Georgia Department of Natural Resources (GADNR)
Environmental Protection Division (GAEPD)
Protocol for Assessing Section 305(b)/303(d) Use Support of Georgia Surface Waters Having Georgia DNR Consumption Guidelines for Fish and Shellfish Due to Presence of Mercury Residues of Concern in Edible Tissues
Application and Implementation of Interim Residue-based Mercury Criterion
Georgia Mercury Trophic-Weighted Assessment Method
October 19, 2001

Background

On January 8, 2001 the USEPA revised the methylmercury ambient water quality criterion for the protection of human health (Federal Register, Vol. 66, No. 5, pages 1344-1359). The new national water quality criterion for methylmercury is based on the tissue residue value in fish and/or shellfish, rather than the previous criterion that was for the water column concentration (*Water Quality Criterion for the Protection of Human Health: Methylmercury*, EPA-823-R-01-001, January 2001). The new methylmercury criterion is 0.3 mg/kg in edible fish tissue. It is well documented in scientific literature that over 90% of the mercury found in edible fish tissues is in the methylmercury form, and the practice of measuring residue levels as total mercury and applying to methylmercury guidance is an accepted conservative approach.

The Georgia EPD (GAEPD) notified the USEPA Region IV Water Management Division in a letter dated July 30, 2001, that the new national criterion would be applied in the future assessment of Section 305(b)/303(d) use support status on waters that have restricted consumption guidelines for mercury in fish tissue. The protocol will be used in the assessment of all Georgia waters having fish consumption guidelines for mercury in the proposed 2002 305(b)/303(d) list. The protocol uses trophic level geometric mean residue concentrations and weighting for comparison to the 0.3 mg/kg target tissue criterion, as outlined in the USEPA methylmercury criteria document. Use Partially Supported will be assessed when the calculated Trophic-Weighted Residue Value for a water body is greater than 0.3 mg/kg, but less than the USEPA recommended No Consumption value of 2 mg/kg (1.9 mg/kg, Table 4, EPA-823-F-01-011, June 2001). Waters will be assessed as Use Not Supported when the Trophic-Weighted Residue Value calculated for a water body or segment is ≥ 2 mg/kg.

Default Values from Criteria Document Used in Calculations

The USEPA default total consumption rate of 17.5 grams/day is apportioned to three different trophic levels that constitute a profile of national dietary intakes (EPA-823-R-01-001, January 2001; Chapter 7). The general trophic levels are:

- Trophic Level 2 (TL2): Planktivores, Herbivores, and/or Detritivores that include filter-feeding species such as bivalve mollusks.

- Trophic Level 3 (TL3): Mid-level Carnivores, including secondary Piscivores, with diets that are not restricted to just fish or other upper trophic level organisms. The diet typically includes lower trophic level organisms including insects and other invertebrates such as crayfish, mollusks, worms, etc (Insectivores, Invertivores).
- Trophic Level 4 (TL4): High-level carnivores that are typically top predators with diets that are primarily Piscivorous, or that include high trophic level prey.

The total consumption rate is proportionally weighted into 3 "fish intake by trophic level", (FI), consumption rates: $TL2^{(FI)}$ = 3.8 grams fish/day; $TL3^{(FI)}$ = 8.0 grams fish/day; and, $TL4^{(FI)}$ = 5.7 grams fish /day. The sum of the 3 trophic level consumption rates totals the national total consumption rate of 17.5 grams fish/day.

The weighting factor for each trophic level that is used in the assessment calculations is the percentage of fish intake (FI) represented by that level:

- $TL2^{(FI)}$: 3.8/17.5 = 0.217 = 21.7 % of average consumer dietary profile.
- $TL3^{(FI)}$: 8.0/17.5 = 0.457 = 45.7% of average consumer dietary profile.
- $TL4^{(FI)}$: 5.7/17.5 = 0.326 = 32.6% of average consumer dietary profile

If only trophic level 3 and 4 species are represented at a site or water body, and appreciable consumption of trophic level 2 species amongst the general population from that waterbody is not presumed to occur, then the weighting factors will be the calculated proportion between levels 3 and 4:

- $TL3^{(FI\ 3:3+4)}$ = 8.0/(8.0 + 5.7) = 0.584 = 58.4% (10.2 grams fish / day)
- $TL4^{(FI\ 4:3+4)}$ = 5.7/(8.0 + 5.7) = 0.416 = 41.6% (7.3 grams fish / day)

If only trophic level 2 and 3 species are represented at a site or water body, and appreciable consumption of trophic level 4 species amongst the general population from that waterbody is not presumed to occur then the weighting factors will be the calculated proportion between levels 2 and 3:

- $TL2^{(FI\ 2:2+3)}$ = 3.8/(3.8 + 8.0) = 0.322 = 32.2% (5.6 grams fish / day)
- $TL3^{(FI\ 3:2+3)}$ = 8.0/(3.8 + 8.0) = 0.678 = 67.8% (11.9 grams fish / day)

If only trophic level 2 and 4 species are represented at a site or water body, and appreciable consumption of trophic level 3 species amongst the general population from that waterbody is not presumed to occur, then the weighting factors will be the calculated proportion between levels 2 and 4:

- $TL2^{(FI\ 2:2+4)}$ = 3.8/(3.8 + 5.7) = 0.400 = 40.0% (7.0 grams fish / day)
- $TL4^{(FI\ 4:2+4)}$ = 5.7/(3.8 + 5.7) = 0.600 = 60.0% (10.5 grams fish / day)

If data are only available at a site for one trophic level, no weighting is used and the geometric mean residue concentration of that trophic level is used for the assessment.

