

Procedure No. WQMA-SWS-6
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Table 4-1. Index of Biotic Integrity metrics used to evaluate wading sites, boat sites, and headwaters stream sites. Original metrics from Karr (1981) are given first with substitute metrics following.

IBI Metric	Headwaters Sites ^{1,2}	Wading Sites ²	Boat Sites ³
1. Total Number of Species ⁴	X	X	X
2. Number of Darter Species % Round-bodied Suckers ⁶	X ⁵	X	X
3. Number of Sunfish Species Number of Headwaters Species	X	X	X
4. Number of Sucker Species Number of Minnow Species	X	X	X
5. Number of Intolerant Species Number of Sensitive Species	X	X	X
6. % Green sunfish % Tolerant Species	X	X	X
7. % Omnivores	X	X	X
8. % Insectivorous Cyprinids % Insectivorous Species	X	X	X
9. % Top Carnivores % Pioneering Species	X	X	X
10. Number of Individuals ⁷	X	X	X
11. % Hybrids % Simple Lithophils Number of Simple Lithophilic Species	X	X	X
12. % Diseased Individuals % DELT Anomalies ⁸	X	X	X

¹ applies to sites with drainage areas less than 20 sq. mi.

² these sites are sampled with wading methods; ³ these sites are sampled with boat methods; ⁴ excludes exotic species; ⁵ includes sculpins.

⁶ includes suckers in the genera Hypentelium, Moxostoma, Minytrema, and Erimyzon; excludes white sucker (Catostomus commersoni).

⁷ excludes species designated as tolerant, hybrids, and exotics.

⁸ includes deformities, eroded fins, lesions, and external tumors (DELT).

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Table 4-2. The distributional characteristics of Ohio's sucker species (family Catostomidae).

Species	Widely Distributed	Small Streams	Large Rivers	Rare or Limited
Quillback carpsucker	X		X	
River carpsucker			X	
Highfin carpsucker			X	
Silver redhorse	X		X	
Black redhorse	X		X	
Golden redhorse	X		X	
Shorthead redhorse			X	
River redhorse			X	X
Greater redhorse				X
Blue sucker			X	X
Bigmouth buffalo			X	
Smallmouth buffalo			X	
Black buffalo			X	
Northern hog sucker	X	X	X	
White sucker	X	X	X	
Spotted sucker	X		X	
Creek chubsucker		X		X
Lake chubsucker				X
Harelip sucker (extinct)				
Longnose sucker				X

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Table 4-3. Criteria for inclusion of species on the Ohio EPA intolerant and tolerant species lists.

Intolerant Criteria

- 1) A distinct and rapid decreasing trend in abundance with decreasing water and habitat quality (based on graphical analysis; Appendix B, Fig. B-1).
- 2) Abundance skewed towards sites with high Iwb scores (which is reflected in high weighted Iwb scores; Appendix B, Table B-2).
- 3) The species is absent from sites with Iwb <6.0, occurs at a few sites <7.0, and is present at the majority of sites >8.0 (Appendix B, Table B-2).
- 4) A significant historical decrease in distribution (based on Trautman 1981).

Tolerant Criteria

- 1) Present in a substantial number of sites with Iwb values <6.0 (Appendix B, Table B-2).
 - 2) No change or a historical increase in abundance or distribution (based on Trautman 1981).
 - 3) A shift towards community predominance with decreasing water and habitat quality (Appendix B, Fig. B-1).
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Table 4-4. List of Ohio fish species considered to be highly tolerant (for calculating IBI and modified I_{wb} values) to a wide variety of environmental disturbances including water quality and habitat degradation.

Tolerant Species - All Sampler Types

<u>Common Name</u>	<u>Scientific Name</u>
Central mudminnow	<u>Umbra limi</u>
White sucker	<u>Catostomus commersoni</u>
Carp	<u>Cyprinus carpio</u>
Goldfish	<u>Carassius auratus</u>
Golden shiner	<u>Notemigonus crysoleucas</u>
Blacknose dace	<u>Rhinichthys atratulus</u>
Creek chub	<u>Semotilus atromaculatus</u>
Bluntnose minnow	<u>Pimephales notatus</u>
Fathead minnow	<u>Pimephales promelas</u>
Green sunfish	<u>Lepomis cyanellus</u>
Yellow bullhead	<u>Ictalurus natalis</u>
Brown bullhead	<u>Ictalurus nebulosus</u>
E. banded killifish	<u>Fundulus diaphanus diaphanus</u>

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Table 4-5. Index of Biotic Integrity metrics and scoring criteria based on fish community data from more than 300 reference sites throughout Ohio. These criteria apply to wading sites only (sampler types D, E, and F at sites >20 sq. mi.; Ohio EPA 1987a).

