United States Environmental Protection Agency
Office of Water (4304)
EPA 822-F-02-006
Summer 2002

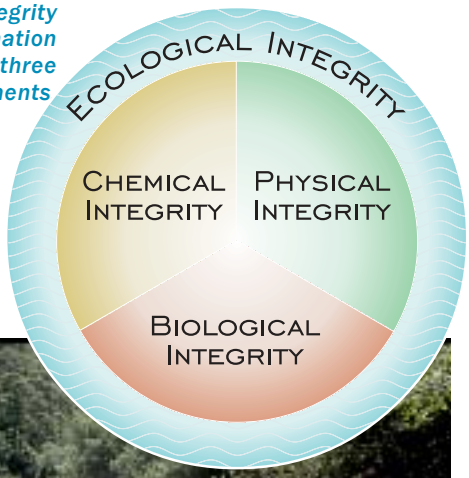
Biological Assessments and Criteria: Crucial Components of Water Quality Programs

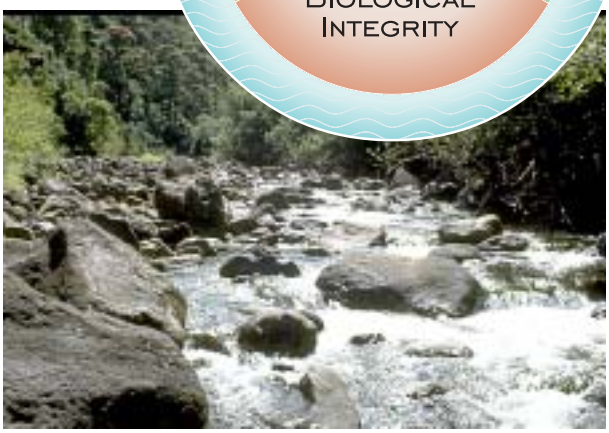
Adult mayfly

What are healthy waterbodies?

Healthy waterbodies exhibit ***ecological integrity***, representing a natural or undisturbed state. As the diagram to the right illustrates, ecological integrity is a combination of three components: chemical integrity, physical integrity, and biological integrity. When one or more of these components is degraded, the health of the waterbody will be affected and, in most cases, the aquatic life living there will reflect the degradation.

Ecological integrity is a combination of three components





The true health of our aquatic environment is reflected by the biological communities that reside within them.

What are bioassessments and biocriteria?

Stonefly nymph

The identification of water quality degradation requires appropriate monitoring tools. Such tools help us detect and characterize the cause and source of chemical, physical and biological impairment. ***Bioassessments*** are the primary tool to evaluate the biological condition of a waterbody. Bioassessments consist of surveys and other direct measurements of aquatic life—aquatic vegetation and algae, fish, insects, crayfish, salamanders, frogs, worms, snails, mussels, etc.—in the waterbody. Bioassessments, along with other physical and chemical assessments, are crucial for evaluating the health of a waterbody.

Aquatic life integrates the cumulative effects of different stressors such as excess nutrients, toxic chemicals, increased temperature, and excessive sediment loading. Therefore, bioassessments allow us to measure the aggregate impact of the stressors. Because biological communities respond to stresses over time, they provide information that more rapidly-changing water chemistry measurements or toxicity tests do not always produce. As such, bioassessment

Definitions

Biological Assessment (Bioassessment): *An evaluation of the biological condition of a waterbody using biological surveys and other direct measurements of the resident living organisms.*

Biological Criteria (Biocriteria): *Numeric values or narrative descriptions that are established to protect the biological condition of the aquatic life inhabiting waters that have been given a certain designated aquatic life use.*

Biological Integrity (Biointegrity): *The capacity of supporting and maintaining 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.*

Benefits of biological information

- *Where criteria for waterbody impacts do not exist (e.g., impacts that degrade habitat), biological communities may be the only practical means of evaluation.*
- *Biological data are essential for successful aquatic life use attainability analyses and site-specific criteria derivations.*
- *Biological data can be used to track water quality trends, list and de-list waters under 303(d) of the Clean Water Act and to assess the effectiveness of TMDLs.*
- *Because biological organisms are exposed to the effects of most all the different stressors in a waterbody, they provide a measure of the stressors' combined impact.*
- *Biological organisms integrate stress over time and thus provide a measure of fluctuating conditions.*
- *Routine monitoring of biological communities can be relatively inexpensive, particularly when compared to the cost of monitoring individual toxic pollutants.*
- *The public views the status of biological organisms as a measure of a pollution-free environment.*

