Long Term Goal 1: Approaches to analyzing stressor effects for use in criteria development

Introduction

The Clean Water Act provides the legislative mandate to restore and maintain the chemical, physical, and biological integrity of the Nation's waters. Therefore, a common management goal for all aquatic ecosystems is to maintain ecological integrity by protecting aquatic systems against degradation of habitat, loss of ecosystem functions and services, and reduced biodiversity. To this end, environmental managers must be able to: 1) assess the condition of an aquatic resource and determine the degree of impairment, 2) diagnose the causes of impairment, 3) forecast the effects of changes in stressor levels, and 4) develop and implement remediation and maintenance strategies. The first step in this process is to assign a designated use for a water body and then to apply the available water quality criteria necessary to protect the use.

The focus of Long Term Goal 1 is to provide the approaches and methods to develop and apply criteria for habitat alteration, nutrients, suspended and bedded sediments, pathogens and toxic chemicals that will support designated uses for aquatic systems. These are the major, pervasive stressors with potentially adverse effects on aquatic systems (along with invasive species which are addressed in the Ecosystem Protection MYP). LTG 1 research aims to increase our understanding of specific responses to each stressor. Research in LTG 1 also addresses methods for assessing the biological response to multiple stressors and includes bioassessment research as a field-oriented approach to setting biocriteria as the basis for relating designated uses to biological condition in streams and rivers. Specific research involves: providing the scientific basis for assessing the role of habitat in order to predict biological effects of habitat alteration, providing load response information to develop nutrient criteria, demonstrating an approach for suspended and bedded sediment criteria for aquatic systems, providing a rapid means of measuring recreational water quality for pathogens, and developing scientifically-defensible methods for better describing the risks of toxic chemicals to aquatic and aquatic-dependent populations and communities. Research to demonstrate bioassement techniques to establish biocriteria for a range of designated uses in freshwater systems is another focus of this long term goal.

Although specific research products are not shown for suspended and bedded sediments (SABS) in the 2003 Water Quality Multi-year Plan (MYP), this stressor is listed because it is one of the top stressors causing impairment in the nation's water. In 2002, an annual performance goal on SABS was completed under the initial version of the MYP that synthesized the state of the science and remaining uncertainties for developing criteria for this stressor. This document, produced by the Office of Research and Development (ORD), is being used by ORD and the Office of Water (OW) to develop a National Strategy for SABS criteria. The strategy also uses a synthesis of methods including approaches now being developed under the Environmental Assessment Monitoring Program (EMAP) within the Goal 4 Ecosystem Protection MYP. The decision to move the SABS research from the Water Quality MYP to the Ecosystem Protection MYP was based on available budgets and full-time staff equivalents.

Currently, the States operate from a mixture of narrative and numerical water quality criteria. The major causes of impairment (nutrients, pathogens, and suspended and bedded sediments)

often reflect nonattainment of narrative criteria caused in many cases by episodic events and that will require, over time, numerically-based reductions in loads and monitoring of the outcomes. The research outlined for this goal will enable the Agency and States to avoid over-or under-managing stressors and their related costs.

The results of LTG 1 research on specific stressor-response relationships can then be used by a range of clients within EPA program offices, states, tribes and other agencies to develop criteria to protect water quality. For each of the stressors listed above, it was necessary to focus the research on specific ecosystems and on specific responses or "endpoints." The choice of systems and endpoints in LTG 1 research took into account the needs of ORD's major clients: OW, states and tribes.

The OW need to develop nutrient criteria for coastal systems led to the ORD focus on coastal areas (with submerged aquatic vegetation, dissolved oxygen, and food webs as endpoints of interest.) There was a need for information on watershed scale responses to habitat loss in order to develop habitat criteria to protect at the population level. ORD toxics research has focused on review/synthesis and method development activities related to guidelines revisions and longer-term projects that are addressing significant uncertainties in criteria methodology. Research has also addressed integration of multiple stressors and methods for extrapolating from single species to populations, in response to the OW need to revise Aquatic Life Guidelines to incorporate a risk-based approach.

