Metrics and the Index of Biotic Integrity

Selecting Metrics

The IBI has made great advances, especially in the selection and testing of metrics and indices. Before an index can be built and tested, the metrics need to be carefully selected. Most approaches today start from a list of dozens of potential metrics (see Table at the bottom of this page) and then use a systematic process to eliminate those metrics that do not meet certain criteria such as:

- **the effective range of response** - metrics with a limited range of values, such as 0 or 1, or 0, 1, 2, will not contribute useful information to the IBI
- **the repeatability of measurements** (signal to noise) - an effective metric should exhibit higher between site variance than within site variance so higher signal to noise is better
- **relationship to watershed area** - if the metrics correlate with watershed area, then those metrics need to be normalized to minimize the effect of natural variability
- **metrics that provided redundant information** - only one selected for further testing
- **the discriminatory ability of the metrics** - metrics should respond predictably to a disturbance gradient (see the Biological Condition Gradient figures below)

One example of an approach used in the Mid-Atlantic Highlands Streams Assessment and is documented in the MAHA Technical Support Document and further discussed in Developing Biological Indicators: Lessons Learned in Mid-Atlantic Streams. Also see Biological Monitoring and Assessment: Using Multimetric Indexes Effectively (155 pp, 10.7MB About PDF)

Standardizing Metrics (Scoring/Normalizing)

Once the metrics are selected, they need to all be on the same scale whether it is the original IBI approach of 1,3,5 or a scale from 1-100.. For example, the potential range of values can be quite different, especially if metrics representing a number of taxa and the percentage of taxa are used. Scoring, or normalizing, the metrics have been done using many different approaches, but they all are attempting to accomplish the same result.

One approach standardized each metric to a 100-point scale where 0 represented the worst condition observed, and 100 the best. A score corresponded to its rank between the 5th and 95th percentiles in the distribution of all data collected (not just the reference sites). Extreme values below the 5th percentile or greater than the 95th percentile were assigned 0 or 100, respectively (see Figure). This practice eliminates the influence of outliers and reduces the effect that different datasets in the future will have on setting the SCI scores.
Disturbance Gradient

One the metrics are scored, or normalized, they can be combined into a new index. The new IBI is then subjected to testing to ensure that the index can consistently and predictably respond to a disturbance gradient (see the figure to the right). For more information on disturbance gradients, see the Biological Condition Gradient discussion.

Learn more about metric and index testing from the report "Developing Biological Indicators: Lessons Learned from Mid-Atlantic Streams".

Figure 1.

IBI Metrics Used - 1995

List of Original index of Biotic Integrity Metrics (in bold) Proposed by Karr (1981) for Streams in the Central United States, Followed by Modifications Proposed by Subsequent Authors for Streams in Other Regions or for Different Streams and River Types

Species Richness and Composition Metrics

A. Total Number of Fish Species (1-7, 11, 13-15, 18, 19, 22)

1. Number of native fish species (8-10, 12, 16, 17, 20, 22)
2. Number of fish species, excluding Salmonidae (13)
3. Number of amphibian species (3, 13)

B. Number of Catostomidae Species (1, 4-6, 8, 9, 12, 15, 17, 19, 20)

1. Percent of individuals that are Catostomidae (9)
2. Percent of individuals that are round-bodied Catostomidae: Cycleptus, Hypentelium, Minytrema, and Moxostoma (9, 17, 19)
3. Number of Catostomidae and Ictaluridae species (10)
4. Number of Catostomidae and Cyprinidae species (17)
5. Number of benthic insectivorous species (7, 11, 17, 22)
6. Number of laterally compressed minnow species (21)
7. Number of minnow species (4, 6, 9, 14, 15, 17, 22)
8. This metric deleted from IBI (2, 3, 13, 14)

C. Number of Darter Species (Percidae genera: Crystallaria, Etheostoma, Percina, Ammocrypta) (1, 2, 4, 5, 8, 9, 12, 15-17, 19, 22)

1. Number of darter and Cottidae species (9, 10)
2. Number of darter, Cottidae, and Noturus (Ictaluridae) species (15, 16, 19)
3. Number of darter, Cottidae, and round-bodied Catostomidae species (17)
4. Number of Cottidae species (6, 13)
5. Abundance of Cottidae individuals (3)
6. Number of benthic species (11, 18)
7. Percent of individuals that are native benthic species (11)(same as #2)
8. Number of benthic insectivorous species (7)
9. Number of darter species, excluding "tolerant darter species" (headwater sites) (21)
10. Percent cyprinids with subterminal mouths (22) K. This metric deleted from IBI (14)

D. Number of Sunfish Species (Centrarchidae excluding Micropterus)(1, 4, 5, 14-17, 20)

1. Number of native sunfish species (9, 12)
2. Number of sunfish and Salmonidae species (10)
3. Number of sunfish species and Perca flavescens (Percidae) (16)
4. Number of headwater (restricted to small streams) species (9, 15, 22)
5. Number of water column (non-benthic) species (7, 17, 18)
6. Number of water column cyprinid species (17)
7. Number of sunfish species including Micropterus (19, 22)
8. This metric deleted from IBI (11)