Benefits of bioassessment to requirements of the CWA:

Aquatic Life Use Attainment (section 305b): *bioassessments clearly determine if a waterbody has healthy aquatic life*

Nonpoint Source (section 319): *bioassessments are the most effective way to evaluate cumulative impacts from nonpoint sources (both chemical and non-chemical stressors*

TMDLs (section 303d): *bioassessments help provide an ecologically based assessment of the status of a waterbody and help prioritize waterbodies for TMDLs based on the severity of biological damage*

NPDES (section 402): *bioassessments directly measure the combined impacts of any and all stressors on the resident aquatic biota and can be used to determine the effectiveness of permit controls*

provides a more reliable assessment of long-term biological changes in the condition of a waterbody. ***The central purpose of assessing biological condition of aquatic communities is to determine how well a water body supports aquatic life.***

Sunfish

Bioassessments reflect the condition of overall ecological integrity (i.e., when the biology is healthy, typically the chemical and physical components of a waterbody are also in good condition). Therefore, bioassessments directly assess the condition of ecosystem health, a primary goal of the Clean Water Act (CWA).

Biologists and other natural resource scientists use accepted scientific principles to derive ***biocriteria*** from bioassessment data. Biocriteria are narrative descriptions or numerical values that states and tribes can adopt into water quality standards to describe a desired condition for the aquatic life in waters they have designated for aquatic life use. The standards, in turn, are used along with chemical and physical criteria to better manage water resources.

What is the status of bioassessment and biocriteria in state programs?

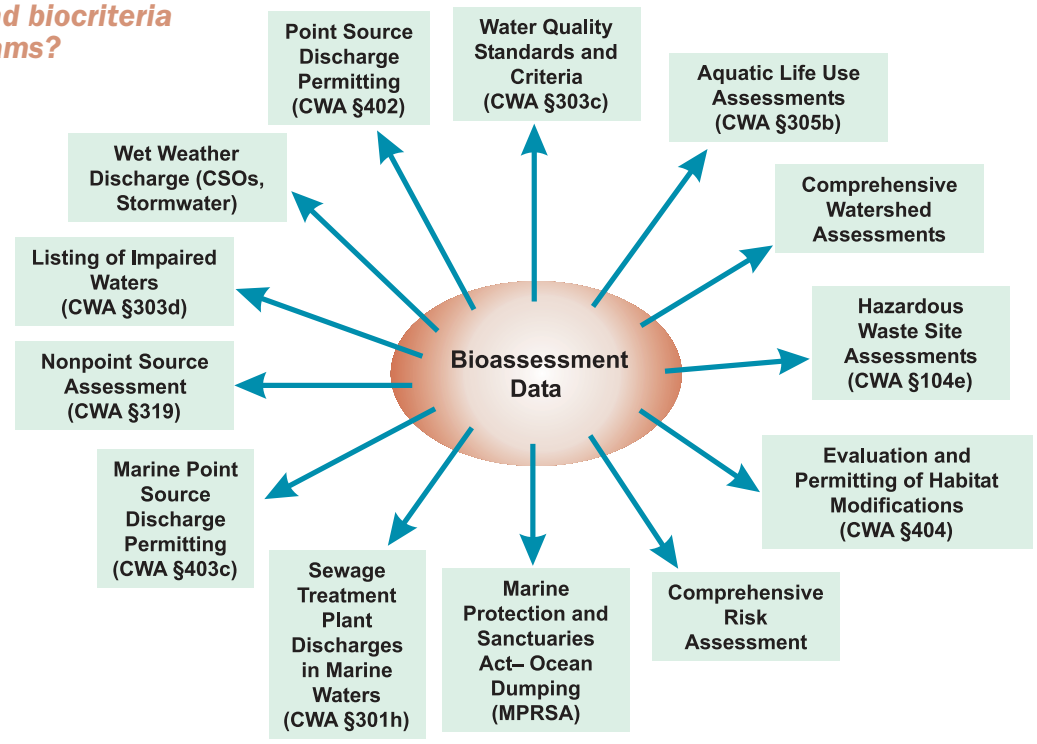
The use of biological assessment and criteria for managing the Nation's waterbodies is progressing and is equipping the states, tribal nations, and EPA with a more effective set of monitoring tools for protecting the ecological integrity of our water resources. In recent years, progress has been made in using bioassessments to establish biocriteria. In 1994, twenty states were beginning a biological assessment program for streams and rivers, and fourteen states had biological programs in place. However, only eleven were developing or had developed biocriteria based on their monitoring programs. By 2001, most states and several tribes had established biological monitoring programs for streams and small or wadeable rivers and were using quantitative biocriteria. The development of biocriteria for bodies of water other than streams and wadeable rivers is more recent.

