# Biological Criteria Development for the Ohio River, USA

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## Abstract

There is a growing trend in the United States to develop biological methods to assess the status of the nations surface waters. The Ohio River Valley Water Sanitation Commission has collected biological data from the Ohio River since the 1950's. Beginning in 1990 the commission began to focus on the development of biological criteria to more accurately monitor and measure improvements to the system. The morphological and hydrological characteristics of the Ohio River require that current collection and assessment methods used for smaller streams must be substantially modified for use on the Ohio River. Sampling has revealed that spatial trends in the biota exist along the length of the river and within navigational pools. The micro-habitat present at each sampling location is also closely correlated to the composition of the biological fauna present. Temporally, improvements to the water quality of the system has resulted in an improving biological community. Each of these patterns are being incorporated into the formation of biological criteria. The riverwide application of biocriteria will allow the characterization and comparison of the water resource quality of the Ohio River and establish biological goals, similar to water quality goals.

**Keywords**: Biocriteria, fish, macroinvertebrates, Ohio River, ORSANCO

## Introduction

The Ohio River Valley Water Sanitation Commission (ORSANCO) is an interstate agency created in 1948 for the purpose of identifying, monitoring and abating water pollution problems in the Ohio River Basin. The value of monitoring biological populations to assess water quality conditions was recognized by the Commission as early as 1957, with the implementation of lockchamber fish population surveys. Today, these surveys are conducted annually on the Ohio River and continue to provide valuable information on Ohio River fish populations and their response to natural and man-made environmental and water quality conditions. While lockchamber fish surveys do provide insight into fish population dynamics on a system-wide basis, they are biased in that they are capable only of assessing the fish community condition within the lockchambers of the navigational lock and dams, an anthropogenic feature of the Ohio River. The inapplicability of these surveys to other habitat types within the river necessitated the formation of collection techniques which could be applied to multiple habitat types.

In response, the Commissions biological programs were expanded in 1990 to include the development of an additional sampling technique, boat-mounted electrofishing. This technique provided the mobility necessary to allow the sampling of fish populations at any near-shore location along the river. This mobility marked the beginning of ORSANCO's characterization of the Ohio River and provided the Commission a tool with which to begin biocriteria development.

Biological criteria can be used by States to confirm impairment from a known source of impact, determine support of designated aquatic life use classifications for application in standards, and represent a programmatic expansion from source control to resource management. Many states now use some form of standardized biological assessment to determine the status of the biota of their waters. Some states even use biological criteria to define aquatic life use classifications and to enforce water quality standards.

Currently, three states have statutory biocriteria, 21 have management biocriteria, 23 are developing biocriteria and only three are not using biocriteria at all.

The states of the Commission have established numeric biological criteria for the Ohio River as a goal. An assessment tool is desired for detecting impairment from a known source of impact, as well as aquatic resource characterization and use support assessments for the entire Ohio River.

The steps to achieving this goal are three-fold: 1) The individual components of the biocriteria must be selected. 2) Current technologies must be modified for use on this large and dynamic system. 3) A strategy must be developed for applying biocriteria to the inter-state waters of the Ohio River.

## Methods

### Study Area

The Ohio River (Figure 1) begins at the confluence of the Monongahela and Allegheny Rivers and flows southwesterly to the confluence with the Mississippi River, covering 981 miles. The river is contained within 20 navigational dams which provide a nine-foot minimum depth for navigation. The study area dissects four ecoregions: the Western Allegheny Plateau, the Interior Plateau, the Interior River Lowland and the Mississippi Alluvial Plain (Omernik, 1987).

### ORSANCO'S Approach

In 1995 ORSANCO assembled a panel of biological and Ohio River experts to facilitate the development of biological criteria for the fish population of the Ohio River. The charge of this panel is to aid in the design of studies and interpretation of data necessary for the development of biocriteria. The panel includes experts from academia, industry, state and federal agencies as well as ORSANCO staff.

In March of 1997, a second panel of experts was formed to assist in the development the macroinvertebrate component of biocriteria. The charge of this panel was similarly focused, but directed towards the second component of biocriteria, aquatic macroinvertebrates.

## Components of Biocriteria

To date, two components of biocriteria have been chosen, fish and macroinvertebrates. Each is an important component of the biota of the Ohio River and has been shown to be good indicator of water quality conditions.

