# DEVELOPMENT OF A STANDARDIZED INDEX OF BIOTIC INTEGRITY FOR THE PIEDMONT REGION OF GEORGIA

Brian L. Shaner

*AUTHORS:* Department of Natural Resources, Wildlife Resources Division, Fisheries Management Section, 2425 Marben Farms Road, Mansfield, GA 30055.
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**Abstract.** The Index of Biotic Integrity (IBI) is a multimetric index developed to assess the quality of a stream based on the structure of its fish community. The IBI consists of 12 measures, or metrics, that evaluate the species richness, health, abundance, and trophic dynamics of the fish community at a sample site. The Fisheries Section of the Georgia Department of Natural Resources is currently in the process of developing a standardized IBI for wadeable streams in the piedmont region of Georgia. The metrics were adapted to the fish communities found in streams in the piedmont region while maintaining the basic ecological framework of the original IBI.

## INTRODUCTION

In the mid 1990's the Georgia Environmental Protection Division (EPD), a branch of the Georgia Department of Natural Resources, was charged by the federal Environmental Protection Agency with establishing Total Maximum Daily Loads (TMDL) for impaired waters throughout Georgia. As part of the process to identify impaired waters and developed TMDL for those waters, EPD is incorporating a biological component (biomonitoring) into its traditional chemical and physical water quality monitoring program.

The Wildlife Resources Division (WRD) is working in conjunction with EPD to establish standardized operating procedures for collecting and processing biomonitoring data throughout Georgia. The procedures and metrics developed by these agencies will be required components for all individuals and organizations collecting biomonitoring data for watershed assessments and obtaining private, municipal or industrial discharge permits from the EPD.

In this process the Fisheries Section of the WRD has been charged with developing and standardizing an Index of Biotic Integrity (IBI) for fish populations in Georgia. This paper will provide a brief overview on the history of biomonitoring and the development of the IBI, and a summary of the methods and metrics used by the WRD.

## BACKGROUND

### Biomonitoring

Biotic integrity has been defined by Karr and Dudley (1981) as "the ability to support and maintain a balanced, integrated, adaptive community of organisms having a species composition, diversity, and functional organization comparable to that of the natural habitat of the region." Since the passage of the Water Pollution Control Act of 1972, water regulatory agencies have been charged with restoring and maintaining the biological, or biotic, integrity of the nation's water resources (Karr, 1991). In the past, efforts to restore the biotic integrity of water resources have been dominated by monitoring point source effluents with such non-biological parameters as chemical and physical water quality. Politically and logistically, monitoring point source discharges provided water regulatory agencies with an apparent means to satisfy the directives of the Water Pollution Control Act. The numerical pollution standards provided a certain degree of statistical validity and legal defensibility and were believed to be sufficient to protect water resources (Karr 1987). It was presumed that improvements in the chemical/physical water quality would be followed by a restoration in biotic integrity.

While the implementation of effluent regulatory programs helped to maintain adequate water quality, this approach allowed continued degradation to a variety of aquatic resources, particularly fish, from nonpoint sources (Karr 1991). Habitat alteration, flow regime modification, and changes in the energy base of the stream biota are all detrimental impacts upon a stream not detected by point source monitoring programs (Karr 1987).

The continued decline in the biotic integrity of aquatic resources despite chemical/physical water quality monitoring programs has compelled some regulatory agencies to integrate a biological approach, or biomonitoring, into their water quality monitoring programs (Karr 1991). Karr (1987) used the term biomonitoring "to evaluate the health of a biological system to assess degradation from any of a variety of impacts of human society" rather than the traditional use of the term as it relates to toxicity testing. Since it is based on the direct observation of aquatic communities, for which traditional chemical/physical water quality monitoring programs have proved to be unreliable surrogates, biomonitoring explicitly addresses the directives of the Water Pollution Control Act to restore and maintain biotic integrity in the nation's water resources.

**Index of Biotic Integrity**

The original IBI was developed by Karr (1981) to assess environmental degradation in wadeable streams in the midwestern United States. It consisted of twelve measures, or metrics, which assessed three facets of the fish community: species richness and composition, trophic composition and dynamics, and fish abundance and condition. Each of the twelve metrics was scored by comparing its value to expected values determined from regional reference sites. A reference site is a stream of similar size in the same ecoregion that has been relatively unperturbed by human impacts. The twelve metrics were scored based on whether they approximated, deviated somewhat, or deviated strongly from the values of the reference site and were assigned values of five, three, or one, accordingly. Metric values were then added to generate a total IBI score. Based on the total IBI score, a stream could then be placed into an integrity class (i.e., excellent, good, fair, poor, very poor, and no fish) which allowed for easy interpretation of the condition of the biotic community for that stream by non-biologists.