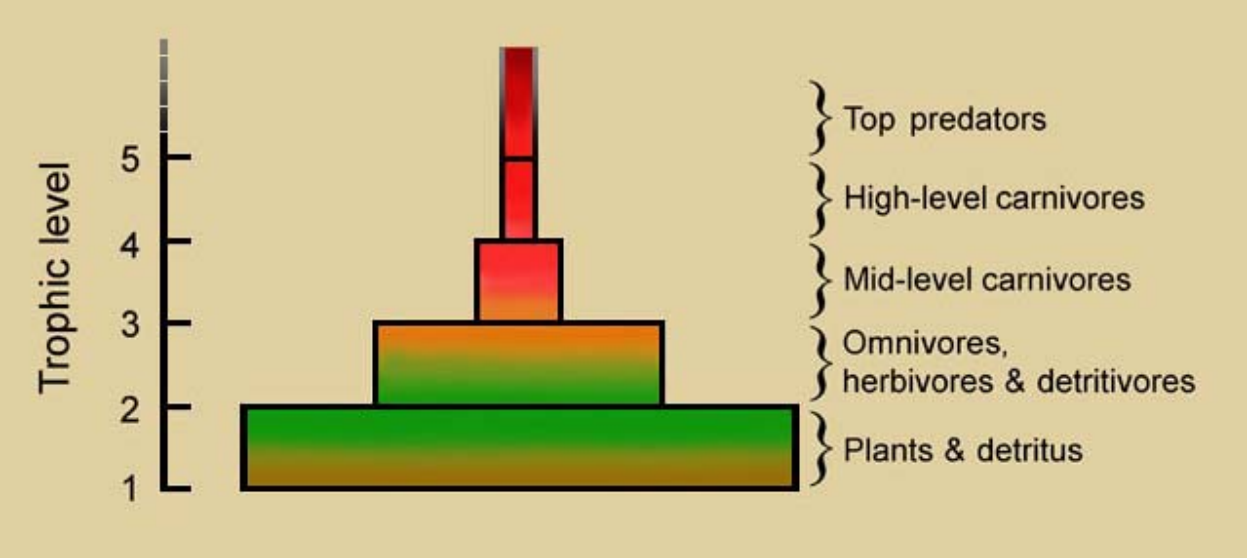
Trophic Level of Species Represented in the Georgia DNR Fish Consumption Guidance

The USEPA *Mercury Study Report to Congress, Volume III: Fate and Transport of Mercury in the Environment* (EPA-452/R-97-005, December 1997), generally described the aquatic food chain as represented by 4 trophic levels: *level 1 -- phytoplankton (algal producers); level 2 -- zooplankton (primary herbivorous consumers); level 3-- small forage fish (secondary consumers); and level 4 -- larger piscivorous fish (tertiary consumers)* (page 1-5, section 1.3). This document acknowledged that this trophic level food chain structure was simplified as it ignored several important species such as benthic detritivores, macroinvertebrates and herbivorous fish.

Determinations of the Trophic Level of many of the species represented in the Georgia DNR Fish Consumption Guidelines was aided by use of the FishBase Consortium that have databases accessible on their WebSite (www.fishbase.org). Diet information and calculated trophic level determinations are provided for many species.

The trophic level assigned in the Georgia use support assessments reflects USEPA guidance, input from Georgia Wildlife Resources Division (GAWRD) fisheries biologists, and published numbers in the FishBase databases. Table 6 provides a summary of the trophic level designation of fish collected by Georgia DNR.

Figure 1: Lindeman Trophic Pyramid (From FishBase Consortium WebSite)



Georgia DNR Fish Tissue Data Used

Updates to the *Guidelines to Eating Fish From Georgia Waters* reflect a reassessment using newer data when available. Fish tissue data used for assessing the use support status of a water body may include data from samples collected over

the last 10 years. The rational for this approach is that fluctuations in the mercury residue level in tissues may result from climatic influences (wet and dry deposition rates; flood and drought periods affecting hydrologic conditions, etc.), and physico-chemical influences that affect the methylation rate of mercury (*e.g.* low dissolved oxygen, elevated sulfide and organic carbon concentrations, and acidic pH).