### Fish

Fish correspond to the regulatory and public perceptions of water quality and reflect cumulative environmental stress over longer time frames. Fish are often used by the public to arbitrarily judge the quality of a waterbody and game species are sought after by thousands of fishing enthusiasts along the river, with many consuming their catch. The public also weighs concerns over fish contamination and the risks involved with consuming fish from the Ohio River.

Fish are relatively long-lived organisms which are easily used to detect impairments through examining the structure and function of the community representing the area in question. ORSANCO has chosen to use two types of descriptive indices to assess fish communities, the Index of Biotic Integrity (IBI) and the Modified Index of Well Being (MIwb). Each of these indices examines a different

component of the structure and function of the fish community and will be modified for use on the Ohio River.

### *Collection Methods*

The collection method used for the biocriteria development process requires that standardized field, laboratory, and data processing methods and procedures are followed according to ORSANCO (1996) and OEPA (1987). Fish are collected using a boat electrofishing technique employed during the night based upon the results of a day -vs- night comparison study (Sanders 1992). A two-person or three-person crew manning an 5.5 meter aluminum john boat, equipped with a 5000-watt generator and a Smith-Root Type VI-A Electrofishing unit providing pulsed DC current, samples each zone beginning no sooner than 30 minutes after sunset. Each zone is 500 meters in length and extended out from the shore/water interface approximately 25 meters. This near shore area is utilized in order to stay in the shallower areas where the sampling gear is more effective. The effective depth of the gear is 3-5 meters. Each zone is fished for 2000 - 3000 seconds, depending upon the structure of the habitat being fished. The stunned fish are netted, placed in an aerated holding tank, weighed, measured and returned safely to the water. Samples are collected from July 1 through October 31 in order to maximize sampling efficiency by collecting only during the stable flow conditions characteristic of the summer and early fall months. To date, 340 collections have been made riverwide, at an average of 100 per year.

## Macroinvertebrates

Macroinvertebrates include organisms such as crayfish, snails, clams, aquatic worms as well as the larval and some adult forms of several insect orders. They form relatively immobile communities, are easily sampled in large numbers and are quick to react to environmental change. They represent the middle of the aquatic food web and are a major food source for many types of fish.

Macroinvertebrate species composition and community structure are very reflective of the environmental conditions experienced throughout the life span of the organisms. A well balanced macroinvertebrate community usually exists in areas of high water quality and suitable habitat and polluted conditions bring about noticeable shifts within the community structure. Pollution tolerant organisms gradually replace sensitive ones until under the most toxic conditions, all species of macroinvertebrates are eradicated from the area.

### *Collection Methods*

Macroinvertebrates are collected using a modified Hester-Dendy (H-D) multi-plate artificial substrate quantitative sampling device. The device consists of eight 7.62 centimeter square, 31.75 millimeter thick masonite hardboard with five 31.75 millimeter spaces, two 63 millimeter spaces and one 95.25 millimeter space. The plates are then drilled and placed on a 63 millimeter eyebolt.

The H-D units are assembled into a cluster of five, attached to a cement block which acts as an anchor, and are submerged into the near-shore area in approximately one meter of water. The units are left in place for six to eight weeks to allow the macroinvertebrates to colonize the sampling unit, and at the end of that time, are gently removed from the water and preserved for analysis. The cluster unit provides a 0.45 square meter quantitative sample, which is used to represent the macroinvertebrate community of the area in question.

## Other Components of Biocriteria

Algae, aquatic macrophytes and mussels are also being considered as components of biological criteria for the Ohio River. Although, at this time all research efforts are being focused on the first two components. It is planned that as the development of one component nears completion, the development of the next will begin. In 1998 as the fish index nears completion, more and more resources will be focused towards the second component, macroinvertebrates.

## Modifying Current Technologies for use on the Ohio River

Current technologies available for the assessment of aquatic biota have not been modified for use on the Ohio River. In fact, great river water resource biological integrity has only been recently recognized (Simon and Lyons, 1995). Useful modifications of the IBI (Simon and Emery, 1995) and the MIwb (ORSANCO, 1992) for application to the Ohio River to assess stream resource quality have been suggested. The Ohio EPA modified the Iwb, making it more sensitive to a wider array of environmental disturbances, particularly those which result in shifts in composition without large reductions in species richness, numbers, and / or biomass. The Modified Index of Well Being (MIwb) retains the same computational formula as the conventional Iwb, but any of the 13 highly tolerant species are eliminated from the numbers and biomass components (ORSANCO, 1992). The modification prevents high MIwb scores from degraded sites with high numbers of pollution tolerant fish.