Category	Metric	Scoring Criteria		
		5	3	1
Species composition	Total species	Varies with drainage area (Fig. 4-2)		
	Darter species	Varies with drainage area (Fig. 4-4)		
	Sunfish species	>3	2-3	<2
	Sucker species	Varies with drainage area (Fig. 4-10)		
	Intolerant species			
	<100 sq. mi.	>5	3-5	<3
	>100 sq. mi.	Varies with drainage area (Fig. 4-13)		
	% Tolerant (no.)	Varies with drainage area (Fig. 4-16)		
Trophic composition	% Omnivores	<18.6	18.6-34.3	>34.3
	% Insectivores			
	≤30 sq. mi.	Varies with drainage area (Fig. 4-20)		
	>30 sq. mi.	>54.6	26.3-54.6	<26.3
	% Top carnivores	>5	1-5	<1
Fish condition	% Simple Lithophils	>36	18-36	<18
	% DELT Anomalies	<0.1 ^a	0.1-1.3 ^b	>1.3
	Fish numbers ^c	>750	200-750	<200

^a or >1 individual at sites with <200 total fish.

^b or >2 individuals at sites with <200 total fish.

^c excludes tolerant species; special scoring procedures are used when relative numbers are less than 200/0.3 km (see Appendix B).

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Table 4-6. Index of Biotic Integrity metrics and scoring criteria based on fish community data from more than 300 reference sites throughout Ohio. These criteria apply to boat sites only (sampler types A and B; Ohio EPA 1987a).

Category	Metric	Scoring Criteria		
		5	3	1
Species composition	Total species	>20	10-20	<10
	% Round-bodied Suckers	>38	19-38	<19
	Sunfish species	>3	2-3	<2
	Sucker species	>5	3-5	<3
	Intolerant species	>3	2-3	<2
	% Tolerant (no.)	<15	15-27	>27
Trophic composition	% Omnivores	<16	16-28	>28
	% Insectivores	>54	27-54	<27
	% Top carnivores	>10	5-10	<5
Fish condition	% Simple Lithophils ≤600 sq. mi.	>50	25-50	<25
	>600 sq. mi.	Varies with drainage area (Fig. 4-29)		
	% DELT Anomalies	<0.5 ^a	0.5-3.0 ^b	>3.0
	Fish numbers ^c	<200	200-450	>450

^a or >1 individual at sites with <200 total fish.

^b or >2 individuals at sites with <200 total fish.

^c excludes tolerant species; special scoring procedures are used when relative numbers are less than 200/km (see Appendix B).

Table 4-7. Index of Biotic Integrity metrics and scoring criteria based on fish community data from more than 300 reference sites throughout Ohio. These criteria apply to headwaters sites only (sampler types D, E, F, and G at sites <20 sq. mi.; Ohio EPA 1987a).

Category	Metric	Scoring Criteria		
		5	3	1
Species composition	Total species	Varies with drainage area (Fig. 4-2)		
	Darters + sculpin	Varies with drainage area (Fig. 4-5)		
	Headwater species	>3	2-3	<2
	Minnow species	Varies with drainage area (Fig. 4-12)		
	Sensitive sp. ^a	Varies with drainage area (Fig. 4-15)		
	% Tolerant (no.)			
	≤10 sq. mi.	<34	34-57	>57
	>10 sq. mi.	Varies with drainage area (Fig. 4-16)		
Trophic composition	% Pioneering sp.	<30	30-55	>55
	% Omnivores	Varies with drainage area (Fig. 4-18)		
	% Insectivores	Varies with drainage area (Fig. 4-20)		
Fish condition	Simple Lithophils	Varies with drainage area (Fig. 4-30)		
	% DELT Anomalies	<0.10 ^b	0.10-1.30 ^c	>1.30
	Fish numbers ^d			
	≤8 sq. mi.	Varies with drainage area (Fig. 4-26)		
	>8 sq. mi.	>750	200-750	<200

- a includes intolerant and moderately intolerant species (Appendix B).
 b or >1 individual at sites with <200 total fish.
 c or >2 individuals at sites with <200 total fish.
 d excludes tolerant species; special scoring procedures are used when relative numbers are less than 200/0.3 km (see Appendix B).

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Table 4-8. The eight steps in the calculation and interpretation of the Index of Biotic Integrity as described by Karr et al. (1986) and appropriately modified for use in Ohio.

Step - Description	Ohio EPA Application	Applicable Figs., Tables, Appendix
1. Develop expectation criteria for each IBI metric.	Stream Regionalization Project study design.	Figs. 2-1; 4-2 through 4-29; Tables 4-1 thru 4-7.
2. Tabulate number of fish by species.	Fish Information System (FINS).	
3. Assign species to trophic guilds.	Literature review Karr et al. (1986)	Appendix B, Table B-3.
4. Identify species tolerances.	Appendix B - based on statewide data base and Trautman (1981).	Appendix B, Table B-3.
5. Summarize information for each IBI metric.	Depends on application (wading, boat, headwaters).	Table 4-1;
6. Rate each IBI metric according to criteria developed.	Follow guidelines for each application (wading, boat, headwaters).	Tables 4-5 through 4-7; Figs. 4-2 thru 4-29.
7. Calculate total IBI score.	Do by hand or use computer assistance.	
8. Convert total IBI score to one of five integrity classes.	Ohio biological criteria for WQS use attainment/non-attainment.	See Table 7-1 and consult Section 8.

