FISH STATUS INDEX

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The Fish Status Index is a multimetric composite index that integrates multiple attributes of fish communities. This approach was chosen for the NAWQA summary reports to provide a widely applicable, consistent measure of environmental degradation, using attributes of fish communities, that was comparable among study units. Biological criteria based on aquatic communities have been formulated by State and Federal agencies to assess and protect freshwater ecosystems (USEPA, 1990; Karr, 1991; Southerland and Stribling, 1995). Multimetric indices are widely used, typically integrating information on many attributes of a biotic community into a numerical index that is scaled to reflect the ecological heath of the community (Barbour and others, 1995). The Index of Biotic Integrity (IBI), the first multimetric index approach to gain wide acceptance (Karr and others, 1986; Karr, 1991), was originally conceived to use data on fish communities to assess the ecological health of streams in the midwestern United States. Later applications of this approach led to IBI development for streams in other regions of North America (Miller and others, 1988; Steedman, 1988; Lyons and others, 1995), and in other continents (reviewed in Hughes and Oberdorff, 1999). However, the IBI would not result in scores that were comparable regionally and nationally, because of modifications that would be needed in different study units and ecological regions (Miller and others, 1988). Nevertheless, the approach is considered to be sufficiently flexible that metrics can be substituted while retaining the basic ecological foundation as originally proposed by Karr (1981). Therefore, the basic ecological foundation of the IBI—a multimetric composite that integrates attributes of fish communities and is sensitive to different sources of degradation (Fausch and others, 1990)—served as a means of assessing environmental degradation across broad geographic scales.

The conceptual framework of the IBI is based on underlying assumptions of how fish communities respond to increasing environmental degradation (Fausch and others, 1990; Yoder and Rankin, 1995). Among these assumptions, the following attributes are believed to increase with increasing environmental degradation: (1) the proportion of individuals that are members of tolerant species; (2) the proportion of trophic generalists, especially omnivores; (3) the proportion of individuals that are members of introduced species; and (4) the incidence of externally evident disease, parasites, and morphological anomalies. Thus, the multimetric approach to be used for the summary reports consists of a composite of percent tolerant, omnivore, and non-native individuals, and the percent of individuals with external anomalies.

Fish were classified as native or introduced based on published literature sources and on the nonindigenous aquatic species database for fish developed by the USGS Biological Resources Discipline (http://nas.er.usgs.gov/fishes/).

Classifications were made at the study-unit level. Fish taxa were classified nationally as "tolerant", "intolerant", or "moderately tolerant" based on information in the literature. "Tolerant" was defined as those fish that are reported to thrive in degraded water quality. Fish species were also classified nationally into 3 trophic categories: insectivores, piscivores, and omnivores based on the primary feeding ecology of adults. Total anomalies were determined based on all anomalies listed as observed. In general, fish are more likely to develop anomalies including deformities, tumors, and parasites in areas with degraded water quality. However, many of the diseases and parasites including in the total anomaly counts (for example, blackspot disease) may be linked to factors other than poor water quality. In the national NAWQA dataset, relatively high values of blackspot disease occurred at many sites. Thus, the metric used to represent anomalies consisted of that portion of the total anomalies restricted to Deformities, Eroded fins, Lesions, and Tumors ("DELT" anomalies).

Most applications of the multimetric approach have involved small- to medium-sized wadeable warmwater streams (Simon and Lyons, 1995). Regional adjustments have been made to IBIs to account for differences in fish communities along the river continuum from headwaters to mouth to account for natural variability across: 1) colder, headwater streams, 2) warmer tributary streams, and 3) mainstem large rivers. The multimetric approach used for the summary reports attempted to adjust for these natural differences by establishing 3 categories of drainage area within each study unit. Within each study unit, quartiles were calculated for drainage area and the quartiles categorized such that drainage areas less than or equal to the 25th percentile were classified as small basins, between the 25th and 75th percentile were classified as medium basins, and greater than or equal to the 75th percentile were classified as large basins (see Table 1 for example).

For fish community samples within each basin size for each study unit, quartiles were calculated for each of the four metrics: % tolerant individuals, % omnivorous individuals, % non-native individuals, and % individuals with DELT anomalies. Because these metrics are generally believed to increase with increasing environmental degradation, each was scored so that values less than or equal to the 25th percentile were scored as "1", values between the 25th and 75th percentiles were scored as "3", and values greater than or equal to the 75th percentile were scored as "5". This scoring was used to group data into categories to represent low ("1"), moderate ("3"), and high ("5") levels of fish community degradation. Scores for each of the four metrics were summed to provide an index value ranging from 4 to 20 for each fish community sample. Median index values were then generated for each site where multiple-reach or multiple-year data were available. National quartiles of the Fish Status Index were calculated to rank fish index values as "low" (values less than or equal to 8), moderate (values between 8 and 12), and high (fish index values greater than or equal to 12).