Suggested modifications to the IBI include selecting individual metric components sensitive to anthropogenic changes associated with impoundment, channelization, dredging, siltation and industrial and municipal dischargers. Biological reference condition expectations need to be developed within a regional framework and metric performance tested on an individual impoundment basis (Simon and Emery, 1995)

Throughout ORSANCO's biocriteria development process, researchers have revealed numerous trends in the biological community which must be understood and interpreted in order to fully assess the condition of the biota.

### Riverwide Trends

Longitudinal patterns of the biota of the Ohio River (Figure 2) may be inconsistent with expectations based upon Omernik's ecoregional boundaries (Simon and Emery, 1995). Macro-scale biogeographic boundaries for the Ohio River will be established and incorporated into the biocriteria development process. This will enable the formation of reference condition expectations within a regional framework.

### Within Pool Trends

The navigational dams create varying hydrologic conditions throughout the pool. A rapid flowing riverine condition exists at the headwaters of each pool, a transitional area exists in the middle area and the lower area is more lacustrine. These varying hydrologic conditions cause a subsequent biological gradient to exist. Stanford et. Al. (1988) indicated that hydrologic equilibrium is attained below dams as energy is balanced along the river continuum. Certain species show a marked affinity for the riverene areas (Figure 3), while others are more common in the lacustrine areas of the lower pool.

## Temporal Trends

Decades of improvements to the nations surface waters have provided a much more suitable environment for the aquatic inhabitants. Although water quality following the Clean Water Act has improved, the biological responses associated with these improvements is relatively undocumented or has shown a decline for large river biological communities (Karr 1992). Figure 4 shows a clear biological response to improving water quality. These responses must be revealed and closely monitored in order to most properly assess the aquatic resource condition of the system.

## Visions for Applying Biocriteria on the Ohio River

The riverwide application of biocriteria will allow the characterization and comparison of the water resource quality of the Ohio River and establish biological goals, similar to water quality goals. It is expected that permits for discharges will be limited to biocriteria in such a manner as to allow for permit limitations to be adjusted, or retained based on downstream attainment or comparison upstream versus downstream. In addition, use of biocriteria can identify inadequacies in chemical criteria and vice versa. For example, continuing violations of chemical criteria established to protect aquatic life may be recorded while criteria are being achieved. Such situations warrant investigation of the criteria comparatively. Finally, use of biocriteria will do much to answer the question of the extent to which the waters are meeting "fishable" goals of the Clean Water Act.

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**Figure 1. Map of the United States and corresponding enlarged view of Ohio River and its tributaries.**