Since regional reference conditions are used to define metric expectations, the IBI has proven to be adaptable to regions outside the midwestern United States while retaining the ecological framework of the original IBI (Fore et al 1994). Miller et al (1988) outlined the development and implementation of the IBI in other regions throughout the United States, including western Oregon and northern California, northeastern Colorado, New England, and the central Appalachian region.

Agencies in the southeastern United States that have developed or are currently evaluating an IBI for inclusion in their water resources monitoring and regulatory programs include the Tennessee Valley Authority, the Kentucky Cabinet for Natural Resources and Environmental Protection, the Alabama Department of Environmental Management, the North Carolina Department of Environment, Health, and Natural Resources, and the South Carolina Department of Health and Environmental Control. The Fisheries Section of the Georgia Department of Natural Resources is currently in the process of developing a standardized IBI for wadeable streams in the piedmont region of Georgia.

## IBI SAMPLING METHODS

IBI sampling was conducted from April through September in 1998 in the piedmont region of west-central Georgia. Each site to be sampled underwent an on-site reconnaissance. If it was determined that the site could be effectively sampled with a backpack electrofishing unit (BPEF), the mean stream width (MSW) was estimated from five randomly selected transects. The length of the sample site was a multiple of the MSW. Statistical analysis of the IBI scores for different multiples of MSW is currently ongoing. A standardized multiple of MSW will be established by April 1999.

The entire length of the sample site was sampled in an upstream direction with a BPEF. The crew consisted of three, and preferably four individuals: a BPEF operator, one or two netters, and a bucket carrier. Riffles were sampled by shocking in a down stream direction into a seine. For streams wider than four meters, two BPEF were used in a tandem, with a minimum crew of five individuals.

All fish collected were kept in a bucket of fresh water until the entire site was sampled. Water in the buckets was replaced frequently to reduce mortality. All readily identifiable fish were identified to species, counted, examined for external anomalies, and released. Any unidentifiable fish were counted and examined for external anomalies at the stream side and returned to the laboratory for identification.

## METRICS FOR THE PIEDMONT REGION OF GEORGIA

The metrics used by the Georgia WRD are slightly revised from those developed by Schleiger (1999) in the early 1990's. Due to the regional differences in fish fauna between the midwestern and southeastern portion of the United States, several of the metrics originally proposed by Karr (1981) required modification.

Metrics 1-6 evaluate species richness and composition at a site. These metrics assess the health of the major taxonomic groups and habitat guilds of fishes and reflect the availability of spawning habitat and food resources. These include:

**Metric 1. Total number of fish species**

This metric is a count of all the fish species in the sample. Hybrids and recently introduced species, such as the rice eel and grass carp, are not included as their presence does not give an accurate assessment of the long term biotic integrity. Rather, their abundance may indicate a loss of biotic integrity to the system (Karr et al 1986).

**Metric 2.**

Total number of darter species. This metric is a count of all the species of *Etheostoma* and *Percina* in the sample. Due to their specificity for feeding and reproducing in benthic habitats, these species tend to be highly sensitive to environmental degradation (Ohio EPA 1987). Schleiger (1999) modified this metric for streams in the Chattahoochee and Flint River drainage basins in the piedmont region which contain depauperate darter populations to also include madtom (*Noturus* spp.) and sculpin (*Cottus* spp.) species.

**Metric 3.**

Total number of sunfish species. This metric is a count of the number of species in the Centrarchidae family in the sample, excluding *Micropterus* and *Pomoxis* species. Sunfish hybrids are also excluded from this metric. This metric measures the effects of the loss of instead cover and pool habitat as well as decreases in the terrestrial food supply to the stream by disruption of the riparian zone habitat (Ohio EPA 1987).

**Metric 4.**

Total number of sucker species. This metric is a count of the number of species in the Catostomidae family in the sample. Catostomid species are generally sensitive to physical and chemical habitat degradation. In addition, the relatively long life span of most Catostomid species provides a long term assessment of past and present environmental conditions (Ohio EPA 1987).