Mayfly nymph

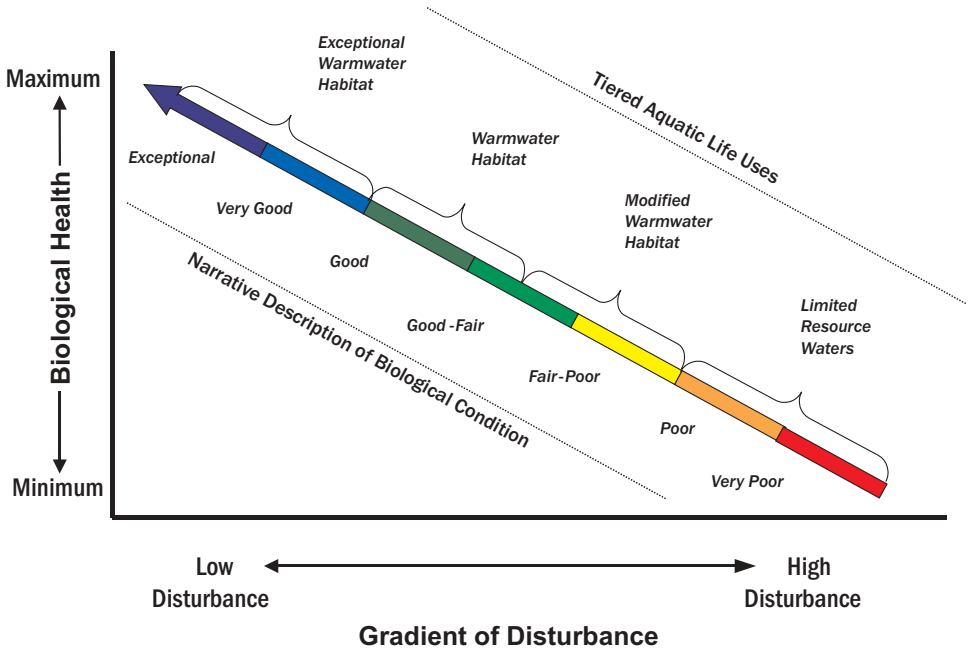
How are bioassessments and biocriteria used in water quality programs?

Bioassessments provide crucial water quality information for managing complex water quality problems. Many natural, chemical, and physical integrity factors directly influence biological integrity. Hence, attaining biological integrity reflects good waterbody health. When human activities disrupt chemical and physical integrity, biological integrity is also compromised, and ecological health declines. Bioassessments are the tool for measuring biological condition and serve three primary functions:

1. screening or initial assessment of conditions
2. characterization of impairment and diagnosis; and
3. trend monitoring to evaluate improvements or further degradation.