The Georgia DNR analyzes fish tissue composite samples for developing the recommendations on meal frequency in the consumption guidelines. Primary assessments target a top predator species (typically largemouth bass), and a bottom feeder species (typically channel catfish). When resources allow and a significant fishery exists for other species such as sunfish, then Secondary assessments are made. Composite samples should be of one species, composed of 5 individuals of a comparable size for similarity in age class and probable exposure period (75% length rule). The 75% rule simply states that the smallest individual be within 75% of the total length of the largest individual in a composite group. Composite samples are used to minimize the analytical cost and to also obtain sufficient numbers of a species population to account for variation within a population. To minimize undue bias in the calculation of the Trophic-Weighted Residue Value, single fish tissue data will not be used on an equal basis with composite sample data.

Calculations in this protocol require some assignment of value to be applied when the mercury concentration was below the laboratory detection limit. Georgia data include detection limits ranging from 0.02 to 0.2 mg/kg for total mercury. Data sets for species at a site may be all below the detection limit, or a mix of measured values and below detection results. These data will be assigned values for use in calculation of the geometric mean trophic level concentration as follows:

- When all reported values for a species collection are below detection limit, ½ the detection limit will be used.
- When the reported values for a species are a mix of measured concentrations and values below the detection limit, the detection limit will be used for the less than detection results in the calculation.

Expression of Results: Significant Figures and Rounding Off

In Standard Methods (APHA-AWWA-WEF, 19th Edition, 1995, pp. 1-16 to 1-17), significant figures for reporting requirements are discussed as follows:

> *To avoid ambiguity in reporting results or in presenting directions for a procedure, it is the custom to use "significant figures." All digits in a reported result are expected to be known definitely, except for the last digit, which may be in doubt. Such a number is said to contain only significant figures. If more than a single doubtful digit is carried, the extra digit or digits are not significant.*

In *Practical Statistics for Analytical Chemists* (Anderson, 1987, pp. 11-15), significant figures in data to be used in calculations, and rounding off of digits are discussed as they pertain to insuring accurate values in mathematical operations.

> *For the number of significant places to use, the rule usually is stated as: For all mathematical operations (addition, subtraction, multiplication, division, and exponentiation) retain the equivalent of two more places of figures than present in the single observed value.*
>
> *No rounding of calculated values or intermediate results should be done until the final values are obtained. This will prevent the propagation of rounding errors.*

The number of significant figures in the GADNR analytical data set for mercury are typically two (0.23 or 2.3 are both values having two significant figures). Whereas analytically, the first digits (0.2 or 2), are reported at a high confidence level of accuracy, the accuracy of the second digit is understood to have a lower confidence level of accuracy. In the series of calculations done to compute the Trophic-Weighted Residue Value, three significant figures are carried through the calculations to minimize inaccuracy that could be introduced through roundoff error. The final value is rounded off at the end of the calculations, to one significant digit, in accordance with comparison with the USEPA criterion of 0.3 mg/kg.

Use of Non-GADNR Fish Tissue Data in Assessments

There are two potential ways that non-GADNR data may be used in the use support assessment made following this protocol. First, data may be reviewed for comparison against the GADNR data, but not incorporated in the calculations made to determine a water body Trophic-Weighted Residue Value. This approach would provide corroborative input to the assessment done without involving the need to validate the quality of the submitted data, or the comparability of the methods used.

Secondly, fish tissue data from a non-GADNR source may be submitted with the intent that it be utilized along with the GADNR data in calculating a water body Trophic-Weighted Residue Value. The GAEPD will consider this on a case-by-case basis, and may incorporate such data only if it can meet quality standards that insure acceptability and comparability requirements involving collection, processing and analytical quality control and assurance issues.

The USEPA Region IV has been collecting and analyzing fish tissue for mercury in support of developing Total Maximum Daily Loads (TMDLs). The USEPA is analyzing single fish fillets rather that composite samples for technical reasons and other data requirements. The GAEPD will utilize these data when they can be grouped by species and size (75% length rule), and arithmetically averaged to provide an estimated composite residue value. This approach will enhance and expand the base of data used in the calculated water body Trophic-Weighted Residue Value without unduly biasing the calculation by giving equal weight to a value typically representing 5

fish in a population with that representing a single individual. If the available USEPA data at a site includes more than one similar species of one trophic level that also meets the 75% length rule, these could be arithmetically averaged together as a mixed species group (such as mixed sunfish spp., bullhead catfish spp., or sucker spp.), to provide an estimated composite residue value.

To demonstrate how this would work, a sample data set of the USEPA was obtained from the *Proposed: Total Maximum Daily Load for Total Mercury Big Haynes Reservoir, GA, August 30, 2001*, (currently on Public Notice for comments). The following data appeared as *Table 4* in the proposed TMDL.