**Metric 5.**

Total number of sensitive species. This metric is a count of all the species in the sample that have been designated as intolerant or moderately intolerant to the effects of human disturbance. This metric distinguishes between sites of good and excellent biotic integrity since species designated as intolerant or moderately intolerant should have disappeared by the time the stream has degraded to the fair category.

**Metric 6.**

Proportion of individuals as tolerant species. This metric replaces Karr's (1981) original metric, the proportion of individuals as green sunfish. Species designated as tolerant to human disturbance are those which shift in abundance and distribution from incidental to dominant members of the fish community
with increasing water quality and habitat degradation. Considering all species designated as tolerant avoids weighing the metric too heavily on a single fish species.

Metrics 7-9 measure the trophic composition and dynamics at a site. These metrics assess the quality of the energy base and the flow of energy through a stream community and offer a means to quantitatively evaluate the shift toward more generalized foraging that occurs with increased habitat degradation. These include:

**Metric 7. Proportion of individuals as omnivores**

Omnivores frequently become the dominant members of the fish community in degraded environments since their opportunistic foraging habits convey a competitive advantage over more specialized feeders (Karr et al 1986). Nutrient enrichment is a primary disturbance which can cause a shift in the trophic composition of the fish community. Therefore, this metric has been modified to include stonerollers (*Campostoma* spp.), a herbivorous species whose increased numbers are normally associated with nutrient enrichment (O'Neil and Shepard 1998).

**Metric 8. Proportion of individuals as insectivorous cyprinids**

Insectivorous cyprinids represent a specialized trophic guild whose abundance reflects the quality of the surrounding environment. Degradations in habitat and water quality induce a shift toward a generalist tropic fish assemblage and decreased abundance of specialized feeders such as insectivorous cyprinids.

**Metric 9.**

Proportion of individuals as pioneercies. This metric measures the proportion of individuals in the sample that are designated as pioneer species. Karr's (1981) original metric, the proportion of top carnivores, was replaced since carnivorous species were not likely to be common in smaller streams in the piedmont region (Schleiger 1999). Pioneer species are those species which are the first to reinvade and predominate in small streams that have been affected by temporal dessication and/or environmental degradation (Ohio EPA 1987). A high proportion of pioneering species is an indication of a highly unstable or temporal environment. WRD personnel are currently analyzing data to determine if the proportion of individuals as top carnivores would be a more relevant metric for larger streams.

Metrics 10-12 measure the abundance and condition of the fish community at a site. These metrics evaluate population density, recruitment, and health. They include:

**Metric 10.**

Number of individuals in the sample. This metric evaluates population abundance as the number of individuals collected per 30 minutes of electrofishing effort. Sites that have sustained environmental degradation generally contain fewer fish. However, some kinds of perturbation, such as nutrient enrichment, may lead to increases in fish abundance. Therefore, species designated as pollution tolerant are excluded from this metric, as are hybrids and exotic species (Ohio EPA 1987).

**Metric 11.**

Proportion of individuals as simple lithophilic spawners. Simple lithophilic spawners are fish species which broadcast their eggs over the stream bottom where they can develop in the interstices of sand, gravel, and cobble substrates without parental care. This metric provides an assessment of the suitability of a site for reproduction. Karr's (1981) original metric, the proportion of hybrids, was replaced due to difficulty in identification and the lack of a consistent relationship between hybridization and environmental degradation (Ohio EPA 1987).

**Metric 12. Proportion of individuals as diseased fish**

This metric is scored by determining the proportion of individuals in the sample that have deformities, eroded fins, lesions, or tumors (DELT anomalies). DELT anomalies may be caused by bacterial, viral, and fungal infestations, neoplastic diseases, and chemical pollution. Individuals with external damage caused by spawning activity or collection techniques (i.e., electrofishing) are not counted in this metric. Individuals infested with parasites are also not included in this metric since no consistent relationship has been found between the incidence of parasitism and environmental degradation (Ohio EPA 1987; Schleiger 1999).

## STATUS OF GEORGIA'S IBI PROGRAM

Development of the database and standard operating procedures manual, ranking of the feeding and reproduction guilds and pollution tolerances, calculations of the drainage basin areas, and fish identifications are ongoing and IBI scores for the 1998 sampling season should be available in spring 1999. In the future, metrics for different ecoregions throughout Georgia (i.e., blue ridge mountains, ridge and valley, southern coastal plains, middle Atlantic coastal plains, southeastern plains, and southwestern Appalachians) will be developed and evaluated as well as methods and metrics for larger non-wadeable bodies of water.

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