÷ 0.118 mg mercury /kg fish
= 0.178 kg fish/day

The maximum allowable consumption rate is expressed as meals per month by multiplying the number of days in a month (30.4) and dividing by portion size (0.227 kg).

CR = 0.178 kg fish/day × 30.4 days/month ÷ 0.227 kg/meal = 24 meals per month or 6 meals/week.

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