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Quantifying Ecosystem Health Targets

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EC Priority/Issue: This work was done as part of the GL2000 Program, as part of both "Restore Degraded Ecosystems" and Conserve Human/Ecosystem Health." It also has application to other regional ecosystem initiatives and programs.

Current Status: This work was presented at the XXVII Congress of SIL, held in Dublin, Ireland, August 8-14, 1998. The principles and procedures continue to be followed in the Great Lakes Areas of Concern (through the development of delisting guidelines), in the individual lakes (through the development of Ecosystem Objectives, especially for the completion and implementation of Lakewide Management Plans) and elsewhere in Canada where quantifiable ecosystem objectives are viewed as essential for the conservation, protection and restoration of the environment.

Next Steps: The development, implementation and ecosystem response will be followed throughout the Great Lakes and elsewhere in North America.

QUANTIFYING AQUATIC ECOSYSTEM HEALTH TARGETS

Abstract

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One attempt to quantify aquatic ecosystem health targets has been through a United States-Canada program to develop and implement comprehensive remedial action plans to restore beneficial uses in Great Lakes Areas of Concern. Narrative descriptions of beneficial use impairments have been used to develop ecosystem type indicators and objectives. This paper examines ecosystem integrity in terms of these use impairments and presents examples of quantitative targets that have been established to restore such uses.

Quantifying aquatic ecosystem health targets

Michael A. Zarull and John H. Hartig

Introduction

The development of ecosystem objectives and their indicators is a two-stage process. The first step is the development of the objectives, which requires reaching agreement among all potential users of the ecosystem. The objectives will, in narrative form, describe desirable conditions and will reflect social values and long-term visions for the ecosystem state. The process is therefore, a social-political one, rather than technical; although, technical input is essential to ensure that the vision has a foundation in the realm of ecological possibilities and scales. Once agreement on the objectives has been reached, then measurable indicators can be considered and targets (that numerically represent the desired conditions) set. The selection of indicators and numerical targets is a technical process that requires expert input based on both historic and current knowledge of ecosystem structure, function and performance. In the Laurentian Great Lakes, some ecosystem objectives, along with their indicators have been proposed for individual lakes and large regions within a lake (RYDER & EDWARDS 1985, EDWARDS & RYDER 1990, BERTRAM & REYNOLDSON 1992).

Canada and the United States have signed a series of water quality agreements for the Laurentian Great Lakes in 1972, 1978 and 1987, as part of their 1909 Boundary Waters Treaty (USA & CANADA 1972, 1978, 1987). The purpose of these agreements is to restore and maintain the chemical, physical and biological integrity of the waters of the Great Lakes Basin ecosystem. As part of this process, the two countries adopted some general and specific objectives to assess water quality. The latest agreement adopts two of the aforementioned

ecosystem objectives and calls for the development of additional ones. In addition, this agreement commits the governments to develop plans and take specific actions to address degraded nearshore areas, which are referred to as Areas of Concern (USA & CANADA 1987). These are areas that fail to meet the general or specific objectives of the Agreement, and where such failure has caused or is likely to cause impairment of beneficial use(s) or impairment of the areas' ability to support aquatic life.

This approach attempts to reconcile the general and specific objectives employed in different parts of the Great Lakes, with an ecosystem, use-based approach to managing the resource. However, the Agreement does not provide detailed definitions of impairments or guidance on their quantification. This paper describes some of the more recent approaches to the development of targets, which reflect the use impairments identified in the Agreement, along with their numerical indicators.

Beneficial Use Goals

The fourteen beneficial use goals, described in the Agreement can be grouped into four aspects of ecosystem health or state: human health, societal value, economic value and biological or ecological performance. These groupings also indicate the diverse nature of the objectives and indicators and therefore, the need to have a variety of professionals and "users" collectively involved in the process. Under the Agreement, impairment of beneficial use means a change in the chemical, physical or biological integrity of the Great Lakes System sufficient to cause any of the following:

Human Health

- restrictions on fish and wildlife consumption;
- restrictions on drinking water consumption, or taste and odour problems;

- beach closings;

Societal Value

- eutrophication or undesirable algae;
- degradation of aesthetics;

Economic Value

- tainting of fish and wildlife flavour;
- restrictions on dredging activities;
- added costs to agriculture or industry;

Biological/Ecological Health

- degradation of fish or wildlife populations;
- fish tumours or other deformities;
- bird or animal deformities or reproduction problems;
- degradation of benthos;
- degradation of phytoplankton and zooplankton populations; and
- loss of fish and wildlife habitat.

Developing Specific Objectives and Quantifying Targets

The statements of beneficial use impairment, contained in the Agreement, provide a common means of defining existing problems along with their causes and a standard way of assessing future conditions throughout the lakes. Earlier attempts to develop specific objectives and numerical targets for the fourteen beneficial use impairments set down in the Agreement,

helped to focus both scientific and public opinion; however, the absence of a single numeric expression for each impairment acknowledges the need for site-specific indicators (HARTIG *et al.* 1990, HARTIG & ZARULL 1992). Agreement on quantitative ecosystem-based targets also assists in implementing an ecosystem approach, accounting for interrelationships among different programs, establishing a foundation upon which relative risk assessment can be performed and priorities set, and securing broad-based support for necessary actions.

