Chapter 2: Lake Biological Monitoring in USEPA, Local, State, Tribal, and Regional Protection and Management Programs

A state monitoring program is the source of data for all other state resource management programs. It helps to identify water quality problems, identify waters needing total maximum daily loads (TMDLs), quantify loads, verify models, and evaluate the effectiveness of point and nonpoint source water quality controls. A state’s monitoring program also serves as the backbone of its water quality programs. The biological monitoring protocols presented in this guidance document will strengthen a state’s monitoring program. An effective and thorough water quality program can help to improve reporting (e.g., 305(b) reporting), increase the effectiveness of pollution prevention efforts, and document the progress of mitigation efforts.

Biological monitoring and the establishment of biocriteria provide scientifically sound and detailed descriptions of designated aquatic life use for waterbodies. Biocriteria are biological benchmarks for measuring the condition of aquatic biota. They help determine whether water quality goals are attained, set priorities, and evaluate the effectiveness of implemented controls and management actions. Developing and implementing biocriteria for lakes and reservoirs is complicated in some states because of a high level of human intervention on a significant percentage of lakes and reservoirs. Many lakes and reservoirs are managed by the states for different uses (e.g., drinking water, recreation, fishing). Several lake management practices mask natural conditions; for example, stocking of fish and periodic lowering of lake levels. In addition, entire regions of the country have no natural lakes but have abundant reservoirs, which do not have the same attributes as most natural lakes.

Despite the variability in lake conditions, performing biological monitoring and developing biocriteria for lakes have important benefits. This section provides suggestions for the application of biological monitoring and biological criteria to lakes and reservoirs through existing state programs (Table 2-1).
### Table 2-1. Applications of lakes biological monitoring protocols and biocriteria.

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<thead>
<tr>
<th>Program</th>
<th>Biological Monitoring and Assessment</th>
<th>Biological Criteria</th>
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| Section 305(b) Reporting                     | • Improving data for beneficial use assessment.  
• Improving water quality reporting.            | • Identifying waters that are not achieving their aquatic life use support.             |
|                                              | • Defining an understandable endpoint in terms of “biological health” or “biological integrity” of watersheds. | • Identifying lakes that are not attaining designated use (including aquatic life use) support. |
|                                              | • Measuring effects of ongoing restoration projects.                                                 | • Defining lakes biological integrity based on a reference condition.                |
|                                              | • Measuring success of lake clean-up efforts and other mitigation activities.                       | • Identify impairments due to toxic substances.                                      |
|                                              | • Assessing lake trophic status and trends assessing biological trends.                             |                                                                                      |
|                                              | [Monitoring and sampling needs vary for each lake]                                                  |                                                                                      |
| Clean Lakes Program                          | [Clean Lakes Program Regulations monitoring components: algal pigments, algal genera, cell densities, algal cell volumes, limiting nutrients, macrophyte coverage, bacteria, and fish flesh analysis] |                                                                                      |
| Section 319/Nonpoint Source Program          | • Evaluating nonpoint source impacts and sources.                                                   | • Determining effectiveness of nonpoint source controls.                             |
|                                              | • Measuring site-specific ecosystem response to remediation or mitigation activities.               |                                                                                      |
|                                              | • Assessing biological resource trends within watersheds.                                          |                                                                                      |
| Watershed Protection Approach                |                                                                                                      | Setting goals for watershed and regional planning.                                  |
| TMDLs                                        | • Identifying biological assemblage and habitat impairments that indicate nonattainment of water quality standards. | • Identifying water quality-limited waters that require TMDLs.                       |
|                                              | • Documenting ecological/water quality response as a result of TMDL implementation.                | • Establishing endpoints for TMDL development, i.e., measuring success.              |
|                                              | • Prioritizing waterbodies                                                                         |                                                                                      |
| NPDES Permitting                              | • Measuring improvement or lack of improvement of mitigation efforts.                              | • Performing aquatic life use compliance monitoring.                                 |
|                                              | • Developing protocols that demonstrate relationship of biological metrics to effluent characteristics. | • Helping to verify that NPDES permit limits are resulting in achievement of state water quality standards. |

Table 2-1. Applications of lakes biological monitoring protocols and biocriteria. (Continued)
2.1 Section 305(b) Water Quality Assessment

Section 305(b) establishes a process for reporting information about the quality of the Nation’s water resources (USEPA 1993c, USEPA 1994f). States, the District of Columbia, territories, and certain River Basin Commissions have developed programs to monitor surface and ground waters and to report the current status of water quality biennially to USEPA. Special grants are available for Native American groups to provide similar assessments of water quality on tribal lands. This information is compiled into a biennial National Water Quality Inventory report to Congress. The 305(b) reports are a major data source helping USEPA to:

- Determine the status of water quality. (Are the designated/beneficial uses being met?)
- Evaluate the causes of poor water quality and the relative contributions of pollution sources.
- Report on the activities under way to assess and restore water quality.
- Determine the effectiveness of control programs.
- Determine the workload remaining in restoring waters with poor quality and protecting threatened waters.

