NEW YORK STATE
- HUMAN HEALTH FACT SHEET -

Ambient Water Quality Value
Based on Human Consumption of Fish

SUBSTANCE: Mercury, dissolved   **CAS REGISTRY NUMBER:** Not Applicable

AMBIENT WATER QUALITY VALUE: 0.7×10^{-3} ug/L

BASIS: Bioaccumulation

INTRODUCTION

This value applies to the water column and is designed to protect humans from the effects of waterborne contaminants that may bioaccumulate in fish; it is referred to as a Health (Fish Consumption) or H(FC) value. The H(FC) value is based on three components, the toxicity of the substance to humans, the extent to which it bioaccumulates in fish, and the rate of fish consumption.

SUMMARY OF INFORMATION

A.   Toxicity

The toxicity of mercury relevant to human health is described in a separate fact sheet (NYS, 1997). That fact sheet, which supports an ambient water quality value for protection of sources of potable water, derives an acceptable daily intake (ADI) of 0.1 ug mercury/(kg · day) for nononcogenic effects.

B.   Bioaccumulation

A measurement of bioaccumulation is necessary to derive a value to protect human consumers of fish. Bioaccumulation is the process by which a substance becomes concentrated in an organism through the organism's exposure to the contaminant in food and water. Bioaccumulation is represented numerically by

a bioaccumulation factor, or BAF, which is the ratio of the concentration of a substance in the organism to that in the water column.

The term bioconcentration also describes the concentration of a substance in an organism relative to the concentration in the water column. A bioconcentration factor (BCF), however, is measured with exposure to the contaminant by water only.   A BCF may be equal to the BAF for many substances, but can substantially underestimate it for others. U.S. EPA (1995a) has promulgated, as final Federal regulations, procedures for deriving bioaccumulation factors. The procedures are believed appropriate for deriving statewide values and are being used in this fact sheet.

U.S. EPA (1995b), as part of the documentation for the Great Lakes Water Quality Initiative (GLI), presents baseline BAFs for a number of substances. For mercury, these values are presented below:

Trophic Level	Baseline BAF (L/kg)
3	27,900
4	140,000

The approach used by U.S. EPA to derive these values consists of using laboratory BCFs for inorganic and methylmercury forms of 2,998 and 52,175 L/kg respectively, a weighting of 17% methylmercury relative to other forms and Food Chain Multipliers (FCMs) of 2.52 and 12.6 for trophic levels 3 and 4 respectively. The Department has reviewed U.S. EPA's derivation, agrees with the general approach, but has concern with the value of 17% methylmercury and the expression of the criterion to include particulate mercury. The issues of the bioavailabilty of mercury and the appropriateness of 17% methylmercury for deriving a NYS Great Lakes System or a statewide value are discussed below.

Bioavailability: Total vs Dissolved

The issue of bioavailability of chemicals has been thoroughly addressed in recent years. U.S. EPA has written and acted on the issue in at least three relevant areas.

1. U.S. EPA (1993a) concluded that the dissolved form of metals best represents the bioavailable form and revised its guidance accordingly to specify standards as the dissolved form for aquatic toxicity for metals, including mercury.

2. In the development of the GLI, U.S. EPA (1995b) concluded that the freely dissolved form of organic chemicals best represents bioavailability for evaluating bioaccumulation. (Note: although criteria were derived on the

basis of dissolved BAFs, final criteria were specified as total chemicals. U.S. EPA used a partitioning relationship to convert from dissolved to particulate chemical. Unlike the criteria for metals where partitioning is determined site by site, U.S. EPA appears to conclude that a single partitioning factor for each chemical was appropriate for organic chemicals.)

3. In addressing the bioavailability of chemicals in sediment, U.S. EPA (1993b) concludes for both hydrophobic and hydrophyllic chemicals that pore water and not the total sediment concentrations correlates to mortality, growth rate and bioaccumulation.