Use of bioassessment in water quality programs

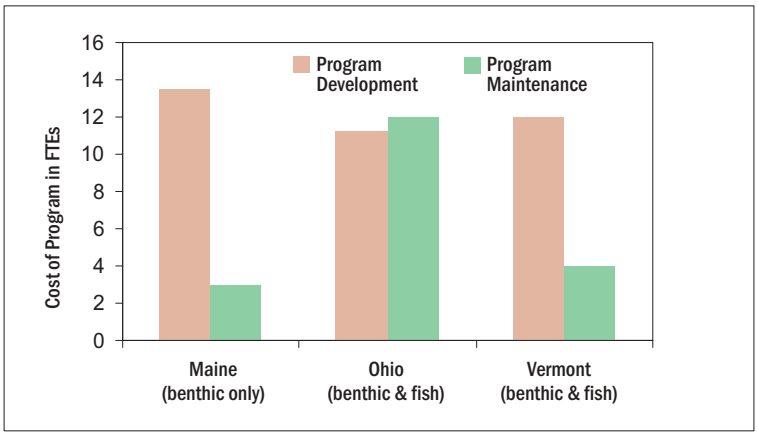


A framework for using bioassessments and criteria to set Aquatic Life Uses

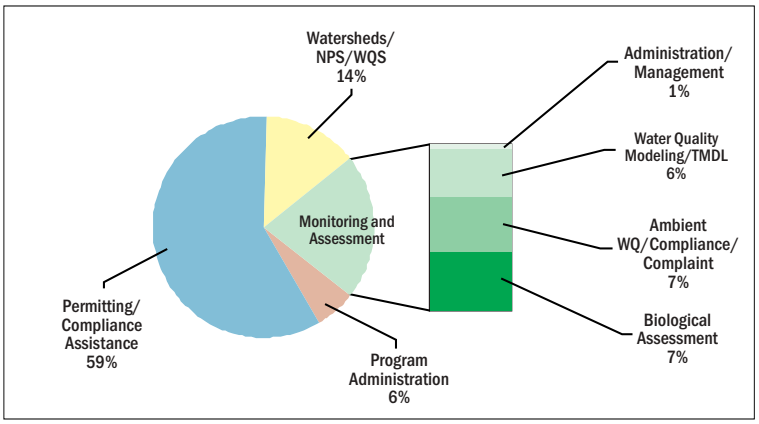
One use of bioassessments is to help states and tribes develop expectations for acceptable biological conditions. This is done through a technical process of establishing aquatic life goals, referred to as ***aquatic life uses*** (ALU). Biological assessments allow various levels of ALUs, so that one set of standards supports intact communities in a waterbody, and other sets of standards establish restoration goals for rural or urban streams or other altered ecosystems. Using several types, or tiers, of ALUs allows states and tribes to allocate limited resources to waterbodies in proportion to their need for protection. The figure above illustrates one such approach.

What does it cost to establish and maintain a biological assessment and criteria program?

Biocriteria programs begin with a strong bioassessment and biomonitoring program. Expertise in ecological principles is required to develop and implement biocriteria. State agencies vary in the level of resources they invest in the process. As an example, the developmental costs for stream bioassessment for Maine (benthic macroinvertebrates), Vermont, and Ohio (fish and benthic macroinvertebrates) were similar. Development and implementation of a bioassessment framework into water quality programs took 7 to 11 years for these states. This timeframe will depend on resource investment and the ability to gather and analyze data. Most states are able to develop the technical framework for bioassessment in less than five years. Once the bioassessment framework is in place, the maintenance or continued monitoring is generally reduced.



Comparison of bioassessment programs in three states (FTEs = full time employees)



The allocation of FTEs to bioassessment in Ohio's water quality program (FTEs = full time employees)

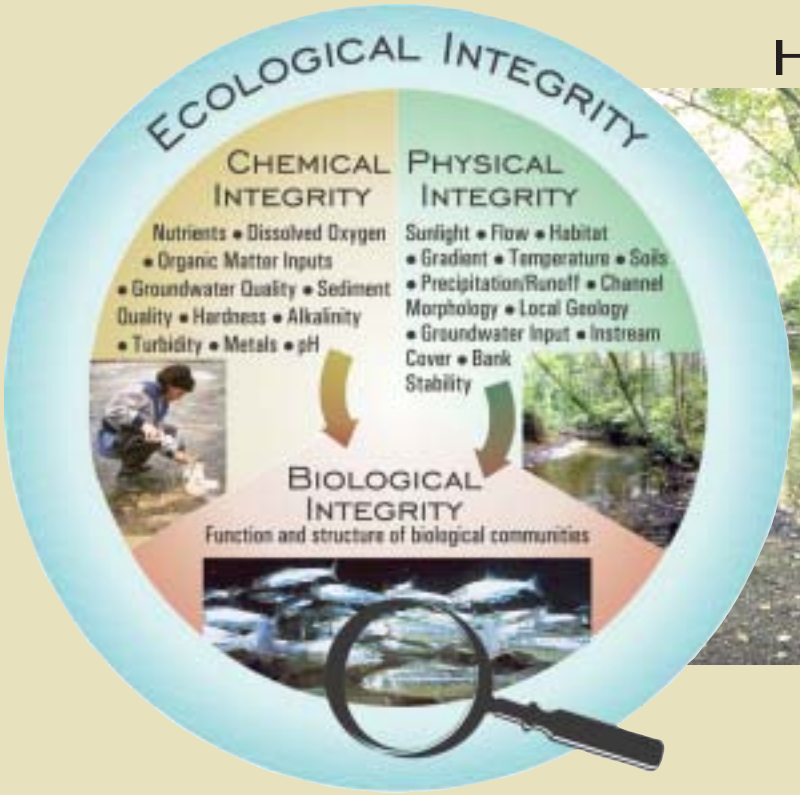
Programs of three states are highlighted as examples of development and maintenance costs for bioassessment. For Vermont and Maine, the equivalent of 4 and 3 FTEs, respectively, are dedicated to bioassessment and biocriteria-related activities. For Ohio, a larger state with a higher number of industrial and municipal discharges to their waters, 12 FTEs are allocated to the bioassessment and biocriteria program for the state's streams and rivers. Although Ohio expends more effort than Vermont and Maine, the ecological assessment component of the state's entire water resources program is only 7% of their personnel. Ohio's ecological assessment program includes all bioassessment and biocriteria activities for all waterbodies–not just streams.