The fish status index approach described for the NAWQA summary reports represents an assessment of the fish community at one point in time and, therefore, interpretations may be coarse. Also, the approach includes fewer metrics than the IBI and thus will be less sensitive to a broad spectrum of environmental degradation than an IBI. Although limitations exist with any index approach, we believe that the multimetric approach described to assess fish communities can provide useful information to assess gross environmental changes across broad geographic scales.

Interpreting Fish Status Index values and ranks:
Assessing effects of land use on fish communities requires a clear understanding of natural factors that influence fish community structure. Ecological processes and aquatic communities in streams gradually change longitudinally as stream size increases and gradient changes (Vannote and others, 1980; Hughes and Gammon, 1987). Overlaid on this longitudinal continuum is a pattern of urbanization and development of arable lands, which historically has occurred along streams and rivers. Thus, these patterns have the potential to mask one another. Small, cold-water, fast-flowing streams draining high elevation watersheds typically have naturally low species diversity and fish abundance. Conversely, slow-flowing, relatively large streams and rivers (at lower elevations, with warmer water temperature) have comparatively greater species diversity and fish abundance. Generally agricultural land use dominates at these lower elevation sites, while forested land use often dominates at the higher elevation sites. Also, the effects of agricultural land use are multiple, including changes in water chemistry, habitat, and flow. Thus, caution must be used when attempting to understand the effects of land use on fish communities within the context of this natural variability in fish communities. Interpretation of land-use effects on fish communities should be made within the context of natural variation as characterized by comparable sites represented by minimally impacted or reference conditions if possible – either through sites sampled as part of the NAWQA program or using reference conditions established from literature sources.

In addition, local scale factors may serve to mitigate the potential impacts of basin-wide land use. Wang and others (1997) noted that even when agriculture in the basin exceeded 80%, IBI scores at some sites suggested fish communities in good condition. The authors reported that whereas at a coarse scale, basin land use may be a predictor of IBI scores, riparian land use was important—and, in some cases, a better predictor of IBI scores than basin land use. The authors also stated that the "distribution of a land use within a watershed may be as important as the amount of the land use in influencing stream ecosystems." Lammert and Allen (1999) found local, site-specific stream conditions were more important than basin-wide landscape factors for explaining biological conditions. Stauffer et al. (2000) found that both basin-wide landscape (soils) and local (riparian vegetative cover) factors were able to explain a significant portion of the variance in IBI scores and fish species richness in agricultural streams in

Minnesota. Effects of local scale factors such as hydrology and habitat should be taken into consideration when interpreting Fish Status Index values and ranks. Important habitat factors could include stream geomorphology (pool/riffle versus run), substrate (silt/sand versus gravel), and riparian condition (for example, canopy angle).

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Table 1. Example of categorizing basins and scoring of fish metrics within basin categories. Example is for illustration only.

I. Small basins — (drainage area 0 to 342 square kilometers)

SCORING CRITERIA

METRIC	1 (LOW)	3 (MOD)	5 (HIGH)
Percent Tolerant	0 – 2	2 – 30	>30
Percent Omnivores	0 – 5	5 – 20	>20
Percent Non-native	0 – 1	2 – 6	>6
Percent Anomalies	0 – 1	2 – 3	>3

II. Medium basins — (drainage area 343 to 4,372 square kilometers)

SCORING CRITERIA

METRIC	1 (LOW)	3 (MOD)	5 (HIGH)
Percent Tolerant	0 – 8	8 – 20	>20
Percent Omnivores	0 – 10	10 – 25	>25
Percent Non-native	0 – 2	2 – 17	>17
Percent Anomalies	0 – 2	3 – 5	>5

III. Large basins — (drainage area 4,373 to 55,407 square kilometers)

SCORING CRITERIA

METRIC	1 (LOW)	3 (MOD)	5 (HIGH)
Percent Tolerant	0 – 20	20 – 40	>40
Percent Omnivores	0 – 20	20 – 33	>33
Percent Non-native	0 – 2	3 – 20	>20
Percent Anomalies	0 – 2	3 – 7	>7