RESEARCH PRIORITIES

FOR THE 1990s

Great Lakes Fishery Commission

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edited by

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TABLE OF CONTENTS

INTRODUCTION

In 1991 the Great Lakes Fishery Commission (GLFC) produced its strategic vision for the next decade, which identified the focus, intent, and direction of programs through the year 2000 (GLFC 1992). This document is centered around vision statements for three major areas: healthy Great Lakes ecosystems, integrated management of sea lamprey, and institutional/stakeholder partnerships. Each vision statement had milestones for accomplishment; some milestones had implications for research. As well, the vision statement on partnerships had a milestone that called for establishment and dissemination of priorities for research by 1993. With these requirements in mind the GLFC asked its Board of Technical Experts (BOTE) to develop a statement of priorities for fishery research on the Great Lakes. This report is submitted in fulfillment.

A collaborative approach was used in developing recommendations for research priorities that complement the strategic vision of the GLFC. After soliciting input from researchers and managers affiliated with the GLFC, a draft statement of research needs was produced. This draft was then shared with commissioners, those persons who responded to the solicitation, and other working committees of the GLFC for review and comment. After reviewing these comments and suggestions, this report was drafted.

These statements on research priorities are of necessity broadly defined, because much creative and innovative research needs to occur before the GLFC vision can be attained. The overall goal of the vision is to apply an ecosystem approach to the management of Great Lakes fishery resources that results in productive and sustainable benefits to the citizenry of the United States and Canada. This approach is holistic in nature, integrating the biological, social, and economic sciences in addressing factors that impede the sustainability of Great Lakes fisheries.

Research priorities in this report have been organized around the three vision statements described in the GLFC vision, and are in the same order: healthy Great Lakes ecosystems, integrated management of sea lamprey, institutional/stakeholder partnerships. Each research priority is numbered sequentially (39 total) throughout the report. No priority was assigned to the various research elements as all priorities are considered important and new information in any of the areas will alter perceptions of need. These statements are intended to be a living document, which will be updated periodically.

RESEARCH IN SUPPORT OF THE HEALTHY GREAT LAKES ECOSYSTEMS VISION STATEMENT

Although the concept of ecosystem health is not well defined, Scientists and society at large increasingly accept the idea that aquatic ecosystems that are relatively undisturbed by anthropogenic forces tend to provide greater and more sustainable benefits to society. BOTE has identified five major areas of research needed to improve understanding of ecosystem health and the influence of anthropogenic forces on health:

1) biodiversity
2) exotics
3) sustainable production
4) habitat
5) contaminants

Biodiversity

Biodiversity is defined as the variety of life and its processes encompassing all levels of biological organization (Hughes and Noss 1992). The new discipline of conservation biology (Soulé 1986) has emerged in response to the increasingly global concern with the continuing loss of biodiversity. Society has begun to voice strongly their objections to the loss of biodiversity in all ecosystems, including the Great Lakes. A better understanding of the causes of losses of biodiversity, and new approaches to the measurement of biodiversity are needed to achieve the GLFC's healthy ecosystem vision. Further, these questions need to be understood not just for economically important fish species, but also for other fishes and for planktonic and benthic organisms that comprise an ecosystem. Specific research areas include:

1. **Identify and characterize anthropogenic causes of loss of species, strains, or stocks.** Historically, human activities around the Great Lakes basin, including land development and exploitation of Great Lakes resources (e.g. food, water), have led to profound changes in the aquatic ecosystems of the Great Lakes (e.g. Christie 1974). Nevertheless, an understanding of the causes of these historical changes is incomplete, and an ability to predict the risk of future losses of biodiversity is far from adequate.

2. **Identify stocks and their level of differentiation.** Great Lakes' scientists agree that biodiversity at the sub-species (i.e. stock) level is important for economically valuable fish species, most notably lake trout (Ryder and Edwards 1985). Assessing biodiversity of fishes and other taxa in the Great Lakes will require the development and application of techniques for stock/strain identification, including morphological and meristic approaches as well as the rapidly developing array of techniques for differentiation using molecular genetics (Allendorf et al. 1987; Billington and Hebert 1991).

3. **Determine stock status and biological characteristics.** The assessment of biodiversity of fish stocks in the Great Lakes requires not only the identification of distinct stocks, but also evaluation of their status (e.g. are certain stocks threatened?) and of biological characteristics of the stocks that might aid in determining risk of endangerment.