Research Framework

The 2003 Water Quality MYP was developed as a result of extensive consultation and collaboration with OW, to help ensure that high priority OW needs were addressed (as reflected in the 2002 ORD report *Aquatic Stressors Framework and Implementation Plan for Effects Research*). The overview prepared by Charles Noss summarizes the four long term goals in the 2003 MYP and their relationship to each other.

Long Term Goal 1: Provide the approaches and methods to develop and apply criteria for habitat alteration, nutrients, suspended and bedded sediments, pathogens and toxic chemicals that will support designated uses for aquatic systems.

The plan called for research on three high priority science questions in order to reach LTG1:

1. What are the quantitative and causal relationships between varying levels of stressors, alone and in combination, and the biological response of aquatic ecosystems and the resulting services such systems provide? For habitat alteration? For nutrients? For pathogens? For toxic chemicals?

2. What are the best ways to classify ecosystems, landscapes, and watersheds to enable efficient and scientifically sound development and application of indicators, biocriteria, listing criteria, and water quality criteria?

3. How can stressor levels, biological-response relationships, classification schemes, bioassessment methods, ecological risk assessments, and indicators be applied across U.S.

surface waters to set criteria for identifying/restoring impaired waters and maintaining designated uses?

Research Outcomes and Impacts

1. *What are the quantitative and causal relationships between varying levels of stressors, alone and in combination, and the biological response of aquatic ecosystems and the resulting services such systems provide? For habitat alteration? For nutrients? For pathogens? For toxic chemicals?*

ORD's research into habitat alteration as a stressor has two primary goals: to link the loss and degradation of habitat to selected fish, shellfish and wildlife endpoints, and to determine which models of biological response to habitat change are most appropriate for criteria decision making. **Poster 1-1** illustrates both objectives. This synthesis of biological effects of habitat alteration for a number of species across a variety of habitat types (coastal Gulf of Mexico, Pacific Northwest, Great Lakes and coastal environments of New England) demonstrates the challenge of defining habitats and determining scale effects. The stressor response models will be key components for the development of designated uses and habitat criteria to protect populations of aquatic organisms.

The goals for toxics stressor research include being able to develop methods for extrapolating chemical toxicity effects across species and populations, and approaches to evaluating the relative and cumulative risks of chemical vs. non-chemical stressors. **Poster 1-2** summarizes a demonstration project focusing on effects of methylmercury exposure and habitat alteration to piscivorous bird populations. This research helps support the development of population risk-based chemical-specific aquatic life and wildlife guidelines and has been of immediate use to state agencies in New Hampshire in protecting loon populations.

Efforts to improve understanding of nutrients as a stressor to aquatic systems have included a focus on impacts of nutrients from watersheds on the dissolved oxygen, submerged aquatic vegetation and food webs of receiving waters. **Poster 1-3** presents tools being developed by the Gulf of Mexico Hypoxia Monitoring and Modeling Program. Results of this research will provide water resource managers with improved decision support tools to establish defensible nutrient management plans to reduce hypoxia in the northern Gulf and improve water quality in the Mississippi River Basin and along the Gulf coast. Nutrients research has additionally focused on development of a variety of empirical and mechanistic modeling tools (**Poster 1-4, Poster 1-5)** that can be applied to development of improved approaches to setting nutrient criteria in physically- and hydrodynamically-diverse systems. Empirical model approaches have been developed relating increasing nutrient loads to decreases in eelgrass coverage, increases in nuisance species, and changes in phytoplankton food webs. Other empirical relationships seek to contribute to improvements in marine dissolved oxygen criteria. Mechanistic models focus on stress-response prediction for dominant seagrasses of the Northeast, Gulf and West coasts. Initial results from this research are being used by the states of CT and RI to determine criteria for nitrogen loads to protect their estuarine waters, by US Army Corps of Engineers to determine dredge material placement in a Texas estuary, and by Office of Water to improve estuarine and coastal nutrient criteria guidance to the states.