U.S. EPA did not discuss the issue of bioavailability for the human health mercury criterion in the derivation document for the GLI. In the Supplementary Information Document for the GLI, U.S. EPA (1995c) commented that they are uncertain of bioavailability for substances where exposure occurs through the food chain. This uncertainty, expressed in the case of mercury, is greatly at odds with their writings and actions on bioaccumulation for organics. The organics for which U.S. EPA has derived bioaccumulation factors on a dissolved basis primarily include substances for which the food chain is the primary route of exposure. These substances include PCBs and DDT.

The Department agrees with U.S. EPA's writings and actions on bioavailability in the three areas described above. U.S. EPA's argument of uncertainty concerning mercury is inconsistent with its prior determinations and is rejected. The Department concludes that particulate mercury is not significantly bioavailable and that a dissolved standard better represents bioavailability. The conversion of the GLI BAF to a dissolved basis is presented below.

The basic tests U.S. EPA used to derive the mercury BAFs are laboratory tests for BCFs. These tests are generally conducted with highly soluble forms of chemical although total chemical is generally reported. For metals, to convert a laboratory test reported as total to a dissolved basis , U.S. EPA has evaluated the likely dissolved fraction occurring in the laboratory tests that were used to determine the specific criterion. For the aquatic toxicity test for mercury, U.S. EPA has used 85% dissolved. Absent specific information on the laboratory tests for the mercury BCFs and recognizing that a high dissolved fraction is likely, a division factor of 0.85 seems reasonable to convert a BCF reported as total to a dissolved basis. This adjustment will be made to compute the baseline BAF.

Percent Methylmercury

As shown above, the BCF for methylmercury is much greater than for the inorganic forms. Consequently, the fraction of mercury that is methylmercury is important to the development of a criterion for mercury that includes methyl and nonmethyl forms.

It has become apparent in recent years that the historical data base for ambient measurements of low levels of mercury is of little use because of contamination problems with sampling and measurement. So-called "clean techniques" have been developed only in recent years such that the data base to evaluate the relative amount of methylmercury in ambient waters has been limited.

In selecting 17% methylmercury for deriving the GLI criterion, U.S. EPA cited a paper by Gill and Bruland (1990). That paper presents data for a number of water bodies, mostly in California, and shows a wide variation. For the GLI, U.S. EPA appears to have selected the measurement for Lake Erie. The paper shows a value of 17% for Lake Erie for dissolved methylmercury over whole total mercury; no measurement was available for dissolved total mercury. The data for Lake Erie is a single sample collected in "mid-lake" on 8/22/87. Recent measurements in NYS, also using clean techniques, provide a much more extensive data base to determine a representative value for percent methylmercury. These data are discussed below.

Litten (1996) surveyed 11 water bodies tributary to Lake Ontario in NYS for mercury. Table 1 presents total and methylmercury for whole samples. The data consist of one or two measurements for each water body. The median methylmercury from this data set is 4.97% of total mercury. Although the data show a wide range, the variability may be attributed to analytical measurement as well as water body differences.   The value for the median, however, is likely to be a reasonable estimate of typical percent methylmercury.

PTI Environmental Services sampled Onondaga Lake and its tributaries very extensively in 1992 in conjunction with remediation efforts for historical mercury contamination. The work was funded by Allied Signal Corp. and was available to the Department on computer disk. Much or all of these data were reported by PTI (1993).

Table 2 presents total mercury and percent methylmercury for whole samples for those tributaries to Onondaga Lake that did not have known point sources of mercury. Tributaries with known point sources with mercury were excluded because these tributaries contained levels of total mercury well above a potential standard and therefore were not considered representative of conditions that would occur as

Table 1
Percent Methylmercury in Tributaries to Lake Ontario

Data From Litten (1996)				
WATER BODY	**No. of Samples**	**Total Hg ng/L**	**Methyl Hg ng/L**	**Me/Tot Hg %**
Black River at Dexter	1	0.341	0.157	46.04
Sandy Creek	1	0.351	0.117	33.33
Salmon River	1	0.533	0.117	21.95
Wine Cr. (lower)	1	5.678	0.138	2.43
Oswego R. at lock 6	2	1.08	0.137	12.69
Oswego R. at Fulton	1	2.515	0.125	4.97
Genesee R. At TP Park	2	2.677	0.122	4.56
Irondiquoit Cr.	1	2.664	0.014	0.53
Oak Orchard Cr.	1	1.753	0.033	1.88
18 Mile Cr. At Olcott Hr	2	2.449	0.012	0.49
N. Side Barge Canal	1	1.05	0.18	17.14
Arithmetic Mean		1.92	0.105	13.27
Median		1.75	0.122	4.97
Geometric Mean		1.37	0.0776	5.67

