

Biotic Integrity Index Aids Aquatic Inventories

By Nancy Hoefs

Management for preservation of the biological integrity of aquatic natural resources of National Parks and Riverways, a goal of the NPS Resource Inventories and Monitoring Program, should be based on ecological evaluation that integrates physical, chemical, and biological variables. The biological integrity of an aquatic ecosystem is its ability to support and maintain a "balanced integrated adaptive community of organisms having species composition, diversity, and functional organization comparable to that of natural habitat of the region." (Karr and Dudley 1981).

The physical and chemical characteristics of natural waters are routinely monitored; direct biological monitoring of aquatic communities is less frequent. As a result, decisions in environmental management too often are based on water quality data rather than biological integrity. Many human impacts such as intermittent additions of contaminants, habitat alteration, reduced or altered energy flow through the system that degrades aquatic communities, are not always detected by physical and chemical monitoring. With increased use and development surrounding National Scenic Riverways and Parks, degradation of aquatic resources due to human impacts will become more of a problem. Protection of natural resources has been guided primarily by a focus on water quality monitoring. Direct monitoring of biological communities into resource management decisions is also needed to assure the integrity of these resources.

As indicators of biological integrity, fish communities have several advantages. Fish integrate the effects of watershed degradation, are typically present in all but the most ephemeral or polluted aquatic habitats, are comparatively easy to identify, and include a range of species representing a variety of trophic levels. Because fish are dependent on habitat and the biotic components (e.g. macroinvertebrates) of the ecosystem for survival and growth, they integrate the effects of complex and varied impacts affecting other components of the ecosystem. Thus, they reflect the direct and indirect effects of environmental stresses on the entire aquatic ecosystem (Karr 1981).

The Index of Biotic Integrity (IBI; Karr 1981) directly assesses the biological integrity of aquatic ecosystems by measuring a range of fish community attributes that reflect the prevailing chemical, physical, and biological conditions of the aquatic environment. Changes in species richness and composition, trophic composition, and other such factors are directly influenced by water quality disturbances and/or man-induced habitat alterations. As a management tool, the IBI measures the overall effects of environmental degradation.

Although fish communities are sampled routinely by state and federal agencies, tools for analysis and interpretation of the data gathered have been insufficient. As a result, these data are not incorporated into management decisions. The strength of the IBI is its ability to assemble information from individual, population, and community data into a single ecologically based index of biotic integrity. Along with information on physical and chemical conditions, the IBI can provide a sound basis for management evaluations and decisions.

The IBI consists of 3 categories of 12 fish community metrics (Table 1) (Karr et al. 1986). Individually, each metric provides information about a specific attribute of the aquatic resource; together, they characterize the underlying biological integrity of that site. The first category assesses species richness and composition; the total number of species, the number of intolerant species, and species in 3 major families of insectivorous

Table 1. Metrics used to assess fish communities (after Karr et al. 1986).

Category	Metric	Scoring criteria ^a		
		5	3	1
Species richness and composition	1. Total number of fish species	Expectations for metrics 1-5 vary with stream size and region		
	2. Number and identity of darter species			
	3. Number and identity of sunfish species			
	4. Number and identity of sucker species			
	5. Number and identity of intolerant species			
	6. Proportion of individuals as green sunfish			
Trophic composition	7. Proportion of individuals as omnivores	<5%	5-20%	>20%
	8. Proportion of individuals as insectivores	<20%	20-45%	>45%
	9. Proportion of individuals as piscivores (top carnivores)	>45%	45-20%	<20%
	10. Number of individuals in sample	>5%	5-1%	<1%
Fish abundance and condition	11. Proportion of individuals as hybrids	Expectations for metric 10 vary with stream size and other factors		
	12. Proportion of individuals with disease, tumors, fin damage, and skeletal anomalies			

^aRatings of 5, 3, and 1 are assigned to each metric according to whether its value approximates, deviates somewhat from, or deviates strongly from the value expected at a comparable site that is relatively undisturbed.

fish. Suckers and darters feed predominantly on benthic invertebrates; sunfish feed primarily on midwater and surface invertebrates. The sensitivity of these groups to degradation of their food sources and habitat make them ideal indicator species. Also the total number of species, the percent intolerant species, and the percent green sunfish (a tolerant species), will be altered with increasing environmental degradation.

The energy base and trophic dynamics of the fish community are assessed in the second category by classifying individual species as omnivores, insectivores or piscivores. The trophic structure of the community can provide information concerning alteration in water quality or other habitat changes, including land use patterns that result in changes in the fish community.

The final category evaluates the quality of fish populations by examining abundance, proportion of hybrids, and physical condition (i.e. the proportion of individuals with disease, tumors, fin damage, and anomalies).

The value of each metric is compared to the value expected from a relatively undisturbed system. Ratings of 5, 3, and 1 are assigned to each metric according to whether its value is what would be expected, moderates slightly, or deviates strongly from the value at a relatively undisturbed site. Criteria for species richness and the composition metrics are set using maximum species richness lines, which describe changes in the number of fish species as a function of stream size. The site is then assigned to an integrity class (ranging from excellent to very poor) based on the total of the 12 metric ratings (Karr et al. 1986).

Many of the metrics and their scoring criteria can be adapted to ecological regions where the structure and function of the fish communities differ. For example Fausch (1986) modified the IBI for use in the St. Croix National Scenic Riverway by changing several community attributes to make the index more sensitive to environmental alterations. The modified IBI was used to screen a large number of sites and identify those that appeared degraded. Recommendations were made about sampling site choice and methods for future bio-monitoring in the Riverway.

We are currently assessing the IBI for applicability to resource inventory on the two principal rivers (Current

and Jacks Fork) within the Ozarks National Scenic Riverways, using diverse data collected over the last 50 years by the NPS and the Missouri Department of Conservation. Index metrics are being modified to respond to changes in land use practices that may affect the biological integrity of the Riverways. Changes incorporate the unique ecological attributes of the fish communities that have evolved in the karst spring fed rivers of the Ozark ecoregion. Once adapted for the Ozarks, the IBI can be used to screen existing data and provide a working model for use in management decisions.

The potential of the IBI as a tool in resource inventory and monitoring of other NPS river systems appears promising. Plans to apply the IBI to aquatic resource inventory are being considered in several prairie parks in Missouri and Nebraska, including Wilson's Creek and Agate Fossil Beds.

The periodic chemical and physical analysis currently being used for nonpoint source pollution that may indicate degradation may be less sensitive than necessary for adequate protection of the aquatic resource, particularly in view of increasing arrays of impacts within the watersheds of many of these areas. Incorporation of resource inventory, biological monitoring, and suitable indices such as the IBI will provide management with a direct measure of biological integrity.

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References

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