Indicator Species Metrics

E. Number of Intolerant or Sensitive Species (1-4, 6-8, 10-12, 14, 15, 17-20, 22)

1. Number of Salmonidae species (3,15)
2. Percent of individuals that are Salmonidae (11)
3. Juvenile Salmonidae presence or abundance (3, 18)
4. Large (>1 5-20 cm) or adult Salmonidae presence or abundance (3, 6, 18)
5. Abundance or biomass of all sizes of Salmonidae (3, 13)
6. Mean length or weight of Salmonidae (13)
7. Percent of individuals that are anadromous Oncorhynchus mykiss (Salmonidae) older than age 1 (3)
8. Presence of Salvelinus fontinalis (Salmonidae) (10)
9. Presence of juvenile or large Esox lucius (Esocidae) (18)
10. Number of Large River (restricted to great rivers) species (19, 22)
11. Percent of species that are native species (3)
12. Percent of individuals that are native species (3)
13. This metric deleted from IBI (2, 14)

F. Percent of Individuals that Are Lepomis cyanellus (Centrarchidae) (1, 17)

1. Percent of individuals that are Lepomis megalotis (Centrarchidae) (5)
2. Percent of individuals that are Cyprinus carpio (Cyprinidae) (6)
3. Percent of individuals that are Semotilus atromaculatus (Cyprinidae)(2)
4. Percent of individuals that are Rutilus rutilus (Cyprinidae) (18)
5. Percent of individuals that are Rhinichthys species (Cyprinidae) (10)
6. Percent of individuals that are Catostomus commersoni (Catostomidae) (4, 7, 11)
7. Percent of individuals that are tolerant species (8, 9, 12, 14-17, 19, 22)
8. Percent of individuals that are "pioneering" species (9, 15, 22)
9. Percent of individuals that are introduced species (4, 6, 12, 14)
10. Number of introduced species (12, 13)
11. Evenness (22)
12. This metric deleted from IBI (3)

**Trophic Function Metrics**

**G. Percent of Individuals that Are Omnivores (1-4, 6-8, 10, 12, 14-20, 22)**

1. Percent of individuals that are omnivorous Cyprinidae species (10)
2. Percent of individuals that are Luxilus cornutus or Cyprinella spiloptera (Cyprinidae), facultative omnivores (9)
3. Percent of individuals that are generalized feeders that eat a wide range of animal material but limited plant material (2, 9, 11)
4. Percent biomass of omnivores (22)
5. This metric deleted from IBI (3, 13)

**H. Percent of Individuals that Are Insectivorous Cyprinidae (1, 17)**

1. Percent of individuals that are insectivores/invertivores (5-7, 9, 12, 14-19)
2. Percent of individuals that are specialized insectivores (2, 4, 20)
3. Percent of individuals that are specialized insectivorous minnows and darters (8)
4. Percent biomass of insectivorous cyprinids (22)
5. This metric deleted from IBI (3, 10, 13)

**I. Percent of Individuals that Are Top Carnivores or Piscivores (1, 5, 7-9, 11, 12, 15-20)**

1. Percent of individuals that are large (> 20 cm) piscivores (10)
2. Percent biomass of top carnivores (22)
3. This metric deleted from IBI (2-4, 6, 13-15)

**Reproductive Function Metrics**

**J. Percent of Individuals that Are Hybrids (1, 7, 8, 13)**

1. Percent of individuals that are simple lithophilous species: spawn on gravel, no nest, no parental care (9, 15-17, 19, 20, 22)
2. Percent of individuals that are gravel spawners (18)
3. Ratio of broadcast spawning to nest building cyprinids (22)
4. This metric deleted from IBI (2-6, 10-12, 14)

**Abundance and Condition Metrics**

**K. Abundance or Catch per Effort of Fish (1 -8, 10-11, 14-15, 18, 19, 22)**

1. Catch per effort of fish, excluding tolerant species (9, 16, 20)
2. Biomass of fish (6, 13, 22)
3. Biomass of amphibians (13)
4. Density of macroinvertebrates (13)
5. This metric deleted from IBI (17)

**L. Percent of Individuals that are Diseased, Deformed, or Have Eroded Fins, Lesions, or Tumors (1-7, 9, 11, 12, 14-16, 18, 19, 20, 22)**
1. Percent of individuals with heavy infestation of cysts of the parasite Neascus (10)
2. This metric deleted from the IBI (13, 17)

Note: The numbers in parentheses correspond to the following references.**

1. Karr (1981); Fausch et al. (1984); Karr et al. (1985a,b); Karr et al. (1986); Angermeier and Karr (1986); Berkman et al. (1986); Karr et al. (1987); Hite and Bertrand (1989); Angermeier and Schlosser (1988); Hite et al. (1992); Osborne et al. (1992).
3. Moyle et al. (1986).
22. Goldstein et al. (1994).


