TOWARD INTEGRATING REMEDIAL-ACTION AND FISHERY-MANAGEMENT PLANNING IN GREAT LAKES AREAS OF CONCERN

A report of a 1993 workshop sponsored by the U.S. Environmental Protection Agency and Environment Canada in cooperation with the Habitat Advisory Board of the Great Lakes Fishery Commission and Wayne State University

THE ECOSYSTEM APPROACH

Great Lakes Fishery Commission

The Great Lakes Fishery Commission was established by the Convention on Great Lakes Fisheries between Canada and the United States, which was ratified on October 11, 1955. It was organized in April 1956 and assumed its duties as set forth in the Convention on July 1, 1956. The Commission has two major responsibilities: first, develop coordinated programs of research in the Great Lakes, and, on the basis of the findings, recommend measures which will permit the maximum sustained productivity of stocks of fish of common concern; second, formulate and implement a program to eradicate or minimize sea lamprey populations in the Great Lakes.

The Commission is also required to publish or authorize the publication of scientific or other information obtained in the performance of its duties. In fulfillment of this requirement the Commission publishes the Technical Report Series, intended for peer-reviewed scientific literature; Special Publications, designed primarily for dissemination of reports produced by working committees of the Commission; and other (non-serial) publications. Technical Reports are most suitable for either interdisciplinary review and synthesis papers of general interest to Great Lakes fisheries researchers, managers, and administrators, or more narrowly focused material with special relevance to a single but important aspect of the Commission's program. Special Publications, being working documents, may evolve with the findings of and charges to a particular committee. Both publications follow the style of the *Canadian Journal of Fisheries and Aquatic Sciences.* Sponsorship of Technical Reports or Special Publications does not necessarily imply that the findings or conclusions contained therein are endorsed by the Commission.

August 1993

TOWARD INTEGRATING REMEDIAL-ACTION AND FISHERY-MANAGEMENT PLANNING IN GREAT LAKES AREAS OF CONCERN

A report of a 1993 workshop sponsored by the
U.S. Environmental Protection Agency and
Environment Canada,
in cooperation with the
Habitat Advisory Board of the
Great Lakes Fishery Commission and
Wayne State University

John H. Hartig
Wayne State University
Department of Chemical Engineering
2163 Engineering Building
Detroit, MI 48202

Citation: Hartig, J. H. 1993. Toward integrating remedial-action and fishery-management planning in Great Lakes Areas of Concern. Great Lakes Fish. Comm. 34 p.

Great Lakes Fishery Commission
2100 Commonwealth Blvd., Suite 209
Ann Arbor, MI 481051563

August 1993

Printed on recycled paper

General Publication 93/2/1500

PREFACE

In recognition of the need for strengthened and broadened partnerships among fishery-management agencies, environmental agencies, and other stakeholders, the Great Lakes Fishery Commission (GLFC) encourages the delivery of complementary programs focused upon achievement of fish-community objectives as adopted by the lake committees for each Great Lake. It is, I believe, essential that such partnerships and coordination be actively pursued in order to achieve common goals. In 1980, the 12 cooperating federal, provincial, state, and tribal natural-resources agencies adopted a Joint Strategic Plan for Management of Great Lakes Fisheries (Joint Plan). The Joint Plan recognized the need for a strong environmental component in fishery-management planning. This environmental component should address protection, rehabilitation, and enhancement of fish habitat. To achieve this and other ends the GLFC established the Habitat Advisory Board (HAB).

HAB is pleased to have cosponsored the workshop and this report along with the U.S. Environmental Protection Agency, Environment Canada, and Wayne State University. Such initiatives that discuss ideas of common interest and recommend practical ways of moving water-quality and fishery-management programs forward in a complementary and reinforcing fashion are an important step toward ecosystem management. HAB commends this report to fishery managers, remedial-action-plan coordinators, and other Area of Concern stakeholders in an effort to advance the rehabilitation of degraded areas of the Great Lakes. I look forward to future joint initiatives that further multistakeholder partnerships and address such high-priority common problems and issues.

Douglas P. Dodge, Chairman
Habitat Advisory Board
1 June 1993

TABLE OF CONTENTS

TOWARD INTEGRATING REMEDIAL-ACTION AND FISHERY-MANAGEMENT PLANNING IN GREAT LAKES AREAS OF CONCERN

A report of a 1993 workshop sponsored by the
U.S. Environmental Protection Agency and
Environment Canada,
in cooperation with
the Habitat Advisory Board of the
Great Lakes Fishery Commission and
Wayne State University

John H. Hartig
Wayne State University
Department of Chemical Engineering
2163 Engineering Building
Detroit, MI 48202

ABSTRACT. A workshop was held in February 1993 to:

review current fish-community and habitat goals/objectives/ targets and current resource status in Areas of Concern (AOCs), and

develop recommendations for water-quality and fishery managers on how to achieve greater coordination and integration of remedial-action and fishery-management planning in AOCs.

Degraded fish populations were identified in 31 of 43 AOCs. Loss of fish habitat or fish-habitat impairment was identified in 38 AOCs. Both water-quality and fishery-management agencies have similar goals-restore degraded fish populations and habitat. Implementing an ecosystem approach and achieving complementary and reinforcing programs will require greater coordination and integration. Coordination and integration are more about process than product. Major workshop recommendations are:

1) Priority should be placed on accelerating establishment of lakewide fish-community objectives by each lake committee under the Joint Strategic Plan for Management of Great Lakes Fisheries (Joint Plan). Concurrently, fishery managers with AOC responsibilities shouldwork

with remedial-action plan (PAP) teams and within RAP institutional structures to set interim, quantitative, and measurable fish-community and habitat goals/objectives/targets that are consistent with lakewide fish-community objectives.

2) Integration of RAPs and fishery-management planning in AOCs should be pursued from both top-down (directed by senior government management) and bottom-up (coordinated at the local level) perspectives.

3) Binational efforts should be made to ensure that RAPs, lakewide-management plans, fishery-management plans for tributary watersheds, the Joint Plan, and other related planning initiatives are complementary and reinforcing by:

   a) use of the biennial state of the lakes conferences of the United States and Canadian federal governments as an ongoing mechanism to address and achieve integration;

   b) expand the terms of reference of an existing binational coordinating committee to ensure integration; or

   c) establish a new binational coordinating committee whose terms of reference would ensure integration among planning initiatives.

4) Where integration and coordination of RAPS and fishery-management planning have been achieved and have resulted in specific actions to rehabilitate fisheries and fish habitat, broad communication of how this was accomplished, including leveraging of funds, must be undertaken. Every effort should be made to celebrate and market successes.

INTRODUCTION

In response to the Great Lakes Water Quality Agreement (GLWQA), the United States federal and state governments and Canadian federal and provincial governments cooperate in the development and implementation of remedial action plans (RAPs) in the 43 Areas of Concern (AOCs) to restore beneficial uses (Fig. 1). The GLWQA states that RAF's shall embody a systematic and comprehensive ecosystem approach to restoring and protecting beneficial uses in AOCs. An ecosystem approach accounts for interrelationships among land, air, water, and all living things, including humans, and involves all user groups in management.