Table 2
Percent Methylmercury in Tributaries to Onondaga Lake

WATER BODY	No. of Samples	Total Hg Median ng/L	Methyl Hg Median ng/L	Me/Tot Hg %
Data from PTI (1993)				
Onondaga Creek	17	4.858	0.235	4.20
Harbor Brook	19	5.74	0.53	10.00
Ley Creek	13	6.66	0.11	2.70
Saw Mill Creek	2	5.87	0.17	5.80
Nine Mile Creek (up)	17	5.89	0.12	2.10
Seneca River	8	3.44	0.07	2.30
Arithmetic Mean		5.41	0.21	4.52
Median		5.81	0.15	3.45
Geometric Mean		5.30	0.16	3.83

the standard was achieved or of NYS waters in general. The tributaries with known contamination of inorganic mercury had lower percent methylmercury than the data set as a whole. For each water body, the Table presents the median value of all samples. Data were collected from April through November. The median value of percent methylmercury for all water bodies is 3.45 %. The range is considerably narrower than the range for data in Table 1 and likely reflects the much greater number of samples collected for the Onondaga Lake Basin study. The median values of the two data sets are in close agreement.

Very extensive data were collected from two stations at the deepest portions of the North and South parts of Onondaga Lake (Stations W1 and W2). Samples were collected from April through November at various depths and for total and dissolved forms of both total and methylmercury. Figure 1 presents percent methylmercury for both total and dissolved forms as a function of depth. The values graphed are median values for the time period and combine the results for both stations. Onondaga Lake is hypereutrophic and the thermocline in summer is at about 9 or 10 meters. The hypolimnion is anoxic and sulfidic during summer.

The values for percent methylmercury for the hypolimnion of Onondaga Lake are not considered representative of water bodies in NYS and are not useful for deriving a standard for the state as a whole or for the Great Lakes System. The value for the epilimnion, i.e., 0, 3 and 6 meters, is about 5%, which is in close agreement with the values in Tables 1 and 2. This suggests the applicability of the values in Tables 1 and 2 to slow moving water bodies with oxic conditions.

The data from Onondaga Lake are most useful in that they show no significant difference between percent methylmercury for dissolved and whole samples. This suggests that the use of percent methylmercury data from whole samples to derive a dissolved standard is sufficiently accurate.

Data were collected in 32 Adirondack lakes by Driscoll (1996) and were submitted to the Department in a summary graph. These data show a one to one relationship between percent methylmercury and dissolved organic carbon (DOC) in mg/L through a DOC concentration of about 10 mg/L under oxic conditions. Representative DOC levels in NYS are generally less than 6 mg/L such that a percent methylmercury of 6% or less seems appropriate for NYS waters. For data collected under anoxic conditions, the percent methylmercury is relatively uniform at about 17%. As discussed above, anoxic conditions are not representive of NYS waters and not appropriate for deriving a statewide standard.