Use of biological assessment in 305(b) reports helps to define an understandable endpoint of relevance to society - the biological health and integrity of waterbodies. Many of the better known and widely reported pollution cleanup success stories have involved the recovery or reappearance of valued sport fish and other pollution intolerant species to systems from which they had disappeared (USEPA 1980b, USEPA 1985a). Improved coverage of biological integrity issues, based on monitoring protocols with clear bioassessment endpoints, will make the 305(b) reports more accessible and meaningful to many segments of the public.

The 305(b) process encourages monitoring and assessment for all lakes. The Clean Water Act Section 314 Clean Lakes Program outlines specific assessment or
classification information for significant publicly owned lakes. Section 314(a)(2) of the CWA, as amended by the Water Quality Act of 1987, requires the states to submit a biennial assessment of their lake water quality as part of their 305(b) reports (USEPA 1993c). The specific elements of the assessment, as outlined in section 314(a)(10)(A-F), constitute the minimal requirements for approval and for subsequent grant assistance as required by section 314(a)(4). Each state report should reflect the status of lake water quality in the state, restoration/protection efforts, and trends in lake water quality. Each state should report the total number of significant publicly owned lakes and their acreage, the trophic status of each lake, control methods, restoration and rehabilitation efforts, the number of impaired and threatened lakes, acid effects on lakes, toxic effects on lakes, trends in lake water quality, and a description of the state's water quality standards that are applicable to lakes.

- Biological monitoring can provide data that could augment several of the 305(b) reporting requirements. In particular, the following lake assessment activities and reporting requirements could be enhanced through the use of the biological monitoring information:
  - Measuring the success of restoration and rehabilitation efforts when measured against reference conditions.
  - Measuring the success of Clean Lakes Program projects.
  - Developing and using lake water quality standards or, if water quality standards have not been developed for lakes, developing and using other biological measures to determine impaired or threatened status of lakes.
  - Identifying lakes and lake acres affected by acidity or toxics and those with elevated levels of toxics.
  - Identifying sources of acidity and toxic pollutants in lakes and estimating the number of affected lake acres attributed to each source.
  - Identifying lake water quality trends, including trends in acidity, toxic pollutants, and their effects.

The Waterbody System (WBS) can generate many of the tables needed to report the required 305(b) summary data (USEPA 1994f). The Waterbody System can record general information on the types of monitoring protocols used in making assessments for specific lakes. Since WBS is intended as a data base of assessments, it does not have facilities for storing actual monitoring data or bioassessment metrics. Bioassessment information could, however, be entered in WBS comment fields.

2.2 Section 314 Clean Lakes Program

Historically, the Clean Lakes Program has been active in awarding grants for the study and restoration of publicly owned lakes. Under this program, states are encouraged to develop integrated water quality strategies that include lake and reservoir management, restoration, and protection activities.

The Clean Lakes Program regulations (40 CFR part 35, subpart H) list the primary components that could be monitored to characterize the biological component of a lake system, including algal pigments, algal genera, cell densities, algal cell volumes, limiting
nutrients, macrophyte coverage (by species), bacteriological components, and fish flesh analysis. The regulations do not specifically require monitoring for macroinvertebrates. Whether a complete limnological investigation or some more focused set of investigations should be undertaken depends on the status of available baseline data and the problems affecting a particular lake.

Monitoring and sampling needs vary from lake to lake. For example, a lake program might do a more detailed benthic macroinvertebrate survey if dredging or restoration work involving the disturbance of sediments is planned. Even if this survey work is being done for dredging purposes only, it can aid in the formulation of an on-site reference. The use of a reference condition, whether it is developed by historical data or through a regional approach, can improve Clean Lakes projects by identifying biological impairments that were previously unknown or not adequately documented based on chemical and physical monitoring data alone. In particular, biological monitoring will provide data to help accomplish the following:

- Determine the success of restoration and rehabilitation efforts when measured against reference conditions.
- Better characterize the biological component of the lake system.
- Measure aquatic life use support.
- Develop and use lake water quality standards, or develop and use other biological measurements to determine impairment or threatened status of lakes.
- Develop and update lake management plans.