Acting through the Great Lakes Fishery Commission (GLFC), United States and Canadian federal, provincial, state, and tribal natural-resources agencies, and other related agencies and organizations, cooperate to:

develop coordinated research and management programs for Great Lakes fish stocks, and

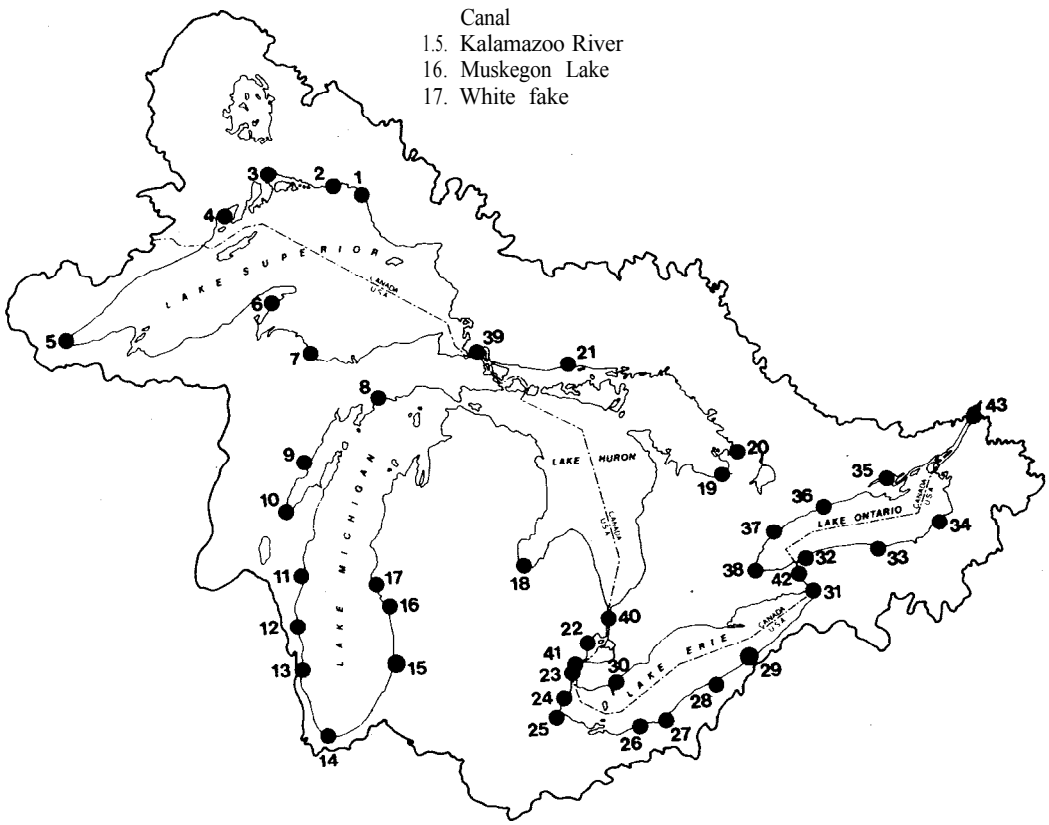
formulate and implement a sea lamprey control program.

The GLFC also uses an ecosystem approach for management and research of Great Lakes fishes. In order to ensure use of an ecosystem approach, fishery cooperators (fishery-management agencies) of the GLFC encourage the delivery of complementary programs focused upon achievement of fish-community objectives established for each Great Lake.

Lake superior
1. Peninsula Harbour
2. Jackfish Bay
3. Nipigon Bay
4. Thunder Bay
5. St. Louis Bay/River
6. Torch Lake
7. Deer Lake/Carp Creek/River

Lake Michigan
8. Manistique River
9. Menominee River
10. Fox River/Southern Green Bay
11. Sheboygan River
12. Milwaukee Estuary
13. Waukegan Harbor
14. Grand Calumet River/Indiana Harbor Canal
15. Kalamazoo River
16. Muskegon Lake
17. White fake

Lake Huron
18. Saginaw River/Saginaw Bay
19. Collingwood Harbour
20. Severn Sound
21. Spanish River Mouth



Lake Erie
22. Clinton River
23. Rouge River
24. River Raisin
25. Maumee River
26. Black River
27. Cuyahoga River
28. Ashtabula River
29. Presque Isle Bay
30. Wheatley Harbour

Lake Ontario
31. Buffalo River
32. Eighteen Mile Creek
33. Rochester Embayment
34. Oswego River
35. Bay of Quinte
36. Port Hope
37. Metro Toronto
38. Hamilton Harbour

Connecting Channels
39. St. Marys River
40. St. Clair River
41. Detroit River
42. Niagara River
43. St. Lawrence River (Cornwall/Massena)

Fig. 1. The Great Lakes basin showing the 43 AOCs.

Remedial-action and fishery-management planners are working toward similar goals. In an effort to achieve greater coordination and strengthened partnerships between remedial-action and fishery-management planners, the U.S. Environmental Protection Agency (USEPA) and Environment Canada (EC) supported a survey of both fish-community and habitat goals/objectives/targets being set for AOCs as part of fishery-management programs. Summary data on the current status of these resources relative to the goals/objectives/targets were also gathered. These survey data were compiled as source material for a workshop on integrating remedial-action and fishery-management planning held on February 4, 1993, as part of the GLFC's Habitat Advisory Board (HAB) meeting held at Maumee Bay State Park Lodge in Oregon, Ohio. The purpose of the workshop was to:

discuss and analyze the survey data, and

develop specific recommendations for water-quality and fishery managers to achieve better coordination and integration of remedial-action and fishery-management planning in the 43 AOCs.

In an effort to assist RAP coordinators and fishery managers, this report presents the findings from the workshop. All fish-community and habitat survey data have been compiled in a separate report available from the GLFC (Hartig 1993).

SURVEY METHODS

The purpose of RAPs is to identify the responsibility and time frame for implementing remedial and preventive actions necessary to restore beneficial uses in AOCs. AOCs are defined in the GLWQA as specific geographic areas that fail to meet the general or specific objectives of the GLWQA where such failure has caused, or is likely to cause, impairment of beneficial use or of the area's ability to support aquatic life (United States and Canada 1987). Impairment of beneficial use has been defined as a change in the chemical, physical, or biological integrity of the Great Lakes ecosystem sufficient to cause any of the following:

restrictions on fish and wildlife consumption;

- tainting of fish and wildlife flavor;

degradation of fish and wildlife populations;

fish tumors or other deformities;

bird or animal deformities or reproductive problems;

degradation of benthos;

restrictions on dredging activities;

eutrophication or undesirable algae;

restrictions on drinking-water consumption, or taste and odor problems;

beach closings;

degradation of aesthetics;

added costs to agriculture or industry;

degradation of phytoplankton or zooplankton populations; and

loss of fish and wildlife habitat.

To help reach agreement on use impairments in AOCs, a set of listing and delisting guidelines was developed for the 14 use impairments identified in the GLWQA (International Joint Commission 1991a). A number of the use impairments address or affect fishery status. However, two of the use impairments (degraded fish and wildlife populations and loss of fish and wildlife habitat) refer explicitly to fishery-management programs and goals. The listing guidelines for these two use impairments are:

1) Degraded Fish and Wildlife Populations. This use will be considered impaired when fish- and wildlife-management programs have identified degraded fish and wildlife populations due to a cause within the watershed. In addition, this use will be considered impaired when relevant, field-validated, fish or wildlife bioassays with appropriate quality assurance and quality controls confirm significant toxicity from water-column or sediment contaminants.

2) Loss of Fish and Wildlife Habitat. This use will be considered impaired when fish- and wildlife-management goals have not been met as a result of fish- and wildlife-habitat loss due to a perturbation in the physical, chemical, or biological integrity of boundary waters (the waters from main shore to main shore of the Great Lakes and connecting channels along which the international boundary **between the United States and Canada passes), including wetlands.**

Therefore, the survey of fishery-management program managers was undertaken to document fish-community and habitat goals/objectives/targets in AOCs relative to these use impairments and the current status of these resources.