2. *What are the best ways to classify ecosystems, landscapes, and watersheds to enable efficient and scientifically sound development and application of indicators, biocriteria, listing criteria, and water quality criteria?*

In order develop criteria that can be applied at a regional scale, it is necessary to develop methods for understanding how stressor-response relationships change with scale and system. **Poster 1-6** addresses an approach to analyzing responses of coastal receiving systems to landscape scale nutrient stressors. Outcomes include improved coastal nutrient criteria guidance to OW, Regions, States, and Tribes and a generic approach that can be used in other coastal areas for aquatic life criteria development, not just for nutrients.

3. *How can stressor levels, biological-response relationships, classification schemes, bioassessment methods, ecological risk assessments, and indicators be applied across U.S. surface waters to set criteria for identifying/restoring impaired waters and maintaining designated uses?*

ORD research on the impacts of habitat alteration has contributed to development of scientifically sound, rapid, and practical methods for states to use to assess the condition of their wetlands. **Poster 1-7** summarizes a rapid assessment method for coastal wetlands that characterizes a number of indicators for plants, soil and hydrology. This practical method can be used by states to improve their ability to assess and manage wetlands.

Poster 1-8 asks what practical and effective improvements can be made to the development of water quality criteria using current knowledge and methods for assessing risk of chemicals to aquatic life and aquatic-dependent wildlife. To date, the Aquatic Life Guidelines Committee has developed a conceptual framework for future aquatic life criteria using EPA's Guidelines for Risk Assessment. This includes the use of more robust conceptual models to determine effects of both non bioaccumulative and bioaccumulative chemicals to both aquatic life and aquatic dependent wildlife populations. New criteria will benefit from the inclusion of empirical models that deal with the evaluation of dosimetry of time-varying exposure and use of population models that are to be validated using field test comparisons. Assessments also will be made to determine the effects of dietary exposure and photo activated toxicity in aquatic systems to fill these data gaps in the scientific knowledge.

The Beaches Environmental Assessment and Coastal Health Act of 2000 mandated that EPA conduct “studies to provide additional information for use in developing appropriate and effective indicators for improving detection in a timely manner in coastal recreation waters of the presence of pathogens that are harmful to human health. **Poster 1-9** summarizes research on a rapid method for measuring microbial indicators of recreational water quality. The rapid, field-validated method, capable of producing results within 2 hours of sample collection, will provide beach managers and public health officials with the means to alert the public the same day about potential health hazards, thereby preventing the exposure of the public to unsafe water.

Three posters **(Posters 10-12**) summarize ORD’s research on bioassessment of large rivers, headwaters and isolated wetlands. The outcomes include simpler, more cost-effective sampling

methods that can provide a foundation for conducting national status/trends assessments; ways to characterize the function and contribution of headwaters to downstream water quality; and the function and contribution of isolated wetlands to surface water quality.

Future Directions

In general, research will evaluate, in greater detail, the costs and benefits of different policies and management approaches, including protection of aquatic ecosystem services. It will also seek to develop mechanisms for increased cross-ORD research collaboration and harmonization in the area of water quality criteria development.

Habitat research: Provide suites of habitat alteration-response relationships and extrapolation schemes for developing broad-scale habitat requirements for streams (e.g., headwater streams) and coastal waters and provide approaches for evaluating combined effects of habitat alteration and other stressors. Integrate this information, where possible, with OW's Tiered Aquatic Life Use (TALU) methodology to help define designated uses for water bodies.

Nutrient criteria: Provide the load-response relationships for establishing nutrient criteria in coastal waters including the Gulf of Mexico and extend this knowledge, where possible, for developing empirically based nutrient criteria for other waterbody types.

Toxics Research: Address selected uncertainties related to methodologies for deriving water-based, tissue-based and site-or taxon-specific criteria to protect aquatic life and aquatic-dependent wildlife populations and communities. Continue to provide technical support and research to OW in support of efforts to produce guidelines that address site-specific conditions, chemicals with limited data, and multiple stressors.

Suspended and Bedded Sediments (SABS): Currently, OW and ORD are jointly preparing a National Strategy for Developing Criteria for SABS. General support for this effort will require the interaction of research from Goal 2 under the Water Quality MYP and from Goal 4 under the Ecosystem Protection MYP. Research on SABS to support the SABS strategy will need to be addressed during the next revision of both the Water Quality and Ecosystem Protection MYPs, where linkages between these plans can be highlighted.