All of the activities listed above can be partially achieved through the use of biological monitoring protocols in lake programs. They will lead to improved data for assessing beneficial uses and for improving both 305(b) and other grant reporting requirements.

2.3 Section 319 Nonpoint Source Program

The 1987 Water Quality Act Amendments to the Clean Water Act added section 319, which established a national program to control nonpoint source (NPS) pollution. States assess their NPS pollution problems and submit these assessments to USEPA. The assessments include a list of “navigable waters within the state which, without additional action to control nonpoint sources of pollution, cannot reasonably be expected to attain or maintain applicable water quality standards or the goals and requirements of this Act.” Other activities under the section 319 process require the identification of categories and subcategories of NPS pollution that contribute to the identification of impaired waters, descriptions of the procedures for identifying and implementing BMPs, control measures for reducing NPS pollution, and descriptions of state and local programs used to abate NPS pollution. Based on the assessments, states have prepared nonpoint source management programs, and USEPA grants are now available to assist in the implementation of approved state programs.

Biological assessment techniques can improve evaluations of nonpoint source pollution controls (or the combined effectiveness of current point and nonpoint source controls) by comparing biological integrity indicators before and after implementation of controls.
Likewise, biocriteria can be used to measure site-specific ecosystem response to remediation or mitigation activities aimed at reducing nonpoint source pollution impacts or response to pollution prevention activities.

Several section 319 projects involve lake restoration (USEPA 1994f). Currently, biocriteria have not been developed for these lakes, but their use would greatly improve the ability of lake managers to focus their efforts. By providing a measuring tool, biocriteria can be key in identifying the most significant sources of a lake’s pollutants. Minimum lake monitoring guidance for nonpoint source pollution assessment is being developed and will include biological protocols for lakes.

### 2.4 Watershed Protection Approach

Since 1991, USEPA has been promoting the Watershed Protection Approach as a framework for meeting the Nation’s remaining water resource challenges (USEPA 1994k). The agency’s Office of Water has taken steps to reorient and coordinate point source, nonpoint source, lakes, wetlands, coastal, ground water, and drinking water programs in support of the watershed approach. USEPA has also promoted multi-organizational, multi-objective watershed management projects across the Nation.

The watershed approach is an integrated, holistic strategy for more effectively protecting and managing surface water and ground water resources and achieving broader environmental protection objectives using the naturally defined hydrologic unit (the watershed) as the integrating management unit. Thus, for a given watershed, the approach encompasses not only the water resource, such as a stream, river, lake, estuary, or aquifer, but all the land from which water drains to the resource. The watershed approach places emphasis on all aspects of water resource quality: physical (e.g., temperature, flow, mixing, habitat); chemical (e.g., conventional and toxic pollutants such as nutrients and pesticides); and biological (e.g., health and integrity of biotic communities, biodiversity).

The Clean Lakes Program (CLP) has been an important model for the Watershed Protection Approach and ecosystem management (USEPA 1994k). The CLP has been referred to as the quintessential watershed program because it has taken a holistic, place-based approach that uses sound science, involves stock holders, and forms partnerships for comprehensive, integrated action to protect and restore lake resources in the Nation. A newly developed Clean Lakes Program framework calls for better integration of the CLP with nonpoint source, water quality management, permitting, and other ecosystem protection activities.

### 2.5 Section 303(d) The TMDL Program

The technical backbone of the Watershed Protection Approach is the process for total maximum daily loads (TMDL). TMDLs is a tool used to achieve applicable water quality
standards. The TMDL process quantifies the loading capacity of a waterbody for a given stressor and ultimately provides a quantitative scheme for allocating loadings (or external inputs) among pollutant sources (USEPA 1994c). In doing so, the TMDL quantifies the relationships among sources, stressors, recommended controls, and water quality conditions. For example, a TMDL might mathematically show how a specified percent reduction of a pollutant is necessary to reach the pollutant concentration reflected in a water quality standard.

Section 303(d) of the CWA requires each state to establish, in accordance with its priority rankings, the total maximum daily load for each waterbody or reach identified by the state as failing to meet or not expected to meet water quality standards after imposition of technology-based controls.

In addition, TMDLs are vital elements of a growing number of state programs. For example, as more permits incorporate water quality-based effluent limits, TMDLs are becoming an increasingly important component of the point source control program.