Fishery managers with responsibilities in AOCs were specifically asked the following questions (quantitative information was sought where possible):

What fish-community goals/objectives/targets have been set for your AOC as part of your fishery-management program?

What fish-habitat goals/objectives/targets have been set for your AOC as part of your fishery-management program?

What is the current status of these goals/objectives/targets within the AOC?

SURVEYRESULTS

Fishery-management planning is underway or being initiated in all 43 AOCs in the Great Lakes basin. Degraded fish populations are identified in 31 (72%) AOCs. See Hartig (1993) for complete survey data for all 43 AOCs. Quantitative fishery objectives or targets have been set in 17 (40%) AOCs (Table 1). Objectives set in 20 (47%) AOCs address self-sustaining fish populations. Exotic species are addressed in goals and objectives established for 20 (47%) AOCs. Goals and objectives established for 14 (33%) AOCs recognize or address interrelationships between the AOC fishery and nearshore or offshore fisheries. For example, a lake trout *(Salvelinus namaycush)* harvest objective (0.24 kg/ha in waters less than 91.4 m deep) has been set for the Peninsula Harbour, Jackfish Bay, Nipigon Bay, and Thunder Bay AOCs. This objective ensures consistency with the Lake Trout Rehabilitation Plan for Lake Superior (Lake Superior Technical Committee 1986).

Objectives set in 38 (88%) AOCs recognize fish-habitat loss or fish-habitat impairment. Physical factors have been identified as a cause of fish-habitat loss in 36 (84%) AOCs. In another 13 (30%) AOCs, physical barriers (dams) limit the fishery or fish habitat. Chemical factors are identified as a cause of fish-habitat loss in 20 (47%) additional AOCs. Persistent toxic substances are identified as a factor in fish-habitat loss in 16 (37%) AOCs. Current goals and objectives established for 10 (23%) AOCs address no net loss or net gain in fish habitat. Old or limited data are recognized as an issue in rehabilitating the fishery or fish habitat in 17 (40%) AOCs.

Table 1. Great Lakes AOCs for which quantitative fishery objectives or targets

AOC	Examples of quantitative objectives or targets
Peninsula Harbour	Achieve a lake trout harvest of 0.24 kg/ha in waters less than 91.4 m deep.
Jackfish Bay	Achieve a lake trout harvest of 0.24 kg/ha in waters less than 91.4 m deep.
Nipigon Bay	Achieve a lake trout harvest of 0.24 kg/ha in waters less than 91.4 m deep. Rehabilitate the walleye *(Stizostedion vitreum vitreum)* population to approximately 40,000 individuals greater than 364 mm long.
Thunder Bay	Achieve a lake trout harvest of 0.24 kg/ha in waters less than 91.4 m deep.
Menominee River	Restore the lake sturgeon *(Acipenser fulvescens)* population to historic levels (20,000-25,000 fish).
Fox River/Southern Green Bay	Achieve the following targets: walleye-17 adults/ha; yellow perch *(Perca flavescens)*—2,600 yearlings and older per trawl hour during August at index stations; northern pike *(Esox lucius)--5* adults/ha; muskellunge *(E. masquinongy)*—0.8 adults/ha; predator- and sport-fish biomass-225337 kg/ha; predator/prey ratio-1:10-1:20.
Muskegon Lake	Restore walleye spawning runs to historic levels (130,000 fish).
Saginaw River/Saginaw Bay	Achieve the following targets: predator-fish harvest-681,800 kg/yr by year 2020; nonpredator-fish harvest-1,365600 kg/yr by year 2020; days of angler recreation - 1,090,000/yr by year 2020; walleye yield - 454,550 individuals& by year 2020; northern pike yield-90,910 kg/yr by year 2020; yellow perch yield-363,640 kg/yr by year 2020; commercial lake herring *(Coregonus artedi)* yield-181,820 kg/yr by year 2020; a sport and commercial harvest of at least 454,550 kg/yr by year 2020 for: carp *(Cyprinus carpio),* carpsucker (Carpiodes *cyprinus),* white sucker *(Catostomus commersoni),* freshwater drum *(Aplodinotus grunniens).*
Collingwood Harbour	Achieve a fish community of: 45%-60% piscivores (116-150 kg/ha), 40%-50% benthivores (103-130 kg/ha), 1% planktivores, and less than 0.5% herbivores.

have been established.

AOC	Examples of quantitative objectives or targets
Severn Sound	Achieve a top-predator biomass that represents ≥10% of the sport-fishing harvest.
Maumee River	Achieve Index of Biotic Integrity (IBI) values of 32 and Modified Index of Well-Being (MIwb) values of 7.5 as interim Lake Erie estuary goals, based on collection and analysis of systematic fish-community-performance data.
Black River	Achieve IBI values of 32 and MIwb values of 7.5 as interim Lake Erie estuary goals, based on collection and analysis of systematic fish-community-performance data.
Cuyahoga River	Achieve IBI values of 32 and MIwb values of 7.5 as interim Lake Erie estuary goals, based on collection and analysis of systematic fish-community-performance data.
Ashtabula River	Achieve IBI values of 32 and MIwb values of 7.5 as interim Lake Erie estuary goals, based on collection and analysis of systematic fish-community-performance data.
Metro Toronto	Achieve a numerical proportion/biomass of at least 10%-20% resident native piscivores. Achieve a biomass of at least 40% specialists and 10%-20% piscivores, and no greater than 20% generalists.
Hamilton Harbour	Achieve the following targets: 200-250 kg/ha total fish biomass in littoral habitats; 20%-25% native piscivore biomass; 80%-90% native species; 4060 kg/ha piscivores in littoral habitats; 70-100 kg/ha specialists; and 30-90 kg/ha generalists.
Niagara River (Ontario)	Achieve the following proposed fishery targets: 40 individuals/ha and 60 kg/ha for predators ≥20 cm long; 200 individuals/ha and 70 kg/ha for other fish ≥20 cm long; 29,800 individuals/ha and 90 kg/ha for total fish <29 cm long; and 30,000 individuals/ha and 220 kg/ha for the total fish community.

WORKSHOP FORMAT

Approximately 40 RAP coordinators/managers and fishery managers took part in the workshop (see Appendix). The workshop began with a series of presentations on current approaches to fishery-management planning activities for AOCs in New York, Ontario, Ohio, Michigan, and Wisconsin. Two break-out groups were formed to:

discuss current approaches to fishery-management planning,

discuss fish-community and habitat-survey data, and

answer specific questions pertaining to the importance of establishing measurable fish-community and habitat goals/objectives/targets for AOCs and to the need for greater coordination and integration of remedial-action and fishery-management planning.

The break-out groups then reconvened in plenary to present and discuss findings. All findings and recommendations are consistent with the questions asked in the break-out groups and are organized and presented in the two sections presented below.

ESTABLISHING QUANTITATIVE OBJECTIVES AND TARGETS

Clear, measurable objectives for rehabilitating degraded aquatic ecosystems need to be established. These objectives should have endorsements of water-quality and fishery researchers and managers, as well as other stakeholders. Hamilton Harbour is a good example of water-quality and fishery researchers and managers working together through the RAP process to establish fish-community and habitat goals/objectives/targets. The water-use goal for the associated fishery is:

> that water quality and fish habitat should be improved to permit an edible, naturally reproducing fishery for warmwater species, and that water and habitat conditions in Hamilton Harbour should not limit natural reproduction and the edibility of cold-water species.
>
> *-Hamilton Harbour Stakeholder Group 1991*

This water-use goal has now been translated into scientifically defensible targets for a stable and desirable fish community in littoral habitats (see Table 1, Hamilton Harbour). These quantitative targets were based on electrofishing data collected

from five different bays in Lake Ontario and Georgian Bay: Hamilton Harbour, Bay of Quinte, Penetang Bay, Hog Bay, and Matchedash Bay (Hamilton Harbour Remedial Action Plan Writing Team 1992). The fish data were evaluated and ranked based on water-quality criteria, human population levels, and degree of eutrophication (Hamilton Harbour Remedial Action Plan Writing Team 1992). Criteria used in establishing these targets included:

emphasis on fish communities in the littoral zone;

attainment of a balanced, stable, and self-sustaining community;

consideration of healthy habitat and ecosystem;

consistency with the International Joint Commission's Delisting Guidelines; and

emphasis on quantifiable and measurable parameters.