Figure 1

Onondaga Lake

Total Samples - Black
Dissolved Samples - Gray

Ratio Me/Tot Hg vs Depth @W1&2
Total and Dissolved Samples
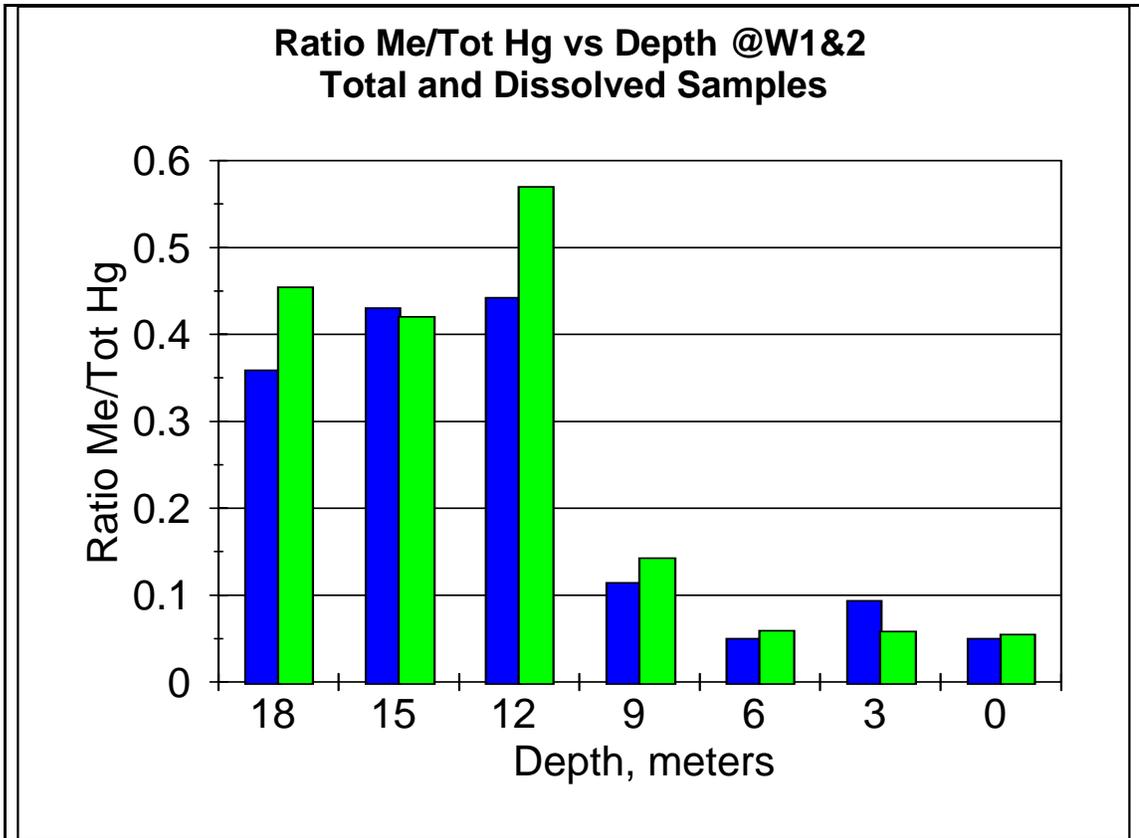
Considering primarily the data of Litten (1996) and PTI (1993), and with the support of Driscoll (1996), the Department concludes that a value of 5% methylmercury is reasonable for use in deriving a statewide standard for freshwaters in NYS.

Although no data are available for marine waters, Bloom (1995) indicates that clear lake waters and sea water will have total mercury of approximately 0.2 to 1 ng/L and methylmercury of <0.01 to 0.05, which results in a percent methylmercury of about 5%. A value of 5% therefore seems reasonable for deriving a statewide standard.

Calculation of a Statewide BAF for Dissolved Mercury

Using the approach in U.S. EPA (1995b), Appendix E, but with 5% methylmercury weighting and a dissolved basis, a BAF is calculated as follows:

The weighted average BCF is:

(0.05) 52,175 + (0.95) 2,998 = 5,457 L/kg

This BCF, which is on a reported basis of whole sample, is converted to a dissolved basis using a division factor of 0.85. The resulting BCF is 6,420 L/kg.

BAFs for trophic levels 3 and 4 are obtained using the BCF and FCMs as follows:

BAF (trophic level 3) = 6,420 (2.52) = 16,178 L/kg

BAF (trophic level 4) = 6,420 (12.6) = 80,892 L/kg

As discussed in U.S. EPA (1995b), most, but not all mercury in fish is methylmercury. It is assumed that 97.5% of mercury in fish is methylmercury and the BAFs, which were determined on a total mercury basis, are multiplied by 0.975 to achieve baseline BAFs as follows:

Trophic Level	Baseline BAFs, L/kg
3	15,774
4	78,870

DERIVATION OF WATER QUALITY VALUE

As required by 6 NYCRR 702.8(a) the water quality value must equal the acceptable daily intake from fish consumption divided by a bioaccumulation factor and by a fish consumption rate of 0.033 kg/day.