TMDLs are suitable for nonchemical as well as chemical stressors (USEPA 1994c). These include all stressors that contribute to the failure to meet water quality standards, as well as any stressor that presently threatens but does not yet impair water quality. TMDLs are applicable to waterbodies impacted by both point and nonpoint sources. Some stressors, such as sediment deposition or physical alteration of instream habitat, might not clearly fit traditional concepts associated with chemical stressors and loadings. For these nonchemical stressors, it might sometimes be difficult to develop TMDLs because of limitations in the data or in the technical methods for analysis and modeling. In the case of nonpoint source TMDLs, another difficulty arises in that the CWA does not provide well-defined support for regulatory control actions as it does for point source controls, and controls based on another statutory authority might be necessary.

Because they directly measure the aquatic community’s response to pollutants or stressors, biological surveys can provide compelling evidence of water quality impairment. Biological assessments and criteria address the cumulative impacts of all stressors, especially habitat degradation, loss of biological diversity, and nonpoint source pollution. Biological information can help provide an ecologically based assessment of the status of a waterbody and thus can be used to decide which waterbodies need TMDLs (USEPA 1993c).

Incorporation of bioassessment data aids in the ranking process to target waters for TMDL development by allowing more accurate prioritization because of the direct link between bioassessment and ecological integrity (i.e., the condition of an unimpaired ecosystem as measured by combined chemical, physical, and biological attributes of surface waters (Barbour et al. 1992).

Finally, the TMDL process is a geographically based approach to preparing load and wastewater allocations for sources of stress that might impact waterbody integrity. The geographic nature of this process will be complemented and enhanced if ecological regionalization is applied as part of the bioassessment activities. Specifically, similarities among ecosystems can be grouped into ecoregions. The ecoregion concept provides a geographic framework for more efficient aquatic resource management.
2.6 Section 402 NPDES Permits and Individual Control Strategies

All discrete sources of wastewater must obtain a National Pollutant Discharge Elimination System (NPDES) permit, which regulates the facility’s discharge of pollutants. The approach to controlling and eliminating water pollution is focused on the pollutants determined to be harmful to receiving waters and on the sources of such pollutants. Authority for issuing NPDES permits is established under section 402 of the CWA (USEPA 1989a).

Point sources are generally divided into two types, industrial and municipal. Nationwide, there are approximately 50,000 industrial sources, which include commercial and manufacturing facilities. Municipal sources, also known as publicly owned treatment works (POTWs), number about 15,700 nationwide. Wastewater from municipal sources results from domestic wastewater discharged to POTWs, as well as the “indirect” discharge of industrial wastes to sewers.

USEPA does not recommend the use of biological criteria as the basis for deriving an effluent limit for an NPDES permit (USEPA 1994e). Unlike chemical-specific water quality criteria, biological criteria do not measure the concentrations or levels of chemical stressors. Instead, they directly measure the impacts of any and all stressors on the resident aquatic biota. Because of this, biological criteria do not definitively establish the causal relationship between a biological impact and its source. This is not to say that biological criteria have no role in the permitting process, now or in the future. Where appropriate, biological criteria can be used for assessment purposes within the NPDES process (USEPA 1996a). The criteria can provide information on the status of a waterbody where point sources might cause, or contribute to, a water quality problem. In conjunction with chemical water quality and whole-effluent toxicity data, biological criteria can be used to detect previously unmeasured chemical water quality problems and to evaluate the effectiveness of implemented controls.

Some states have already demonstrated the usefulness of biological criteria under certain circumstances to indicate the need for additional or more stringent permit limits (e.g., sole-source discharge into a stream where there is no significant nonpoint source discharge, habitat degradation, or atmospheric deposition) (USEPA 1996a). In these situations, the biological findings triggered additional investigations to establish the cause-and-effect relationship and to determine the appropriate limits. In this manner, biological criteria support regulatory evaluations and decision making. Biological criteria can also be useful in monitoring highly variable or diffuse sources of pollution that are treated as point sources such as wet-weather discharges and stormwater runoff (USEPA 1996a). Traditional chemical water quality monitoring is not usually appropriate for these types of point source pollution, and a biological survey of their impact might be critical to evaluate these discharges and treatment measures effectively.
2.7 Risk Assessment

Ecological risk assessment is defined as “The process that evaluates the likelihood that adverse ecological effects may occur or are occurring as a result of exposure to one or more stressors” (USEPA 1992c). Risk management is a decision-making process that involves all the human-health and ecological assessment results, considered with political, legal, economic, and ethical values, to develop and enforce environmental standards, criteria, and regulations (Maughan 1993). Ecological risk assessment can be performed on an on-site basis or can be geographically based (i.e., watershed scale) to assess risks to ecologically valuable endpoints (USEPA 1996d).