Indeed, experience has shown that establishing broad-based agreement on quantitative objectives and targets for a rehabilitation project (such as the Hamilton Harbour RAP) is essential for setting direction and demonstrating success.

Workshop participants also recognized the promising work of the Ohio Environmental Protection Agency (1990) on use of fish-community and habitat indices to manage Lake Erie tributaries. Most Lake Erie tributaries in Ohio are designated for protection of warmwater habitat by the state. The attainment or nonattainment of aquatic-life uses in warmwater habitat is determined by using a number of biological-community performance measures. For the fish community, these measures include the IBI and MIwb (Ohio Environmental Protection Agency 1990). Table 2 presents a comparison of the IBI and MIwb indices.

Interim IBI and MIwb goals for aquatic life in Lake Erie estuaries are greater than or equal to 32 and 7.5, respectively (Thoma 1990). Figs. 2a and 2b present the mean and range of IBI and MIwb values for 14 Ohio tributaries to Lake Erie. These data demonstrate nonattainment of the interim goals for warmwater-habitat uses in 11 of the 14 Lake Erie tributaries sampled in Ohio. Use of such a systematic index approach in Ohio has not only provided a practical, useful, quantitative assessment tool, but an ability to discern geographical differences and a basis for taking regulatory and enforcement actions (Ohio Environmental Protection Agency 1990; Yoder 1991).

Table 2. Descriptions of three indices used by the Ohio Environmental Protection Agency to assess attainment or nonattainment of aquatic-life uses in warmwater habitat.

Index	Description
Index of Biotic Integrity (IBI)	IBI incorporates 12 fish-community metrics within three broad categories: 1) species richness and composition, 2) trophic composition, and 3) fish abundance and condition. The value of each metric is compared to the value expected at a reference site located in a similar ecoregion where human influence has been minimal. IBI incorporates some elements of professional judgement, but primarily provides for a quantitative analysis for determining what is exceptional, good, fair, poor, and very poor-based on established criteria.
Modified Index of Well-Being (MIwb)	MIwb incorporates four measures of fish communities that have traditionally been used separately: 1) numbers of individuals, 2) biomass, 3) Shannon Diversity Index (SDI) based on numbers, and 4) SDI based on weight.
Qualitative Habitat Evaluation Index (QHEI)	The QHEI is based on six interrelated metrics: 1) substrate, 2) instream cover, 3) channel morphology, 4) riparian and bank condition, 5) pool and riffle quality, and 6) gradient. These metrics describe attributes of physical habitat that may be important in explaining the species presence, absence, and composition of fish communities in a stream.

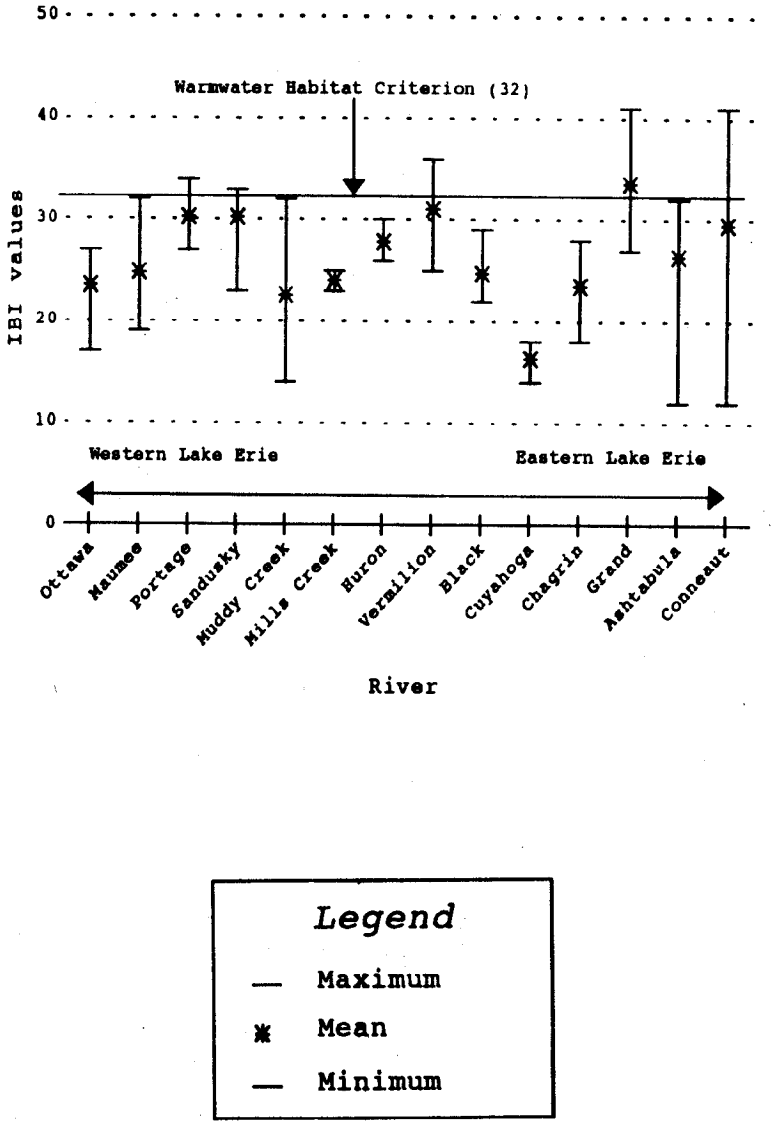
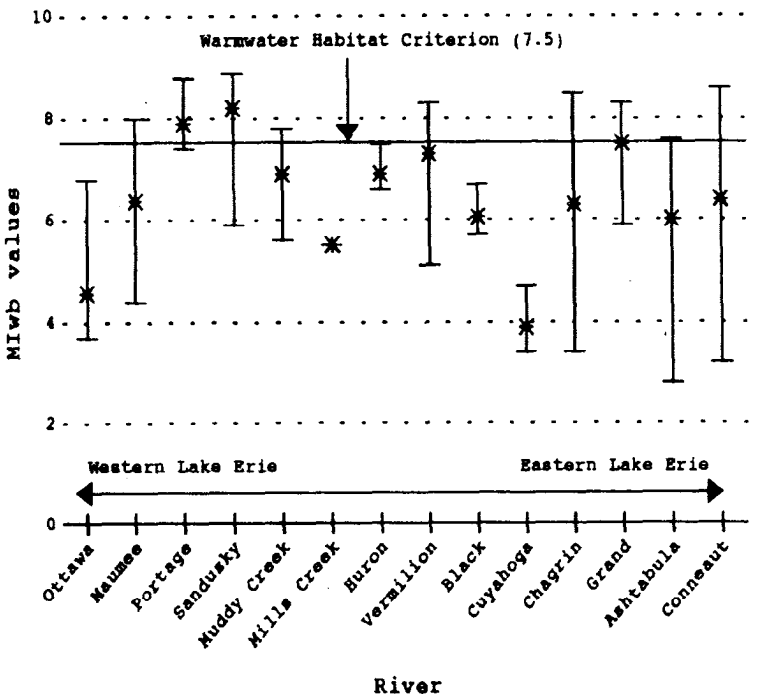


Fig. 2a. Mean and range of IBI values calculated from fishery data collected from 14 Lake Erie tributaries in Ohio (Thoma 1990).