USEPA Region 4 Fish Tissue Data, Big Haynes Reservoir (Collected March/April 2001)

Station	Waterbody	Trophic Level	Species	Total Length (mm)	Whole Wt (gm)	Filet Wt (gm)	THg (mg/kg) Wet Weight
BHL	Big Haynes Reservoir	4	Largemouth Bass	335	523	223	0.57
BHL	Big Haynes Reservoir	4	Largemouth Bass	350	527	209	0.55
BHL	Big Haynes Reservoir	4	Largemouth Bass	315	384	143	0.63
BHL	Big Haynes Reservoir	4	Largemouth Bass	310	326	129	0.19
BHL	Big Haynes Reservoir	4	Largemouth Bass	288	286	108	0.14
BHL	Big Haynes Reservoir	3	Brown Bullhead	349	581	141	0.079
BHL	Big Haynes Reservoir	3	Brown Bullhead	361	673	148	0.088
BHL	Big Haynes Reservoir	3	Bluegill	168	87	33	0.14
BHL	Big Haynes Reservoir	3	Bluegill	168	85	33	0.094
BHL	Big Haynes Reservoir	3	Redear Sunfish	191	121	48	0.062
BHL	Big Haynes Reservoir	3 *	Longnose Gar *	149	55	21	No data provided

* The Longnose Gar, *Lepisosteus osseus*, is a predator with a diet consisting of fish and crustaceans. FishBase Trophic Level listed as 3.8. If data from this species is used by Georgia, this species will be designated as Trophic Level 4.

Three estimated composite residue values can be obtained from these data that meet the 75% rule on length (shaded area): one composite of 5 largemouth bass; one composite of 2 brown bullhead; and one composite of 2 bluegill. The estimated total mercury residue concentration would be: largemouth bass = 0.416 mg/kg; brown bullhead = 0.084 mg/kg; and bluegill = 0.117 mg/kg. These data are incorporated with the GADNR fish tissue data from this site in Example 5.

Calculation of a Water Body Trophic-Weighted Mercury Residue Value

The calculation of a water body Trophic-Weighted Residue Value for determining the use support status will involve several steps. These are:

1. Sorting of species data into Trophic Level 2, 3 or 4.
2. Calculation of the geometric mean concentration in each of the Trophic Levels.
3. Multiplication of each Trophic Level group geometric mean concentration, by the fish intake trophic consumption rate weighting factor ($TLn^{(FI)}$), for weighting.
4. Summation of all weighted trophic level concentrations, for the water body Trophic-Weighted Residue Value.
5. Evaluation of use support status:
   Partial Support: 0.3 mg/kg **>** Trophic-Weighted Residue Value (Sum) < 2 mg/kg
   Not Support: Trophic-Weighted Residue Value (Sum) ≥ 2 mg/kg

Example Calculations and Use Support Assessments Using Georgia and USEPA Data

Several examples of the calculations used in assessing the use support status of Georgia waters using this protocol are provided in the following pages. The data used in Examples 1-4 are GADNR data used in developing the meal frequency recommendations in the *2001 Update, Guidelines for Eating Fish From Georgia Waters*. Example 5 is an assessment done using both GADNR and USEPA fish tissue data.

EXAMPLE 1: Lake Acworth; Coosa River Basin

Table 1: Steps 1 and 2: Sorting By Trophic Level and Calculation of Geometric Means

YEAR	SPECIES	SIZE CATEGORY	SAMPLE #	N PER COMPOSITE	SIZE	Hg mg/kg	Trophic' Level	Trophic Level Geometric Mean mg/kg
1997	**Largemouth Bass**	12"-16"	PS470	5	14.7	0.14	4	
			PS471	5	12.5	0.14	4	
				Arithmetic Average	13.6	0.14		
		>16"	PS469	5	16.8	0.26	4	
				Arithmetic Average	16.8	0.26		0.172
1997	**Bluegill**	<12"	PS472	5	5.9	0.04	3	
			PS473	5	5.4	0.06	3	
			PS474	5	4.8	0.05	3	0.049

Steps 3 and 4: Multiplication of Trophic Level Geometric Mean Concentration by fish intake weighting factors (when only Trophic Levels 3 and 4 in database) and summation of these results:

Trophic 3 Weighting = 0.584(0.049) = 0.029
Trophic 4 Weighting = 0.416(0.172) = 0.072
Trophic-Weighted Residue Value (Sum) = 0.1

