FIBI, BIBI and PHI: An Acronymic Assault to Assess Aquatic Assemblages

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Abstract

Over the last quarter century, fish communities have been extensively employed to assess freshwater ecosystem health. Significant advances in this arena have led to development of integrative ecological indices, such as Indices of Biotic Integrity (IBI), that relate fish communities to both biotic and abiotic ecosystem components. In addition to the development of fish IBIs, recent work has also led to development of benthic and physical habitat IBIs to supplement fish IBIs. In Maryland, there has been extensive development of these indices through the Maryland Biological Stream Survey (MBSS), a state program that started in the early 90s.

The MBSS Sampling Program was designed to provide comprehensive information on the status of biological resources in Maryland streams, and how these resources are affected by acidic deposition and/or other cumulative effects of anthropogenic stressors. For many years, the Maryland Department of Natural Resources (MDNR) recognized that atmospheric deposition, resulting from electric power generation, was one of the most significant environmental problems affecting not only Maryland, but also the entire Chesapeake Bay watershed. The link between surface water acidification and acidic deposition was well established and many studies pointed to adverse biological effects of low pH and acid neutralizing capacity.

To determine the extent of Maryland stream acidification, MDNR conducted the Maryland Synoptic Stream Chemistry Survey (MSSCS) in 1987 – a survey designed to estimate the number and extent of streams affected statewide by acidification. This program was instrumental in determining that the greatest concentrations of fishery resources at risk were found in the Appalachian Plateau and Coastal Plain sampling strata. These regions of Maryland have geological formations with low buffering capacities. The MSSCS demonstrated the potential for adverse acidification effects on biota but there was little information relating biological responses of Maryland streams to overall water chemistry conditions. Although there were many studies completed on biological resources in Maryland, these data sets were not useful to compare biological differences across regions or watersheds, and could not be tied into data developed through the MSSCS. To develop a comprehensive approach for resource assessment in Maryland, MDNR initiated the MBSS in 1993.

The MBSS is a unique program. Prior to sampling, workshops were held to determine methodology as well as statistical approaches to sampling, along with one-year pilot and demonstration projects. Primary objectives of the MBSS are to: 1) assess the current status of biological resources in Maryland's non-tidal streams; 2) quantify the extent to which acidic deposition is affecting biological resources in Maryland; 3) examine which other water chemistry, physical habitat and land-use factors are important in explaining the current status of stream biological resources; 4) compile the first statewide inventory of stream biota; 5) establish a benchmark for long-term monitoring of trends in Maryland's biological resources; and 6) target future local-scale assessments and mitigation measures needed for restoration of biological resources.

In creating the MBSS, MDNR implemented a probability-based sampling design as a cost-effective method to characterize statewide stream resources – a unique design that is encouraged by EPA. Through a random-site selection process, MBSS data may be used to make quantitative inferences about characteristics of all 14,899 km of first to third order, non-tidal streams in Maryland (based on a 1:250,000 base map scale). This design allows robust estimates at the level of stream size (Strahler orders 1, 2, and 3), large watershed (18 major river basins), and statewide. Other inferences, such as counties or smaller watersheds, may be done based on the number of MBSS sampling points.

During the MBSS, three key indices were developed – a fish index of biotic integrity (FIBI), a benthic index of biotic integrity (BIBI), and a physical habitat index (PHI). The FIBI was specifically tailored to Maryland fish populations taking into account the physiographic variation found within the state. Coupled with the FIBI, a BIBI was also developed using the same general approach. Consequently, Maryland had two indices that related biotic factors to water quality and habitat.

Coupled with chemical-physical water quality, habitat quality (and quantity) is important to consider when examining fish communities, especially all derived biotic IBIs. To explain the interrelationship of biotic indices to habitat, the PHI was derived for Maryland, also using the same general approach. However, indices of habitat quality have lagged behind biotic IBI development. In part, this is because of difficulty in developing accurate, precise and complete methodologies to assess quantitatively and qualitatively habitat characteristics. Impetus for including stream habitat as an important measure came initially from the western states.

These indices are extremely useful in stream monitoring and represent a critical tool to monitor stream health in Maryland. Because of the nature of the program design, these indices have been used to provide estimates of the number of stream miles in Maryland that have been affected by various stressors. Future refinement will take place as the program increases sample size (currently at over 1000 samples stream reaches).