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Table 4-9. Evaluation of the fish community at two sites in the upper Hocking River during August-September, 1982 using the Index of Biotic Integrity modified for application to Ohio waters (boat sites). Scores are assigned based on whether the individual metric values (in parentheses) approximate (5), partially deviate (3), or strongly deviate (1) from what is expected in a least impacted stream or river.

IBI Metrics	Sampling Station (River Mile)					
	82.4	82.4	82.4	78.3	78.3	78.3
<u>NUMBERS OF</u>						
Total Species	1(6)	1(5)	1(4)	3(16)	3(14)	3(14)
Total Individuals	1(8)	1(12)	1(4)	1(87)	1(106)	1(130)
Sunfish Species	3(2)	1(1)	3(2)	5(4)	3(3)	5(4)
Sucker Species	1(2)	1(1)	1(2)	3(3)	3(5)	3(3)
Intolerant Species	1(0)	1(0)	1(0)	1(0)	1(0)	1(0)
<u>PROPORTION OF INDIVIDUALS (%)</u>						
Round-bodied Suckers	1(4)	1(0)	1(4)	3(19)	3(32)	3(34)
Omnivores	1(70)	1(67)	1(76)	1(53)	1(41)	1(38)
Insectivores	1(22)	1(19)	1(20)	3(36)	3(54)	3(50)
Tolerant Species	1(85)	1(86)	1(92)	1(60)	1(44)	1(42)
Top Carnivores	3(7)	3(7)	1(4)	3(5)	1(4)	3(10)
Simple Lithophils	1(22)*	1(7)*	1(8)*	5(60)	5(72)	5(57)
Anomalies	1(0)*	1(0)*	1(0)*	5(0)	5(0)	5(0)
Index Value	16	14	14	34	30	34
Drainage Area	334	334	334	437	437	437

* these metrics are adjusted because of low overall numbers according to the guidelines for "low-end" scoring.

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Table 4-10. Guidelines for scoring the proportional metrics of the IBI in severely impacted streams in Ohio with less than 200 individuals per 0.3 km (wading methods) or per 1.0 km (boat methods). "Total individuals" in this table refers to relative number.

Metric	Guidelines for IBI Scoring Modifications
Proportion as Omnivores	For wading sites results we recommend assigning a score of "1" for this metric with less than 50 total individuals. With 50-200 total individuals a score of "1" is assigned when species considered as generalist feeders are numerically dominant. In Ohio creek chub and blacknose dace are the generalist feeders that usually predominate in these situations. The same procedure is used for boat sites results. For headwaters sites less than 8 sq. mi. drainage area, the numbers cutoff changes from 200 to 25, reflecting the fewer expected individuals at these sites.
Proportion as Insectivores	At sites with a high proportion of insectivorous species and less than 50 total individuals (25 individuals at headwaters sites <8 sq. mi.) a score of "1" is automatically assigned. At sites with 50-200 total individuals this metric can be scored "1" if this metric is predominated by either striped shiner, common shiner, or spotfin shiner, species that can act as omnivores under certain conditions (Angermeier 1985).
Proportion as Top Carnivores	At boat sites the levels of top carnivores that would normally attain a score of "5" at sites with less than 200 total individuals should be scored a "1", dependent on the judgement of the biologist involved in scoring. A similar procedure should be used at sites sampled with wading methods if the high proportion of top carnivores is due to a predominance of grass pickerel in impacted areas.
Proportion as Simple Lithophils	This metric always scores a "1" at sites with less than 50 total individuals; however, this is rarely different from its score without the adjustment. This applies at both wading and boat sites. No adjustment is necessary at headwaters sites.

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Table 4-10. (continued).

Metric	Guidelines for IBI Scoring Modifications
Proportion with DELT Anomalies	Sites with less than 50 total individuals are scored a "1" for this metric (25 individuals at headwaters sites). Sites with 50-200 total individuals are also scored a "1" if circumstances suggest that DELT anomalies may be underestimated. A predominance of young fish that have not "accrued" anomalies may also be sufficient reason to score a "1".
Proportion as Pioneering Species	At headwaters sites this metric is scored a "1" if there are less than 50 total individuals at >8 sq. mi., and 25 at <8 sq. mi.
Proportion as Tolerants	No adjustments are necessary for this metric.
Proportion as Round-bodied Suckers	No adjustments are necessary for this metric.

Table 4-11. Computational formulae for the modified index of well-being (I_{wb}) and the Shannon diversity index.

Modified Index of Well-Being (I_{wb})

$$I_{wb} = 0.5 \ln N + 0.5 \ln B + \bar{H} \text{ (no.)} + \bar{H} \text{ (wt.)}$$

where:

N = relative numbers of all species excluding species designated "highly tolerant" (Appendix B, Table B-3).

B = relative weights of all species excluding species designated "highly tolerant" (Appendix B, Table B-3).

\bar{H} (no.) = Shannon diversity index based on numbers.

\bar{H} (wt.) = Shannon diversity index based on numbers.

Shannon Diversity Index

$$\bar{H} = - \sum \frac{(n_i)}{N} \log_e \frac{(n_i)}{N}$$

where;

n_i = relative numbers or weight of the i th species

N = total number or weight of the sample