Step 5: Evaluation of Support Status: Supporting Uses

EXAMPLE 2: Lake Tugalo; Savannah River Basin

Table 2: Step 1: Sorting Data by Trophic Level

YEAR	SPECIES	SIZE CATEGORY	SAMPLE #	N PER COMPOSITE	SIZE (IN.)	Hg mg/kg	Trophic Level
1992	**Largemouth Bass**	12"-16"	PS365	5	14.9	0.20	4
			PS366	5	12.0	0.18	4
			Arithmetic Average		13.5	0.19	
		>16"	PS364	5	19.3	0.22	4
			Arithmetic Average		19.3	0.22	
1992	**White Catfish**	12"-16"	PS367	5	13.6	0.06	3
			PS368	5	13.5	0.10	3
			PS369	5	13.3	0.07	3
			Arithmetic Average		13.5	0.08	
1996	**Largemouth Bass**	<12"	AB54964	4	11.9	0.53	4
			Arithmetic Average		11.9	0.53	
		12"-16"	AB54955	3	15.6	0.78	4
			AB54963	5	12.9	0.51	4
			Arithmetic Average		14.3	0.65	
1996	**White Catfish**	12"-16"	AB54952	5	14.8	0.20	3
			AB54953	5	12.8	0.22	3
			AB54954	5	12.2	0.13	3
			Arithmetic Average		13.3	0.18	
1997	**Bluegill**	<12"	AC19581	5	9.0	0.10	3
			AC19582	5	7.9	0.14	3
			AC19583	5	7.3	0.13	3
			Arithmetic Average		8.1	0.12	
1998	**Largemouth Bass**	12"-16"	AC58172	5	15.7	1.10	4
			AC58173	5	12.5	0.73	4
			AC58174	5	13.0	1.20	4
			AC58175	5	13.8	0.96	4
			Arithmetic Average		13.8	1.00	
		>16"	AC58170	5	19.5	1.40	4
			AC58171	5	16.9	0.96	4
			Arithmetic Average		18.2	1.18	

Step 2: Calculation of Trophic Level Geometric Means:

Trophic Level 3 Geometric Mean = 0.118 mg/kg

Trophic Level 4 Geometric Mean = 0.598 mg/kg

Steps 3 and 4: Multiplication of Trophic Level Geometric Mean Concentration by intake weighting factors (when only Trophic Levels 3 and 4 in database) and summation:

Trophic 3 Weighting = 0.584(0.118) = 0.069

Trophic 4 Weighting = 0.416(0.598) = 0.249

Trophic-Weighted Residue Value (Sum) = 0.3

Step 5: Evaluation of Support Status: Supporting Uses.

EXAMPLE 3: Little River Above And Below Rocky Creek; Savannah River Basin

Table 3: Steps 1 and 2: Sorting By Trophic Level and Calculation of Geometric Means

YEAR	SPECIES	SAMPLE #	N PER COMPOSITE	SIZE	Hg mg/kg	TROPHIC LEVEL	TROPHIC LEVEL GEOMETRIC MEAN mg/kg
		Above Rocky Creek					
1996	**Largemouth Bass**	AB49382	5	14.4	0.38	4	
		AB49384	5	12.7	0.18	4	
		AB49387	5	16.0	0.30	4	
		Arithmetic Average		14.4	0.29		0.274
1996	**Silver Redhorse**	AB49416	5	16.4	< 0.10 (0.05)	3	
		AB49421	5	10.0	<0.10 (0.05)	3	
		Arithmetic Average		13.2			0.05
		Below Rocky Creek					
1996	**Largemouth Bass**	AB49388	5	11.8	0.21	4	
		AB49389	5	12.9	0.26	4	
		AB49392	5	15.2	0.34	4	
		Arithmetic Average		13.3	0.27		0.265
1996	**Spotted Sucker**	AB49419	5	14.6	<0.10 (0.1)	3	
		AB49420	5	17.5	0.29	3	
		AB49424	5	13.0	<0.10 (0.1)	3	
		AB49425	5	17.4	0.11	3	
		Arithmetic Average		15.6	0.15		0.134

Steps 3 and 4: Multiplication of Trophic Level Geometric Mean Concentration by intake weighting factors (when only Trophic Levels 3 and 4 in database) and summation:

Above Rocky Creek:

Trophic 3 Weighting = 0.584(0.05) = 0.029
Trophic 4 Weighting = 0.416(0.274) = 0.114
Trophic-Weighted Residue Value (Sum) = 0.1

Below Rocky Creek:

Trophic 3 Weighting = 0.584(0.134) = 0.078
Trophic 4 Weighting = 0.416(0.265) = 0.110
Trophic-Weighted Residue Value (Sum) = 0.2

Step 5: Evaluation of Support Status: Supporting Uses.

EXAMPLE 4: Talking Rock Creek; Coosa River Basin

Table 4: Steps 1 and 2: Sorting By Trophic Level and Calculation of Geometric Means

YEAR	SPECIES	SAMPLE #	N PER COMPOSITE	SIZE	Hg mg/kg	Trophic Level	Trophic Level Geometric Mean mg/kg
1996	**Redeye Bass**	AB48896	5	9.8	0.51	4	
		AB48897	5	8.4	0.36	4	
		AB48898	5	7.2	0.29	4	
		Arithmetic Average		8.5	0.39		0.376

Steps 3 and 4: Multiplication of Trophic Level Geometric Mean Concentration by fish intake weighting factors and summation of these results: These steps are not applicable as only one trophic level represented at this site and no weighting is necessary.

Step 5: Evaluation of Support Status: Partially Supporting Uses.