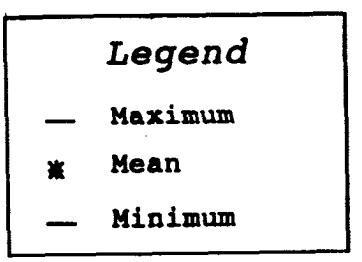


Fig. 2b. Mean and range of MIwb values calculated from fishery data collected from 14 Lake Erie tributaries in Ohio (Thoma 1990).

Application of such measurement indices to the nearshore environments of the Great Lakes is both needed and timely. Benefits include:

a systematic approach that allows comparison between different areas;

an ability to measure attainment or nonattainment of biological-use criteria;

quantification of status and trends; and

greater understanding and appreciation by resource managers, regulators, and other stakeholders for biological changes in Great Lakes nearshore environments and their association with water-chemistry changes (Thoma 1990).

Workshop participants emphasized that agreement on clear objectives and targets is essential to assure successful resolution of natural-resources problems. Measurable objectives and targets can be used to evaluate progress and sustain momentum of management programs. Therefore, priority should be placed on accelerating establishment of lakewide fish-community objectives by each lake committee. Lake committees were established by the GLFC in 1966 and are comprised of a single fishery manager from each fishery-management agency. The provision for fish-community objectives is identified in the Joint Strategic Plan for Management of Great Lakes Fisheries (Joint Plan) (Great Lakes Fishery Commission 1980), which was adopted be federal, provincial, state, and tribal natural-resources agencies, and provincial fishery-management agencies.

Concurrent with the establishment of lakewide objectives, fishery managers with responsibilities in AOCs should work with RAP teams (multidisciplinary teams charged with RAP development) to set interim quantitative and measurable fish-community objectives and targets for AOCs. These interim objectives and targets should be consistent with the lakewide fish-community objectives being established by each lake committee. Advantages of setting interim objectives and targets include:

preservation of future options,

flexibility in adapting to future options,

greater probability of achievement, and

greater practicality.

Both water-quality and fishery managers should recognize that quantitative fish-community objectives and targets will be periodically reviewed and updated using new data and information. Participants also pointed out that the quantity and quality of the fishery in some AOCs may be high; in these cases there may be no need to develop new, quantitative objectives or targets.

As noted earlier, habitat loss or impairment is recognized in 38 of the 43 AOCs. However, specific fish-habitat goals and objectives have only been established in a few AOCs (Hamilton Harbour, Green Bay, Thunder Bay, Nipigon Bay, and Ohio's Lake Erie tributaries). For example, assessment of macrohabitat quality in Ohio's Lake Erie tributaries is performed using the QHEI (Table 2). This index is designed to provide a lotic-habitat measure that corresponds generally to physical factors that affect fish communities and which are often important to other aquatic life such as invertebrates. QHEI scores of less than 45 are usually associated with streams that do not attain warmwater-habitat uses because habitat modifications are generally severe and widespread. QHEI scores of more than 60 usually do achieve warmwater-habitat uses because the effects of stream modification are usually not severe and many natural characteristics of the stream still exist. Intermediate QHEI scores of 46-60 may or may not achieve warmwater-habitat uses depending on what habitat characteristics appear to be limiting aquatic life. For the intermediate QHEI scores of 46-60, other information such as biological data should be evaluated. The index will be modified in the future for Lake Erie nearshore areas, harbors, and bays.

Workshop participants recognized that there is often difficulty in translating national, state, or provincial policy on habitat (no net loss or net gain) into:

quantitative habitat objectives and targets, and

where authority exists, into local rehabilitation strategies.

Therefore, a systematic approach for addressing habitat in RAPs is needed. An International Joint Commission (1991b) workshop recommended that fishery managers and RAP teams collaboratively use the following step-wise approach for rehabilitating physical habitat in AOCs:

define the geographic extent;

classify and inventory existing habitat;

compare present habitat with previously existing habitat using all available historical documentation;

identify and give priority to critically important habitat needs;

reach agreement on goals and quantitative objectives and targets for habitat protection, mitigation, restoration, and rehabilitation;

evaluate alternatives and select strategies and techniques to achieve habitat goals and objectives;

address policy issues or other obstacles requiring resolution to implement strategies and techniques;

develop and implement an evaluation plan to assess the strategies and techniques to meet habitat goals and objectives; and

use evaluation results to modify strategies and techniques as necessary to achieve habitat goals and objectives.

Concern was also expressed that many fishery managers may have too simplistic a model of the relationship between fish and their habitat. Greater emphasis must be placed on scientific understanding of the relationship between fish production/community structure and aquatic habitat, Such fundamental understanding is essential to ensure a sound ecological basis for management actions.

INTEGRATION AND COORDINATION

Better integration and coordination among fishery-management and water-quality perspectives are needed to ensure an ecosystem approach to management. Areas of achievement in integration and rehabilitation include Hamilton Harbour in Ontario, Green Bay in Wisconsin, and AOCs along the northern shore of Lake Superior.

Hamilton Harbour benefitted from considerable seed money, numerous dedicated individuals who moved the RAP forward, and proximity to the research facility of Canada Centre for Inland Waters (Rodgers 1992). Currently, the Department of Fisheries and Oceans Canada is the lead agency in a cooperative effort with the Royal Botanical Gardens, the Hamilton Harbour Commissioners, and several other groups and stakeholders to cooperatively fund $12.6 million in habitat rehabilitation and public access. In addition, there will be spin-off benefits to shore protection and boaters. Broad communication of how funds were successfully leveraged will be important.

In Green Bay, integration of water-quality and fishery perspectives was achieved early in RAP development with the formation of a Biota and Habitat Management Technical Advisory Committee (Harris 1992). Within this committee, water-quality and fishery personnel reached agreement on quantitative and qualitative fish-community and habitat goals and objectives, and developed recommendations for rehabilitating the fishery, preserving and enhancing existing habitats, and creating new habitats. Some examples of fishery and habitat preservation and rehabilitation include:

installing an electric carp barrier at the water-intake structure at Sensiba State Wildlife Refuge (located on the western shore of Green Bay) to exclude carp and, therefore, stabilize substrates and help reestablish submerged aquatic vegetation;

constructing two walleye spawning beds by placing riprap material along 335 m of shoreline at the northern end of Voyageur Park in DePere;

- stocking approximately 10,000 fingerlings (5-25 cm long) in the Fox River and inner bay in an effort to reestablish the Great Lakes strain of muskellunge; and

acquiring private wetlands along Green Bay's western shore and creating a new wetland habitat on state land by plugging old drainage ditches and drain tiles near the interchange of U.S. Highway 41 and Interstate 43 (Center for Public Affairs 1990).