A.   **Acceptable Daily Intake From Fish Consumption**

As required by 6 NYCRR 702.8(b), the most stringent acceptable daily intake from fish consumption is 20% of the ADI for non-oncogenic effects, as determined from 6 NYCRR 702.5. The ADI for non-oncogenic effects is 0.1 ug mercury/(kg · day) from NYS (1997) as described above. The acceptable daily intake from fish consumption is:

0.2 x 0.1 ug mercury/(kg · day) = 0.02 ug mercury/(kg · day)

B.   Final BAF

The final BAF for mercury is the same as the baseline BAF. The final BAFs are 15,774 and 78,870 L/kg for trophic levels 3 and 4, respectively.

C.   Human Exposure (Fish Consumption)

6 NYCRR 702.8 requires that H(FC) values be based on a fish consumption rate of 0.033 kg/day.

D.   Calculation of Water Quality Value

The water quality value (WQV) is derived using a human body weight of 70 kg and a daily fish consumption rate of 0.033 kg as shown below. The fish consumption is apportioned as 24% trophic level 3 and 76% trophic level 4.

$$\text{WQV} = \frac{\text{Acceptable Daily Intake from Fish Consumption} \times 70 \text{ kg}}{[(\text{BAF}_{TL3})(0.24) + (\text{BAF}_{TL4})(0.76)] \times 0.033 \text{ kg/day}}$$

$$\text{WQV} = \frac{0.02 \text{ ug mercury/(kg} \cdot \text{day)} \times 70 \text{ kg}}{[(15,774 \text{ L/kg})(0.24) + (78,870 \text{ L/kg})(0.76)] \times 0.033 \text{ kg/day}}$$

$$= 0.666 \times 10^{-3} \text{ ug/L, rounded to } 0.7 \times 10^{-3} \text{ ug/L}$$

E.   Discussion

The 40 CFR Part 132 Human Health value for mercury is 1.8×10^{-3} ug/L total mercury. U.S. EPA has indicated that it will accept a value of 3.3×10^{-3} ug/L total mercury based on the more recent toxicity data that was used in the derivation of the value in this Fact Sheet. Numerically, the value of 0.7×10^{-3} ug/L derived above for NYS is about five times more stringent than the GLI value, but the GLI value includes particulate forms of mercury. The Department believes that the GLI value would be just as protective if it were expressed as dissolved and therefore believes that the much more stringent value of 0.7×10^{-3} ug/L is as protective as GLI.

Furthermore, a dissolved standard for mercury requires application of a permit by permit translation to a total effluent limitation using, wherever possible, water

body specific information on the relative forms of the metal. Although water body specific information is not currently available, a good estimate of the relative amount of particulate and dissolved forms can be made from partitioning theory. Partitioning between dissolved and particulate forms will be a function of the type and amounts of suspended solids in the water body. Hurley (1995) determined a partitioning coefficient, Log Kd, for total mercury of 4.84 (fall) and 4.91 (spring) L/kg. This coefficient results in 57% and 21% dissolved mercury for suspended solids concentrations of 10 and 50 mg/L respectively. Critical suspended solid concentrations used for calculating effluent limitations are likely to be within this range for most water bodies. Consequently, total effluent limitations calculated using a dissolved standard of 0.7×10^{-3} ug/L are anticipated to be more stringent and thus more protective than limitations calculated using the GLI criterion of 3.3×10^{-3} ug/L, total. The dissolved criterion of 0.7×10^{-3} ug/L should therefore be as protective as the GLI criterion for the purpose of calculating effluent limitations. The dissolved standard however is preferable for interpreting water quality where the suspended solids concentrations may vary considerably such as during storms or where the sediment is disturbed.

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