EXAMPLE 5: Big Haynes Reservoir; Ocmulgee River Basin
GADNR and USEPA Fish Tissue Data

Table 5: Steps 1 and 2: Sorting By Trophic Level and Calculation of Geometric Means

YEAR	SOURCE	SPECIES	SIZE CATEGORY	SAMPLE #	N PER COMPOSITE	SIZE	Hg mg/kg	Trophic Level	Trophic Level Geometric Mean mg/kg
1997	GADNR	Largemouth Bass	<12"	AC01959	5	11.2	0.82	4	
				Arithmetic Average		11.2	0.82		
			12"-16"	AC01957	5	15.1	0.79	4	
				AC01958	5	13.5	0.79	4	
				Arithmetic Average		14.3	0.79		
2001	USEPA	Largemouth Bass	12"-16"		5	12.6	0.416	4	0.679
1997	GADNR	Channel Catfish	<12"	AC01961	5	11.5	0.15	3	
				AC01962	4	9.7	0.19	3	
				Arithmetic Average		10.6	0.17		
			12"-16"	AC01960	5	13.7	0.49	3	
				Arithmetic Average		13.7	0.49		
2001	USEPA	Brown Bullhead	12"-16"		2	14.0	0.084	3	
2001	USEPA	Bluegill Sunfish	<12"		2	6.6	0.117	3	0.169

Steps 3 and 4: Multiplication of Trophic Level Geometric Mean Concentration by fish intake weighting factors (when only Trophic Levels 3 and 4 in database) and summation of these results:

Trophic 3 Weighting = 0.584(0.169) = 0.099
Trophic 4 Weighting = 0.416(0.679) = 0.282
Trophic-Weighted Residue Value (Sum) = 0.4

Step 5: Evaluation of Use Support Status: Partially Supporting Uses

Table 6: Georgia Species List and Trophic Information and Designations

Common Name	Genus	species	Family	Common Group	Environment	Category	Trophic Designation	Trophic #	Feeding Habits	FishBase Trophic Level
Bass, Hybrid (WXS)	Morone	chrysops saxatilis	Moronidae	hybrid true bass	FW	Predator	Piscivore	**4**	Shad	
Bass, Largemouth	Micropterus	salmoides	Centrarchidae	Black Bass	FW	Predator	Piscivore	**4**	Shad, Sunfish, Minnows, Crayfish, Worms, Frogs	3.8
Bass, Redeye	Micropterus	coosae	Centrarchidae	Black Bass	FW	Predator	Piscivore, Invertivore	**4**	Insects, minnows, crayfish	3.5
Bass, Rock	Ambloplites	rupestris	Centrarchidae	Sunfish	FW	Predator	Piscivore	**4**	minnows, crayfish, insects	3.4
Bass, Shoal	Micropterus	cataractae	Centrarchidae	Black Bass	FW	Predator	Piscivore, Insectivore	**4**	Insects, minnows, crayfish	
Bass, Spotted	Micropterus	punctulatus	Centrarchidae	Black Bass	FW	Predator	Piscivore	**4**	minnows, crayfish, worms, insects	3.6
Bass, Striped	Morone	saxatilis	Moronidae	Temperate Bass	EM/FW	Predator	Piscivore	**4**	shad, fish	3.5/4.3
Bass, Suwannee	Micropterus	notius	Centrarchidae	Black Bass	FW	Predator	Piscivore, Invertivore	**4**	small fish, crayfish, insects, crustaceans	3.2
Bass, White	Morone	chrysops	Moronidae	Temperate Bass	FW	Predator	Piscivore	**4**	minnows, insects, zooplankton	4.0
Bowfin	Amia	calva	Amiidae	Bowfin	FW	Predator	Piscivore	**4**	fish, minnows, crayfish, frogs, large insects	3.8
Bream (ssp)			Centrarchidae	Sunfish	FW	Predator	Insectivore,	**3**	Insects, crustaceans, plants, fish eggs, small fish, mollusks	
Buffalo, Smallmouth	Ictiobus	bubalus	Catostomidae	Sucker	FW	Bottom Feeder	Omnivore	**3**	algae, benthic crustacea, insects, detritus	3.0
Bullhead (ssp)			Ictaluridae	Bullhead catfish	FW	Bottom Feeder		**3**		
Bullhead, Brown	Ameiurus	nebulosus	Ictaluridae	Bullhead catfish	FW	Bottom Feeder	Insectivore	**3**	mollusks, insects, worms, algae, fish	3.1/3.4
Bullhead, Flat	Ameiurus	platycephalus	Ictaluridae	Bullhead catfish	FW	Bottom Feeder	Invertivore, Omnivore	**3**	worms, crustacea, general scavenger	3.2
Bullhead, Snail	Ameiurus	brunneus	Ictaluridae	Bullhead catfish	FW	Bottom Feeder	Invertivore, Omnivore	**3**	worms, crustacea, general scavenger	3.2
Bullhead, Spotted	Ameiurus	serracanthus	Ictaluridae	Bullhead catfish	FW	Bottom Feeder	Invertivore, Omnivore	**3**		3.2
Bullhead, Yellow	Ameiurus	natalis	Ictaluridae	Bullhead catfish	FW	Bottom Feeder	Insectivore	**3**	detritus, fish, mollusks, insects	3.1/3.3
Carp, Common	Cyprinus	carpio	Cyprinidae	Carp	FW	Bottom Feeder	Omnivore	**3**		2.5/2.7
Catfish, Blue	Ictalurus	furcatus	Ictaluridae	Bullhead catfish	FW	Bottom Feeder	Piscivore, Omnivore	**3**	fish, crayfish	3.1/3.4
Catfish, Channel	Ictalurus	punctatus	Ictaluridae	Bullhead catfish	FW	Bottom Feeder	Piscivore, Omnivore	**3**	fish, crayfish, worms, insects	3.1/4.2