RAPs for AOCs along the northern shore of Lake Superior have also benefitted from numerous dedicated people, a good information base, seed money to help catalyze the process, staff working at the local level, and rehabilitation projects that were feasible, measurable, and action-oriented. Those RAPs have been substantially influenced by the Lake Superior Program Office (Thunder Bay, Ontario). The Lake Superior Program Office has staff from several agencies within provincial and federal governments who are focused on integration of water-quality and fishery programs, and program delivery. This integrated process is literally a new way of doing business-focusing resources on delivering specific projects. Both upper- and lower-level management support is achieved within and among agencies. The end result is partnerships between governments and other stakeholders to rehabilitate the AOCs along the northern shore of Lake Superior. Two examples of rehabilitation projects include:

1) a six-staged, four-year project began in 1990 to rehabilitate the walleye population in Nipigon Bay by augmenting the remnant fish stock, reopening migratory routes, and restoring degraded habitats ($930,000 was provided from the Great Lakes Clean-Up Fund and $1,862,000 was provided from other agency partners); and

2) a six-staged, four-year project began in 1990 to create and restore degraded and lost nearshore aquatic habitat in four tributaries, rehabilitate the littoral zone, stabilize wetlands, restore riverine diversity, and increase abundance of fish and wildlife populations in the Thunder Bay AOC ($2,305,000 was provided from the Great Lakes Clean-Up Fund and $3,006,000 was provided from other agency partners).

These examples of integration of remedial-action and fishery-management planning are not intended to infer that no additional examples occur in other AOCs, but they show successful efforts that have led to concrete actions to rehabilitate fisheries and fish habitat. Indeed, there are many additional examples of successful integration and rehabilitation of fisheries and fish habitat in Great Lakes AOCs.

Workshop participants generally agreed that what was needed was an integrated approach within and among Great Lakes water-quality programs (RAPs and lakewide-management plans being developed to address use impairments caused by critical pollutants) and fishery-management programs (fishery-management plans being developed for AOCs and the Joint Plan which calls for restoring and maintaining desired, lake-specific fish communities). Table 3 compares these different Great Lakes water-quality and fishery-management planning initiatives. Workshop participants suggested that integration should be pursued from both top-down (directed by senior-government management) and bottom up (coordinated at the local level) perspectives.

Table 3. A comparison of the major water-quality and fishery-management planning initiatives for the Great Lakes.

Planning initiative	Purpose or intent
Remedial Action Plans	Identify the responsibility and time frame for implementing remedial and preventive actions necessary to restore impaired beneficial uses in the 43 Great Lakes AOCs.
Fishery Management Plans	- Describe existing environmental conditions and fish communities in Great Lakes tributary watersheds. - Identify problems and potential improvements. - Define management goals. - Identify options and obstacles to achieve management goals.
Lakewide Management Plans	Identify the responsibility and time frame for implementing remedial and preventive actions necessary to reduce loadings of critical pollutants in order to restore impaired beneficial uses in the open waters of each of the Great Lakes.
Joint Plan	Plan for the restoration and maintenance of desirable fish communities as defined by consensus among all agencies with management responsibilities for Great Lakes fisheries.

From a top-down perspective, integration within AOCs can be pursued by senior management recognizing the need for integration in program mission statements and manifesting a commitment to integration by formally directing staff to promote integration in agency work plans. Integration from a binational, basinwide perspective should also be sought. One way of accomplishing this objective could be for the federal governments' environmental agencies (USEPA and EC) to utilize their biennial state of the lakes conferences not only to evaluate ecosystem trends, but evaluate progress in integration, account for interrelationships among management initiatives, and provide opportunity for midcourse corrections (Hartig et al. 1991; Eshenroder et al. 1991). The primary advantage of this mechanism would be the utilization of a major, basinwide event which attracts senior program managers. The primary disadvantage of this mechanism is that it would be a considerable expansion of the purpose of state of the lake conferences-to document the health of the Great Lakes.

Other ways of achieving binational, basinwide integration would be for:

1) the United States and Canadian federal governments to expand the terms of reference of an existing binational coordinating committee, or

2) to establish a new binational coordinating committee whose terms of reference would be drafted to ensure: an integrated approach to RAPs, fishery-management plans for AOCs and other tributaries, lakewide-management plans, the Joint Plan, and other related planning initiatives.

The primary advantages of expanding the terms of reference of an existing binational coordinating committee are:

1) building upon the foundation of an existing institutional structure, and

2) taking advantage of established working relationships.

The primary disadvantages are:

1) the relatively low priority that integration might be given due to substantive program responsibilities of an existing binational coordinating committee, and

2) relatively-infrequent meetings.

The primary advantage and disadvantage of establishing a new binational coordinating committee with appropriate terms of reference would be establishing integration as a chief priority and obtaining the necessary resources.

Coordination and integration are essential to ensure an ecosystem approach to management. A binational coordinating committee could also be given the responsibility of:

- periodically measuring progress in integration,

- ensuring accountability, and

- auditing impacts and unintended effects.

In addition to ensuring integration, such mechanisms could provide immediate benefit in elevating the priority for addressing rehabilitation of fish and fish habitat in those nearshore waters of the Great Lakes that are not being systematically or comprehensively addressed by any of the planning initiatives (Table 3).

From a bottom-up perspective, workshop participants recommended that integration would probably be accomplished best through RAP teams and RAP networks. The degree and extent of fishery involvement in RAPs will undoubtedly vary among AOCs. However, workshop participants agreed that there is a need for fishery managers to provide RAP teams with:

- site-specific fish-community/habitat objectives or targets that are quantifiable and measurable;

- fishery input for the priority-setting process; and

- a fishery reality check to prevent management actions from being at odds with one another.

Indeed, RAPs are a vehicle for fishery managers to achieve their goals. A bottom-up perspective is also important for recognizing and addressing effects of scale on planning (linkages of AOC fish-community objectives and targets with lakewide fish-community objectives). Workshop participants emphasized that citizens and stakeholders within AOCs were the best qualified to determine trade-offs, measure attainment of goals and objectives, and ensure integrated planning.

The relationship between fish-community structure and water quality is often not well established. Therefore, adequate communication and cooperative working relationships must be established between water-quality and fishery personnel. Indeed, this task has been accomplished in many of the AOCs. Where adequate communication and cooperative working relationships have been achieved, they must be sustained. In AOCs where integration between the two groups is in an early stage, every effort must be made to improve communication and strengthen working relationships. Immediate benefit could be achieved by having local fishery managers provide site-specific fish-community objectives and targets (Table 1), and by assisting RAP teams and other stakeholders reach agreement on use impairments and causes relative to the fish community and fish habitat. Experience has shown that the degree of degradation of fish populations and loss or degradation of fish habitat must be made explicit in the planning process. When linkage between habitat degradation and fish loss has been accomplished, fishery managers should continue to help identify, prioritize, and implement actions necessary to rehabilitate the fish community and its habitat.

To ensure complementary and reinforcing remedial-action and fishery-management planning in AOCs, effective communication among RAF' coordinators, fishery managers, and other stakeholders will be required (Hartig and Zarull 1992). As communication increases, cooperation and coordination will increase. Workshop participants felt that RAF' teams and RAP institutional structures (stakeholder groups, public advisory councils, and coordinating committees) provide a good opportunity to share knowledge and experience, listen, learn, and cooperate (Table 4). Issues which must be considered and addressed include:

limitations of scientific understanding;

practicality of objectives,

limited or missing historic data,

need for a wetland perspective,

need for greater scientific analysis and transfer,

accounting for biodiversity;

undertaking establishment of fish-community objectives before establishment of physical-habitat objectives, and

addressing the terrestrial and aquatic interface (the need for land-use and urban-planners involvement).