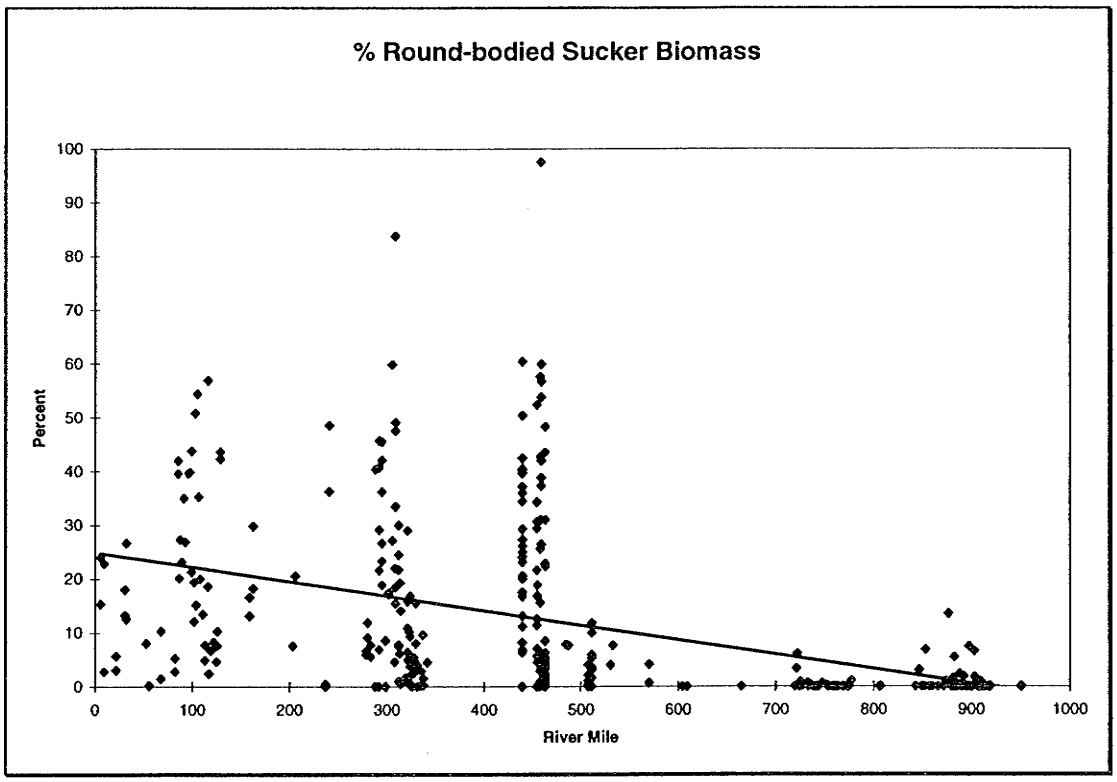


**Figure 2. A single metric component of the proposed biocriteria fish index showing uneven distribution on a riverwide scale.**

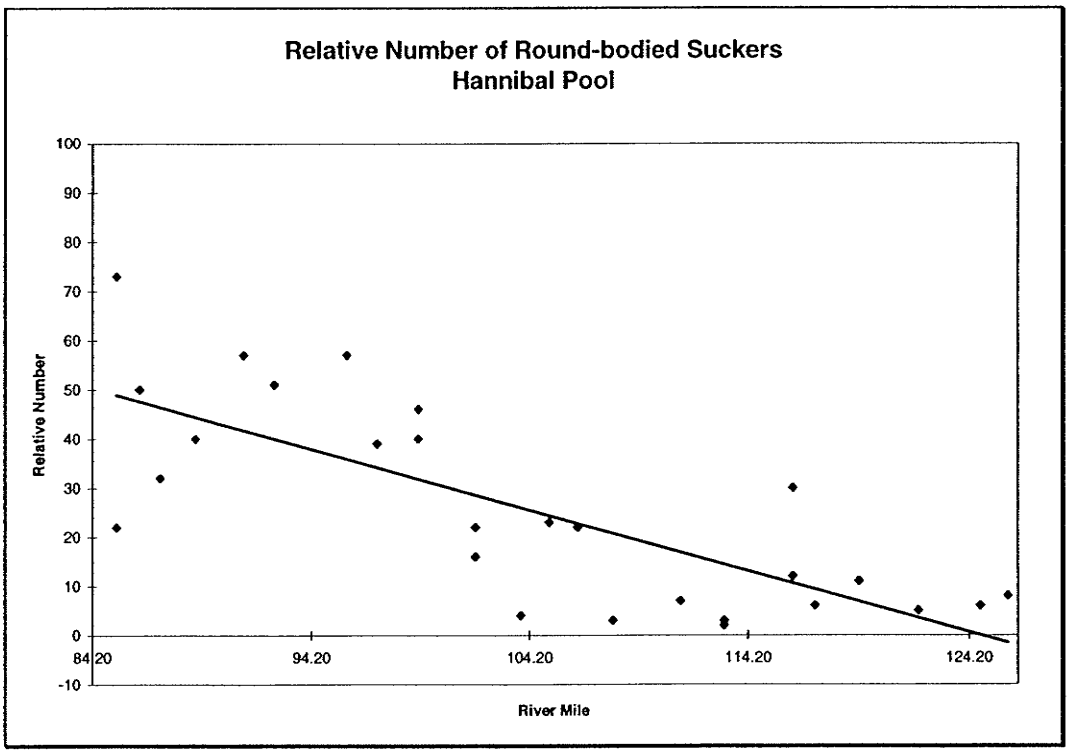


**Figure 3. Plot displaying single metric component of the proposed biocriteria fish index showing uneven distribution within the Hannibal Pool of the Ohio River.**

# Foreword

These Proceedings contain the presentations, discussions, and resulting recommendations from among nearly 400 participants representing monitoring interests from federal, state, tribal, local, academic, and private organizations. The conference from which they were taken was, in part, made possible by financial support provided by the U.S. Environmental Protection Agency, the U.S. Geological Survey, the National Oceanographic and Atmospheric Administration, and the U.S. Department of Agriculture.

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*Appropriate Citation*: U.S. Environmental Protection Agency. 1998. Proceedings of the NWQMC National Conference *Monitoring: Critical Foundations to Protect Our Waters*. U.S. Environmental Protection Agency, Washington, DC. 663 pages plus appendixes.