In one Area of Concern (Hamilton Harbour, Ontario), the initial part of the process — developing goals and principles for the development of a comprehensive Remedial Action Plan, was done by a "Stakeholders Group." This group consisted of members from citizen groups, academics, industry, government agencies (federal, provincial and municipal), local politicians and other user group representatives. It was based on a round-table concept, with the objective of achieving consensus on the goals and principles for the future state of this particular aquatic ecosystem. A team of experts then provided quantification of these "goals" that identified the criteria that needed to be achieved for the goals to be realized. Below, is an example of the results of this process (CANADA-ONTARIO 1992).

Problem to be Addressed

"A warmwater fishery population that is heavily stressed, unbalanced towards pollution - tolerant species, experiencing health problems (tumours, skin lesions) and subject to restrictions on their human consumption due to contaminant content of the fish fillets."

Use Goal

"THAT water quality and fish habitat should be improved to permit an edible, naturally reproducing fishery fro warmwater species. Water and habitat conditions in Hamilton

Harbour should not limit natural reproduction and the edibility of coldwater species."

Delisting Objectives (quantitative indicators of goals)

"That the fish community has the following structure:

1. Shift from a fish community indicative of eutrophic environments, such as white perch, alewife, bullheads, and carp to a self sustaining community more representative of a mesotrophic environment, containing pike, bass, yellow perch, and sunfish.
2. Attain a littoral fish biomass of 200 - 250 kg/ha.
3. Increase the species richness from 4 species to 6-7 species per transect.
4. Increase the native species biomass from 37% to 80-90% of the total biomass.
5. Reduce the spatial variability in fish biomass within the harbour.
6. Proposed nearshore fish community of Hamilton Harbour:

Category	Littoral Biomass (kg/ha)
Piscivores (pike, bass)	40-60
Specialists (insectivores like pumpkinseeds an yellow perch)	70-100
Generalists (omnivores like carp and brown bullheads)	30-90

[The percent of fisheries biomass allocated to the three trophic groups was based on the effects of improved water quality in the Bay of Quinte and Severn Sound. The littoral fish biomass of 200-250 kg/ha was based on electrofishing data collected from Hamilton Harbour, Bay of Quinte and Severn Sound in 1990.]"

Rehabilitative Action

With a series of narrative objective or goals (developed by a consensus of users) and their accompanying quantified indicators of achievement (developed by technical experts) in hand,

specific actions to realize these goals are then defined. In the case of Hamilton Harbour, a schedule (and order) of specific actions was developed and implemented to achieve the fish community goals:

- habitat construction/protection
- nutrient loading reductions
- oxygen demanding substances loading reductions
- toxic substances loading reductions
- erosion control/protection
- species stocking/control
- species (including humans) access/disturbance control

Summary

1. Quantitative, ecosystem-based targets are required to both adequately protect and rehabilitate aquatic environments.
2. To accommodate multi-use of the resource, desired beneficial uses should be identified.
3. This process requires both consensual objectives and technical targets.

References

CANADA - ONTARIO, 1992: *Remedial Action Plan for Hamilton Harbour: Goals, Options and Recommendations. Volume 1 — Summary*. 44 pp., Hamilton, Ontario, Canada.

BERTRAM, P.E. & REYNOLDSON, T.B., 1992: Developing ecosystem objectives for the Great Lakes: policy, progress and public participation. — *J. Aquatic Ecosys. Health* **1**: 89-95.

EDWARDS, C.J. & RYDER, R.A. (eds) 1992: *Biological surrogates of mesotrophic ecosystem health in the Laurentian Great Lakes.* 69 pp., Windsor, Ontario, Canada.

HARTIG, J.H., RATHKE, D.E. & WILLIAMS, D.J. 1990: How clean is clean in Great Lakes Areas of Concern? Report from the 1988 IAGLR Symposium. *J. Great Lakes Res.* **16:** 169-179.

HARTIG, J.H. & ZARULL, M.A. 1992: Towards defining aquatic ecosystem health for the Great Lakes. *J. Aquatic Ecosys. Health* **1:** 97-107.

RYDER, R.A. & EDWARDS, C.J. (eds) 1985: *A conceptual approach for the application of biological indicators of ecosystem quality in the Great Lakes Basin. A joint effort of the International Joint Commission and the Great Lakes Fishery Commission.* 169 pp., Windsor, Ontario, Canada.

UNITED STATES & CANADA. 1987: *Great Lakes Water Quality Agreement of 1978. As amended by protocol.* 64 pp., Windsor, Ontario, Canada.

UNITED STATES & CANADA. 1978: *Great Lakes Water Quality Agreement of 1978.* 52 pp., Windsor, Ontario, Canada.

UNITED STATES & CANADA. 1972: *Great Lakes Water Quality Agreement of 1972.* 40 pp., Windsor, Ontario, Canada.

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