Why should we adopt biological criteria?

The concept of ecological integrity is embedded in the statutory and regulatory structure of clean water law in the USA. One of the Clean Water Act's fundamental long-term goals is to protect aquatic resources by maintaining and restoring ecological integrity (combination of physical, chemical, and biological integrity). Bioassessments are the tool for states and tribes to determine the health of their waterbodies and achieve the level needed to support the waterbody's designated uses.

Under the CWA, states and tribes must designate aquatic life uses for their waters (i.e., environmental goals) that will achieve the purposes and objectives of the Act. This includes protecting and enhancing biological integrity and adopting the criteria necessary to protect those uses. Designated uses supporting aquatic life cover a broad range, or continuum, of biological conditions, with some waters being closer to an ideal of natural, undisturbed (biological integrity) status or condition.

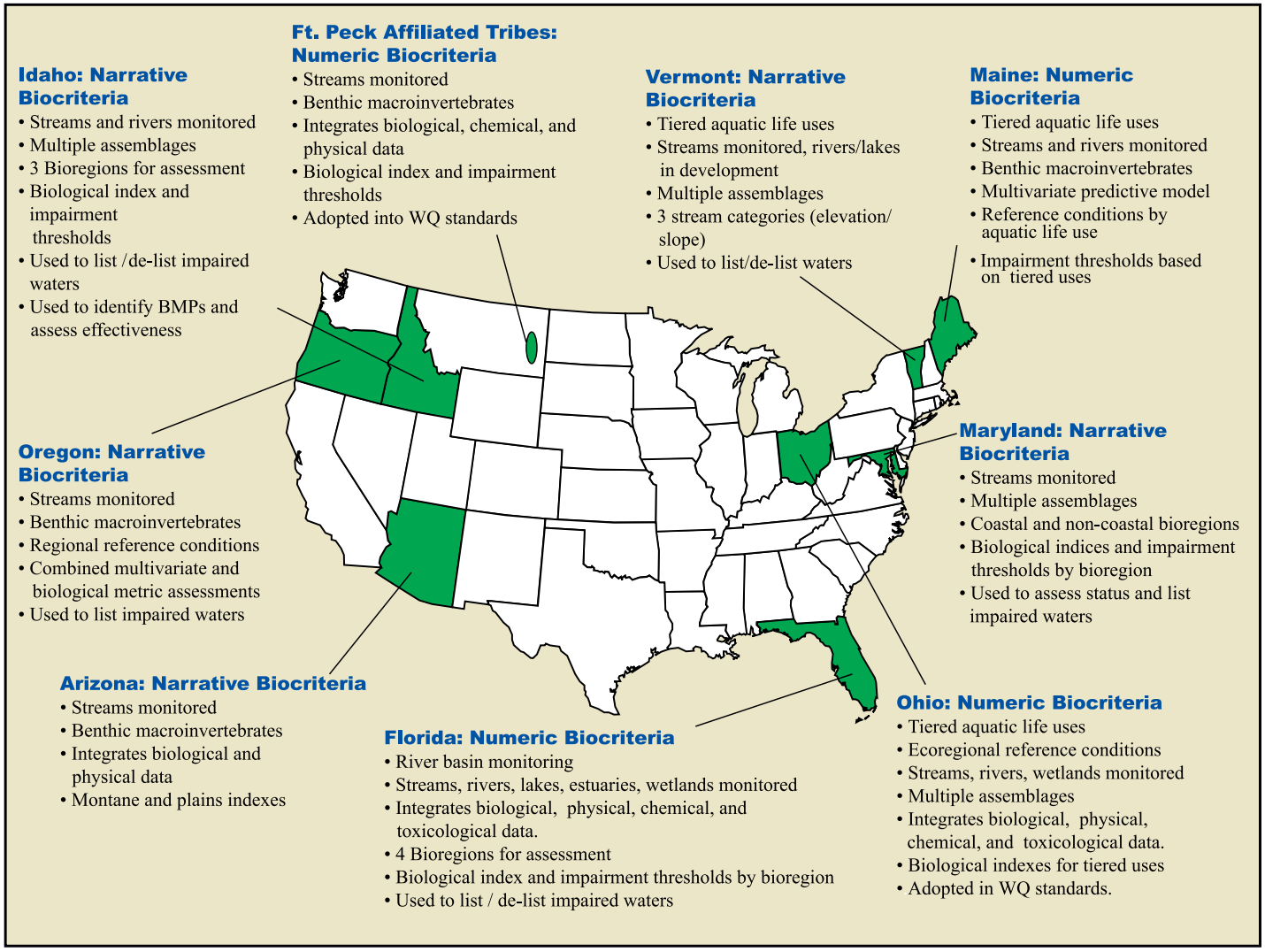
Collecting macroinvertebrates



Healthy Waterbody

Unhealthy Waterbody

The concept of ecological integrity, as defined in the CWA, is a combination of three components: chemical, physical, and biological integrity. Biological condition is the most comprehesive indicator of waterbody health.



Examples of bioassessment programs in the U.S.

References

Barbour, MT, J Gerritsen, BD Snyder, and JB Stribling. 1999. Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers: Periphyton, Benthis Macroinvertebrates and Fish. U.S. Environmental Agency, Office of Water, Washington, DC. EPA 841-B-99-002.

Biological Criteria: Guide to Technical Literature. U.S. Environmental Protection Agency, Office of Water. July 1991. EPA/5-91-004.

Biological Criteria: National Program for Surface Waters. U.S. Environmental Protection Agency, Office of Water, Washington, DC. 1990. EPA-440/5-90-004.

Biological Criteria: Research and Regulation—Proceedings of a Symposium. U.S. Environmental Protection Agency, Office of Water. July 1991. EPA-440/5-91-003.