Results of regional bioassessment studies can be used in watershed ecological risk assessments to develop regional empirical models of biological responses to stressors. Such models can then be used in a predictive mode, together with predicted exposure information, to predict risk due to stressors or to alternative management actions. Risks to biological resources are characterized, and sources of stress can be prioritized. Watershed risk managers can use such results for critical management decisions.

2.8 Section 303(c) USEPA Water Quality Criteria and Standards

The water quality standards program, as envisioned in section 303(c) of the CWA, is a joint effort between the states and USEPA. The states have primary responsibility for setting, reviewing, revising, and enforcing water quality standards. USEPA develops regulations, policies, and guidance to help states implement the program and oversees states’ activities to ensure that state-adopted standards are consistent with the requirements of the CWA and that water quality standards regulations (40 CFR Part 131) are met. USEPA has authority to review and approve or disapprove state standards and, where necessary, to promulgate federal water quality standards. A water quality standard defines the water quality goals of a waterbody, or a portion thereof, by designating the use or uses to be made of the water, setting criteria necessary to protect those uses, and preventing degradation of water quality through antidegradation provisions. States adopt water quality standards to protect public health or welfare, enhance the quality of water, and protect biological integrity.

Environmental stressors can be chemical, physical, or biological in nature, and likewise can impact the chemical, physical, and biological characteristics of an aquatic ecosystem. For example, the impact of a chemical stressor might be observed in impaired functioning or loss of a sensitive species and a change in community structure. The impact of a biological stressor, such as an introduced species, can result in a change in community structure through competition, predation, etc. Ultimately, the number or intensity of all stressors within an ecosystem will be evidenced by a change in the condition and function of the biotic community. The interactions among chemical, physical, and biological stressors and their compounding impacts emphasize the need to directly detect and assess actual water quality impairments of the biota.

Sections 303 and 304 of the CWA require states to protect biological integrity as part of their water quality standards. This can be accomplished, in part, through the
development and use of biological criteria. As part of a state or tribal water quality standards program, biological criteria can provide scientifically sound and detailed descriptions of the designated aquatic life use for a specific waterbody or segment. They fulfill an important assessment function in water quality-based programs by establishing the biological benchmarks for (1) directly measuring the condition of the aquatic biota, (2) determining water quality goals and setting priorities, and (3) evaluating the effectiveness of implemented controls and management actions.

The challenge of evaluating effects from ecological stressors will best be met when the condition of the biota within an ecosystem can be assessed directly. Biological criteria for aquatic life will help meet this need by allowing direct assessment of the condition of the biota that live either part or all of their lives in aquatic systems. These criteria (narrative or numeric) describe the expected biological condition of an aquatic community. They can be used as benchmarks to identify biological impairments and to help define ecosystem goals and endpoints. Biological criteria supplement traditional measurements (for example, as backup for hard-to-detect chemical problems) and will be particularly useful in assessing impairment due to nonpoint source pollution and nonchemical (e.g., physical and biological) stressors. Thus, biological criteria fulfill a function missing from USEPA’s traditionally chemical-oriented approach to pollution control and abatement (USEPA 1996a).

Biological criteria can also be used to refine the aquatic life use classifications for a state. Each state develops its own designated use classification system based on the generic uses cited in the CWA, including protection and propagation of fish, shellfish, and wildlife. States frequently develop subcategories to refine and clarify designated use classes when several surface waters with distinct characteristics fit within the same use class or when waters do not fit well into any category; for example, cold-water versus warm-water habitat. As data are collected from biosurveys to develop a biological criteria program, analysis may reveal unique and consistent differences between aquatic communities that inhabit different waters with the same designated use. Therefore, measurable biological attributes can be used to refine aquatic life use or to separate one class into two or more subclasses.

2.9 Other Uses

Although biological criteria and monitoring might be perceived in a regulatory context as one form of water quality management, they serve many other equally important functions, including the following:

- Evaluating the effectiveness of management practices.
- Regional planning.
- Watershed planning.
- Determining management priorities for multiple waterbodies.
- Further classifying and qualifying relative water quality in a waterbody.
- Characterizing aquatic life that is at risk from various hazards.
- Providing a means to evaluate impacts that might not be protected by traditional risk assessment methods.