Table 4. Remedial-action-plan institutional structures established in Great Lakes

	Area of concern	Institutional structure
1)	Peninsula Harbour	Peninsula Harbour Public Advisory Committee
2)	Jackfish Bay	Jackfish Bay Public Advisory Committee
3)	Nipigon Bay	Nipigon Bay Public Advisory Committee
4)	Thunder Bay	Thunder Bay Public Advisory Committee
5)	St. Louis Bay/River	St. Louis River Citizens Advisory Committee
6)	Torch Lake	None established
7)	Deer Lake/Carp Creek/Carp River	None established
8)	Manistique River	Manistique River Partnership Council
9)	Menominee River	Menominee River RAP Citizens Advisory Committee
10)	Fox River/Southern Green Bay	Green Bay RAP Public Advisory Committee North East Wisconsin Waters of Tomorrow, Inc.
11)	Sheboygan River	Sheboygan County Water Quality Task Force
12)	Milwaukee Estuary	Milwaukee Estuary RAP Citizens Advisory Committee
13)	Waukegan Harbor	Waukegan Harbor Citizens Advisory Committee
14)	Grand Calumet River/ Indiana Harbor Canal	Citizens Advisory for the Remediation of the Environment Committee (CARE)
15)	Kalamazoo River	Kalamazoo River Public Advisory Council
16)	Muskegon Lake	Muskegon Lake RAP Public Advisory Council
17)	White Lake	White Lake RAP Public Advisory Council
18)	Saginaw River/Saginaw Bay	Saginaw Basin Natural Resources Steering Committee Saginaw Basin Alliance
19)	Collingwood Harbour	Collingwood Harbour RAP Public Advisory Committee
20)	Severn Sound	Severn Sound RAP Public Advisory Committee
21)	Spanish River Mouth	Spanish River Public Advisory Committee
22)	Clinton River	Clinton River RAP Public Advisory Council
23)	Rouge River	Rouge RAP Advisory Council Friends of the Rouge

Areas of Concern.

AOC	Examples of quantitative objectives or targets
24) River Raisin	River Raisin Public Advisory Council
25) Maumee River	Maumee River RAP Advisory Committee
26) Black River	Black River RAP Coordinating Committee
27) Cuyahoga River	Cuyahoga RAP Coordinating Committee Cuyahoga River Community Planning Organization
28) Ashtabula River	Ashtabula River RAP Advisory Council
29) Presque Isle Bay	Public Advisory Committee for the Presque Isle Bay RAP
30) Wheatley Harbour	None established
31) Buffalo River	Buffalo River Citizens Committee Buffalo River Remedial Advisory Committee Friends of the Buffalo River
32) Eighteen Mile Creek	None established
33) Rochester Embayment	Monroe County Water Quality Management Committee
34) Oswego River	Oswego River RAP Advisory Committee
35) Bay of Quinte	Bay of Quinte Public Advisory Committee
36) Port Hope	Port Hope Harbour Local Advisory Croup
37) Metro Toronto	Metro Toronto Public Advisory Committee
38) Hamilton Harbour	Hamilton Harbour Stakeholders Bay Area Implementation Team (BAIT) Bay Area Restoration Council (BARC)
39) St. Marys River	St. Marys River Binational Public Advisory Council
40) St. Clair River	St. Clair River Binational Public Advisory Council
41) Detroit River	Detroit River Binational Public Advisory Council Friends of the Detroit River
42) Niagara River (Ontario)	Public Advisory Committee for the Niagara River RAP
Niagara River (New York)	Niagara River Action Committee
43) St. Lawrence River (Cornwall, Ontario)	St. Lawrence Public Advisory Committee
St. Lawrence River (Massena, New York)	St. Lawrence Remedial Advisory Committee

A number of barriers exist to achieving integration of water quality and fishery programs in AOCs. Some barriers include:

human- and financial-resource limitations;

a low priority for AOCs within some agencies;

a low priority for the planning process within some agencies;

a perception of uncertain benefits;

an extended time period to achieve benefits;

a lack of interdisciplinary emphasis;

interagency competitiveness for activities (funding and budgeting);

narrow agency focus and limited interagency coordination;

limited support for an ecosystem approach within agencies;

a perception of losing control;

program constraints; and

the traditional focus of fishery-management efforts on lakewide issues, instead of nearshore areas or AOCs with small geographic extent.

However, a number of enticements also exist to encourage water-quality and fishery personnel working in partnerships to achieve common goals. Some enticements include:

- a common understanding of problems, causes, and solutions;
- a greater probability of achieving success and common goals;
- greater stakeholder satisfaction;
- positive public perception and support;

- greater resources by pooling funds from different sources; and

- an opportunity to provide benefit to, and generate support from, greater numbers of people affected by problems in small geographical areas.

Workshop participants recognized both barriers and enticements, and concluded that considerable opportunity exists to integrate and move programs forward in a complementary and reinforcing fashion. Governments should consider establishing a team of experts to provide technical assistance on issues such as habitat rehabilitation to all RAP teams. Every effort should be made to market success stories. Communication among agencies should be more visible at all levels. RAP coordinators, fishery managers, and other stakeholders should advocate fishery-rehabilitation and habitat-restoration demonstration projects. Possibly, several AOCs could be elevated in priority as habitat demonstration projects. Broad communication to those who are impacted and affected by these projects will be needed after a commitment to a demonstration project has been made. In other words, there is a need to mobilize stakeholders to support and contribute to these demonstration projects.

CONCLUDING REMARKS AND RECOMMENDATIONS

Both fishery- and water-quality agencies have endorsed and adopted an ecosystem approach to management of the Great Lakes. Implementation of the ecosystem approach and achievement of complementary and reinforcing policies and programs will require greater coordination and integration. Coordination and integration are more about process than products, such as documents, reports, or written plans. A process of coordination and integration of water-quality and fishery-management programs will be successful if there is:

- broad-based stakeholder participation;

- a common understanding of problems, causes, and solutions;

- agreement on quantitative fish-community and habitat goals/objectives/targets, and on quantitative environmental and water-quality objectives;

- an open forum among agencies that promotes cooperation;

- United States and Canadian federal leadership for binational, basinwide coordination and integration; and

- public oversight and auditing of effects of management actions.

Benefits of such a process include more-effective management programs and achievement of "win-win" solutions for all parties.

Based on a review of the fish-community and habitat goals/objectives/targets for AOCs and the related workshop discussions on integrating remedial-action and fishery-management planning, the following recommendations emerge for water-quality and fishery-management agencies.

1) Priority should be placed on accelerating establishment of lakewide fish-community objectives by each lake committee under the Joint Plan. Concurrently, fishery managers with AOC responsibilities should work with RAP teams and within RAP institutional structures to set interim, quantitative, and measurable fish-community and habitat goals/objectives/targets that are consistent with lakewide fish-community objectives.

2) Integration of RAPs and fishery-management planning in AOCs should be pursued from both top-down and bottom-up perspectives. Top-down support for integration would be accomplished by senior-management's acknowledgment of the need for integration in program mission statements and manifesting a commitment to integration by formally directing staff to promote integration in agency work plans. Bottom-up support for integration would be demonstrated by fishery managers providing RAP teams with quantitative, site-specific, fish-community and habitat goals/objectives/targets, fishery input to the priority-setting process, and a fishery reality check to prevent inconsistent management actions.

3) Binational efforts should be made to ensure that RAPs, lakewide-management plans, fishery-management plans for tributary watersheds, the Joint Plan, and other related planning initiatives are complementary and reinforcing. Possible ways to accomplish this effort are:

   a) use the biennial state of the lakes conferences of the United States and Canadian federal governments as an ongoing mechanism to address and achieve integration,

   b) expand the terms of reference of an existing binational coordinating committee to ensure integration, or

   c) establish a new binational coordinating committee whose terms of reference would ensure integration among the planning initiatives.