Table 6 Cont'd: Georgia Species List and Trophic Information and Designations

Common Name	Genus	species	Family	Common Group	Environment	Category	Trophic Designation	Trophic #	Feeding Habits	FishBase Trophic Level
Catfish, Flathead	Pylodicitis	olivaris	Ictaluridae	Bullhead catfish	FW	Predator (deep)	Piscivore	4	Sunfish, minnows, chubs, crayfish	4.2
Catfish, White	Ameiurus	catus	Ictaluridae	Bullhead catfish	FW/B	Bottom Feeder	Insectivore, Piscivore	3	worms, insects, minnows	3.1/3.8
Chub, Bluehead	Nocomis	leptocephalus	Cyprinidae	Minnow	FW	Minnow		3		2.9
Chubsucker, Creek	Erimyzon	oblongus	Catostomidae	Sucker	FW	Bottom Feeder		3		3.0
Chubsucker, Lake	Erimyzon	sucetta	Catostomidae	Sucker	FW	Bottom Feeder		3		3.0
Crab, Blue	Callinectes	sapidus	Portunidae	Swimming Crabs	EM	Predator	Omnivore, Detritivore	3	detritus, mollusks, crustacea, decaying animal matter	2.6/3.0
Crappie, Black	Pomoxis	nigromaculatus	Centrarchidae	Sunfish	FW	Predator	Piscivore	4	Shad, Minnows, Insects, Worms	4.2
Crappie, White	Pomoxis	annularis	Centrarchidae	Sunfish	FW	Predator	Piscivore	4	fish, insects	4.4
Croaker, Atlantic	Micropongonias	undulatus	Sciaenidae	Drum	EM	Bottom Feeder		3	worms, crustacea, fish	3.3/3.7
Drum, Black	Pogonias	cromis	Sciaenidae	Drum	EM	Bottom Feeder	Invertivore, Omnivore	3	oysters, mussels, crabs, shrimp	3.4/3.9
Drum, Red	Scianenops	ocellatus	Sciaenidae	Drum	EM	Predator	Piscivore, Invertivore	3	crustacean (crabs, shrimps), minnows, mollusks	3.4/4.1
Flier	Centrarchus	macropterus	Centrarchidae	Sunfish	FW	Predator	Insectivore, Invertivore	3	insects, crustacea, mollusks, worms, fish, phytoplankton	3.0
Flounder (ssp)			Bothidae	Flounder	EM		Invertivore, Piscivore	3	crustacean (crabs, shrimps), minnows, mollusks	
Hake, Silver	Merluccius	bilinearis	Gadidae	Cods ("whiting")	EM	Predator		4	fish, crustacea, mollusks	3.8/4.3
Hog Sucker, Alabama	Hypentelium	etowanum	Catostomidae	Sucker	FW	Bottom Feeder	Insectivore, Invertivore	3		3.0
Hog Sucker, Northern	Hypentelium	nigricans	Catostomidae	Sucker	FW	Bottom Feeder	Insectivore, Invertivore	3		2.8
Jumprock, Striped	Moxostoma	rupiscartes	Catostomidae	Sucker	FW	Bottom Feeder	Invertivore	3		3.0
Kingfish, Southern	Menticirrhus	americanus	Sciaenidae	Drum (GA "whiting")	EM	Bottom Feeder	Invertivore, Piscivore	3	benthic crustacea, mollusks, fish, detritus	3.4/3.7
Mackerel, King	Scomberomorus	cavalla	Scombridae	Mackerel	M	Predator (pelagic)	Piscivore	4	fish, squid	4.0/4.5
Mullet, Striped	Mugil	cephalus	Mugilidae	Mullets	EM/B	Bottom Feeder	Herbivore, Planktivore	2	grasses, periphyton, zooplankton	2.1
Oysters, Eastern	Crassostrea	virginica	Ostreidae	Oysters	EM/B	Filter Feeder	Planktivore	2	plankton	2.1
Perch, Silver	Bairdiella	chrysoura	Sciaenidae	Drum (yellowtail)	EM	Predator		3	fish, benthic crustacea, detritus, worms	3.0