Biological Criteria: Technical Guidance for Streams and Small Rivers. U.S. Environmental Progection Agency. May 1996. EPA 822-B-96-001.

Danielson, TJ. 1998. Wetland Bioassessment Fact Sheets. U.S. Environmental Protection Agency, Office of Water, Washington, DC. EPA 843-F-98-001.

Estuarine and Coastal Marine Waters: Bioassessment and Biocriteria Technical Guidance. December 2000. U.S. Environmental Protection Agency, Office of Water, Washignton, DC. EPA 822-B-00-024.

Lakes and Reservoir Bioassessment and Biocriteria Technical Guidance Document. U.S. Environmental Protection Agency, Office of Water. August 1998. EPA 841-B-98-007.

Macroinvertebrate Field and Laborator Methods for Evaluating the Biological Integrity of Surface Waters. U.S. Environmental Agency, Office of Water. 1990. EPA/600/4-90/030.

Regionalization as a Tool for Managing Environmental Resources. U.S. Environmental Protection Agency, Environmental Research Laboratory, Corvallis, OR. July 1989. EPA/600/3-89/060.

Standard Operating Procedures for the Collection of and Laboratory Identification of Freshwater Benthis Macroinvertebrates. U.S. Environmental Protection Agency, Region 5, Chicago, IL. 1989.

Standard Operating Procedures for Conducting Rapid Assessment of Ambient Water Quality Conditions Using Fish. U.S. Environmental Protection Agency, Region 5, Chicago, IL.

Stressor Identification Guidance Document. U.S. Environmental Protection Agency, Offices of Water and Research and Development. December 2000. EPA 822-B-00-025.

Summary of State Biological Assessment Programs for Rivers and Small Streams. U.S. Environmental Protection Agency, Washington, DC. 1996. EPA 230-R-96-007.

The Volunteer Monitor's Guide to Quality Assurance Project Plans. 1996. U.S. Environmental Protection Agency, Office of Water, Washington, DC. EPA 841-B-96-003.

For more information and to view or download some of the above documents, visit the U.S. EPA website for Biological Criteria at http://www. epa.gov/ost/biocriteria.