4) Where integration and coordination of RAPs and fishery-management planning have been achieved and resulted in specific actions to rehabilitate fisheries and fish habitat (Hamilton Harbour, Green Bay, Nipigon Bay, and Thunder Bay), broad communication of how this was accomplished (including leveraging of funds) must be undertaken. Every effort should be made to celebrate and market successes.

Future successes in restoring and maintaining the integrity of the Great Lakes basin ecosystem will undoubtedly depend even more on partnerships and coalitions of fishery- and water-quality managers, and other stakeholders.

ACKNOWLEDGMENTS

The workshop and this report were made possible by a grant from the USEPA and EC to Wayne State University, Detroit, Michigan. I gratefully acknowledge the following contributors: all fishery biologists who provided survey data; W. Culligan, D. Jester, C. Schrank, R. Thoma, and J. Atkinson who served as speakers for the workshop; J. Koonce who facilitated a break-out session; N. Law who helped conduct the workshop; and all workshop participants identified in the Appendix for enriching workshop discussions with their knowledge, insights, and practical experiences. Other individuals who helped facilitate the acquisition of survey information included: V. Cairns, D. Conway, V. Harris, R. Lange, R. Desjardine, P. Smith, J. Thomas, B. Fredrickson, and N. Larson. M. Dochoda helped organize and coordinate the workshop with GLFC's HAB. I especially thank K. Fuller (USEPA), D. Epstein (EC), and D. Dodge (chairman, HAB) for their support and encouragement of this project.

REFERENCES

Center for Public Affairs. 1990. Progress Report for the Green Bay and Fox River Remedial Action Plan. Univ. Wisc.-Green Bay, Green Bay, WI. 51 p.

Eshenroder, R. L., J. H. Hartig, and J. E. Gannon. 1991. Lake Michigan: an ecosystem approach for remediation of critical pollutants and management of fish communities. Great Lakes Fish. Comm. Spec. Pub. 91-2. 58 p.

Great Lakes Fishery Commission (GLFC). 1980. A joint strategic plan for management of Great Lakes fisheries. Great Lakes Fish. Comm., Ann Arbor, MI. 23 p.

Hamilton Harbour Remedial Action Plan Writing Team. 1992. The remedial action plan for Hamilton Harbour. Goals, options, and recommendations. Vol. 2, Main Report. Stage II RAP. Burlington, Ontario, Canada. 329 p.

Hamilton Harbour Stakeholder Group. 1991. The remedial action plan for Hamilton Harbour. Burlington, Ontario, Canada. 285 p.

Harris, V. A. 1992. From plan to action: the Green Bay experience, p. 37-58. In J. H. Hartig and M. A. Zarull [eds.] Under RAPs: toward grassroots ecological democracy in the Great Lakes basin. Univ. Mich. Press, Ann Arbor, MI. 289 p.

Hartig, J. H. 1993. A survey of fish-community and habitat goals/objectives/targets and status in Great Lakes areas of concern. Great Lakes Fish. Comm. 96 p.

Hartig, J. H., J. F. Kitchell, D. Scavia, and S. B. Brandt. 1991. Rehabilitation of Lake Ontario: the role of nutrient reduction and food web dynamics. Can. J. Fish. Aquat. Sci. 48:1574-1580.

Hartig, J. H. and M. A. Zarull. [EDS.] 1992. Under RAPs: toward grassroots ecological democracy in the Great Lakes basin. Univ. Mich. Press, Ann Arbor, MI. 289 p.

International Joint Commission (IJC). 1991a. Review and evaluation of the Great Lakes remedial action plan program. Great Lakes Water Quality Board, Windsor, Ontario, Canada. 47 p.

International Joint Commission (IJC). 1991b. Summary of the remedial action plan forum held in Traverse City, Michigan. Windsor, Ontario, Canada. 9 p.

Lake Superior Technical Committee. 1986. A lake trout rehabilitation plan for Lake Superior. Lake Superior Committee Meeting (Minutes). March 20, 1986. Great Lakes Fish. Comm. Appendix IX: 47-64. (Cited by permission of the author).

Ohio Environmental Protection Agency. 1990. The use of biocriteria in the Ohio Environmental Protection Agency surface water monitoring and assessment program. Columbus, OH. 52 p.

Rodgers, G. K. 1992. Hamilton Harbour remedial action planning. p. 59-72. *In* J. H. Hartig and M. A. Zarull [eds.] Under RAPs: toward grassroots ecological democracy in the Great Lakes basin. Univ. Mich. Press, Ann Arbor, MI. 289 p.

Thoma, R. F. 1990. A preliminary assessment of Ohio's Lake Erie estuarine fish communities. Ohio Environmental Protection Agency, Columbus, OH. 27 p.

United States and Canada. 1987. Protocol to the 1978 Great Lakes Water Quality Agreement. International Joint Commission, Windsor, Ontario, Canada. 130 P.

Yoder, C. 0. 1991. The integrated biosurvey as a tool for evaluation of aquatic life use attainment and impairment in Ohio surface waters. ***In*** Biological Criteria: Research and Regulation. National Conference of U.S. Environmental Protection Agency, Office of Water, Washington, DC. p. 110-122.

APPENDIX
WORKSHOP PARTICIPANTS

Jim Atkinson
Ontario Ministry of Natural Resources

Tim Bader
Ohio Department of Natural Resources

Alfred Behm
U.S. Army Corps of Engineers

Mary Beth Binns
Northeast Ohio Areawide Coordinating Agency

Mark Breederland
International Joint Commission

John Cooley
Department of Fishery and Oceans Canada

Bill Culligan
New York State Department of Environmental Conservation

Ken Cullis
Ontario Ministry of Natural Resources

David Davies
Ohio Department of Natural Resources

Marg Dochoda
Great Lakes Fishery Commission

Doug Dodge
Ontario Ministry of Natural Resources

Wayne Faatz
Indiana Department of Natural Resources

Kent Fuller
U.S. Environmental Protection Agency

John Gannon
U.S. Fish and Wildlife Service

Murray German
Ontario Ministry of Natural Resources

Michael Gilbertson
International Joint Commission

Vic Gillman
Department of Fisheries and Oceans Canada

John Hartig
Wayne State University

Liz Hay-Chmielewski
Michigan Department of Natural Resources

Ava Hottman
Ohio Environmental Protection Agency

Diana Klemans
Michigan Department of Natural Resources

Joseph Koonce
Case Western Reserve University

Douglas Jester
Michigan Department of Natural Resources

Neely Law
Wayne State University

Julie Letterhos
Ohio Environmental Protection Agency

Allison MacArthur-Whitman
Michigan Department of Natural Resources

Bruce Manny
U.S. Fish and Wildlife Service

Gerry Mikol
New York State Department of Environmental Conservation

Art Ostaszewski
Michigan Department of Natural Resources

Ken Paxton
Ohio Department of Natural Resources

Ed Rankin
Ohio Environmental Protection Agency

Kelvin Rodgers
Ohio Environmental Protection Agency

Candy Schrank
Wisconsin Department of Natural Resources

Harvey Shear
Environment Canada

Fred Snyder
Ohio Sea Grant

Ron Spitler
Michigan Department of Natural Resources

Roger Thoma
Ohio Environmental Protection Agency

Bob Wysenski
Ohio Environmental Protection Agency

Michaela Zint
Michigan Sea Grant

Great Lakes Fishery Commission
2100 Commonwealth Blvd., Suite 209
Ann Arbor, MI 48105-1563
(313) 662-3209

Cover art from "Use of an Ecosystem Approach to Restore Degraded Areas of the Great Lakes" (Ambio 18:423-428, 1989)