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Perch, White	Morone	americana	Moronidae	Temperate Bass	FW	Predator	Piscivore	4	planktonic crustacea, insects, mollusks, fish	3.1/3.5/3.8
Pickerel, Chain	Esox	niger	Esocidae	Pike	FW	Predator	Piscivore	4	fish, frogs, insects, crayfish, mice	4.4
Redhorse, Black	Moxostoma	duquesnii	Catostomidae	Sucker	FW	Bottom Feeder	Insectivore, Invertivore	3		2.8
Redhorse, Blacktail	Moxostoma	poecilurum	Catostomidae	Sucker	FW	Bottom Feeder	Insectivore, Invertivore	3		2.8
Redhorse, Golden	Moxostoma	erythrurum	Catostomidae	Sucker	FW	Bottom Feeder	Insectivore, Invertivore	3		3.0
Redhorse, Grayfin	Moxostoma	sp. cf. poecilurum	Catostomidae	Sucker	FW	Bottom Feeder	Insectivore, Invertivore	3		
Redhorse, Silver	Moxostoma	anisurum	Catostomidae	Sucker	FW	Bottom Feeder	Insectivore, Invertivore	3		3.0
Seatrout, Spotted	Cynoscion	nebulosus	Sciaenidae	Drum	EM	Predator	Piscivore, Invertivore	4	shrimp, fish	4.0
Sheepshead	Archosargus	probatocephalus	Sparidae	Porgie	EM	Bottom Feeder	Invertivore	3	mollusks, crustaceans (crabs, shrimp), worms	3.4
Shrimp, Brown	Penaeus	aztecus	Penaeidae	Shrimp	EM	Scavenger	Omnivore, Detritivore	3		2.8
Shrimp, White	Penaeus	fluviatilis	Penaeidae	Shrimp	EM	Scavenger	Omnivore, Detritivore	3		
Spot	Leiostomus	xanthurus	Sciaenidae	Drum	EM	Bottom Feeder	Omnivore	3	detritus, benthic crustacea, worms, fish	3.4/3.9
Stone Roller, Large-scale	Campostoma	oigolepsis	Cyprinidae	Minnow	FW	Bottom Feeder	Herbivore, Omnivore	3		2.9
Sucker (ssp)			Catostomidae	Sucker	FW	Bottom Feeder		3		
Sucker, Greater Jumprock	Moxostoma	lachneri	Catostomidae	Sucker	FW	Bottom Feeder	Insectivore, Invertivore	3		3.0
Sucker, Spotted	Minytrema	melanops	Catostomidae	Sucker	FW	Bottom Feeder	Insectivore, Invertivore	3		2.8
Sucker, White	Catostomus	commersoni	Catostomidae	Sucker	FW	Bottom Feeder	Omnivore	3	plant, animal and detrital material	2.8
Sunfish, Bluegill	Lepomis	macrochirus	Centrarchidae	Sunfish	FW	Predator	Insectivore,	3	Insects, crustaceans, plants, fish eggs, small fish, mollusks	3.3
Sunfish, Green	Lepomis	cyanellus	Centrarchidae	Sunfish	FW	Predator	Insectivore, Invertivore	3	insects	3.1
Sunfish, Redbreast	Lepomis	auritus	Centrarchidae	Sunfish	FW	Bottom Feeder	Invertivore, Insectivore	3	Insects, snails, clams, shrimp, crayfish, small fish	3.1

Table 6 Cont'd: Georgia Species List and Trophic Information and Designations

Common Name	Genus	species	Family	Common Group	Environment	Category	Trophic Designation	Trophic #	Feeding Habits	FishBase Trophic Level
Sunfish, Redear	Lepomis	microlophus	Centrarchidae	Sunfish	FW	Bottom Feeder	Invertivore	**3**	snails, clams, insects, fish eggs, small fish, crustaceans	3.2
Trout, Brook	Salvelinus	fontinalis	Salmonidae	Trout	FW	Predator	Insectivore, Invertivore	**3**	Insects, worms, fish eggs	3.0/3.6
Trout, Brown	Salmo	trutta	Salmonidae	Trout	FW	Predator	Piscivore, Insectivore	**4**	Insects, worms, snails, frogs, crayfish, small fish	3.3/4.0
Trout, Rainbow	Oncorhynchus	mykiss	Salmonidae	Trout	FW	Predator	Piscivore, Insectivore	**4**	Insects, crustaceans, fish	3.4/4.0
Walleye	Stizostedion	vitreum	Percidae	Perch	FW	Predator	Piscivore, Omnivore	**4**	fish, minnows, leeches, crayfish, insects	4.1/4.5
Warmouth	Lepomis	gulosus	Centrarchidae	Sunfish	FW	Predator	Piscivore, Insectivore	**4**	minnows, crayfish, insects, shrimp	3.7

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