4. **Determine the consequences of fish stocking on genetic diversity and fitness of wild fish.** Recently, concerns have been raised regarding the potential impacts of stocking on the genetic diversity of native fish stocks (Nehlsen et al. 1991; Hindar et al. 1991). In the Great Lakes most of the stocked-fish species are non-native, so the issue is less acute; nevertheless, it warrants attention, particularly if interspecific interactions are considered, and as naturally reproducing populations of lake trout expand in the Great Lakes.

5. **Identify and characterize human beliefs, attitudes, and behaviors related to biodiversity.** People are one of the major controlling factors in determining if ecosystems will be healthy, and, more specifically, in determining if the variety of life and its processes will be maintained with sound stewardship. Any attempts to adopt goals for biodiversity without an understanding of what motivates people to be, or prevents people from being, good stewards is doomed to social and political failure. This avenue of research may address questions such as: What do people know and believe about biodiversity in the Great Lakes? What are people willing to do to stop or reverse current trends toward species losses? How do the public and managers define, and to what extent do they support, biodiversity goals? What impact do agency mandates, ethics, philosophies, and management plans have upon achieving biodiversity milestones? What interagency systems exist or are needed to support biodiversity? What human-related barriers exist to achieving biodiversity goals, and why do they exist?

6. **Determine the influence of biodiversity on the level and sustainability of fish production in the Great Lakes.** One of the challenges involved with developing fish community goal statements for the Great Lakes concerns determining reasonable expectations for levels of fish production, particularly as they relate to sustainable levels of use, or exploitation. There are reasons to believe that these levels are influenced by community composition; greater trophic diversity may imply more efficient transfer of energy up the food chain to the top predators that are most often heavily exploited. Such concepts are at best hypotheses, however, and further research is needed to improve our understanding of the influence of biotic diversity on sustainable production.

Exotics

Introduction of species to an ecosystem often alters the structure and function of natural communities, making the system unstable [and less predictable] (Herbold and Moyle 1986), and commonly causing undesirable changes. The sea lamprey invasion of the Great Lakes is a classic case in point. Even deliberate introductions into aquatic systems have often resulted in more problems than they have solved because the behavior or the dispersal ability of the exotic in its new surroundings were not well predicted (Li and Moyle 1981). Our recently completed research on introductions in the Great Lakes (Mills et al. 1993) concluded that much still needs to be understood about the dynamics of invasions before confident predictions on the

consequences of a particular introduction can be made. Research on exotics is needed especially in two broad areas:

7. **Develop prevention and control strategies for invasions and evaluate their social, economic, and biological consequences.** Just as preventative measures are the most cost-effective means of health care in humans, so too is prevention the most desirable means of minimizing the loss of ecosystem health due to invasions of exotics. Clearly this goal is easier said than done, and much needs to be learned about the efficacy of existing and proposed control strategies. In addition, virtually any control strategy involves trade-offs: social, economic, and ecological; these must be carefully examined before expensive control measures are likely to be supported.

8. **Develop an understanding of established exotics with a view to their management.** Enormous challenges remain for species that have successfully invaded the Great Lakes, if these species are to exert minimal impacts on the health of aquatic communities. The sea lamprey has been the object of decades of research oriented towards its control. Yet, unanswered questions about sea lamprey ecology make the outcome of attempts to optimally manage it difficult to predict with confidence. For more recent invaders, such as the zebra mussel, the spiny water flea, and the ruffe, much less is known. Understanding the ecology of these species in the Great Lakes is crucial to developing strategies that minimize their disruption of aquatic communities in the Great Lakes.

Sustainable Production

The aquatic communities of the Great Lakes supply numerous important social and economic benefits for which a significant part is derived from exploitation (harvest) of economically important fish species. The GLFC is committed to ensuring that these benefits are sustainable. Sustainable production can be defined as fish production that is used (harvested) to meet current needs without compromising the ability of future generations to meet their needs (GLFC 1992). Determining the level of use that is sustainable is one of the great challenges for fisheries management throughout the world. In the Great Lakes, as elsewhere, several specific areas require further research:

9. **Develop innovative methods of determining the range of allowable harvest consistent with sustainable production.** Overexploitation of fish stocks has led to important changes in fish community structure in many locations worldwide, including (arguably) the Great Lakes. This question has therefore been a preoccupation of fisheries scientists throughout the past century. The principal needs here are to better understand the process of fish recruitment and to use and adapt some of the more recently developed stock-assessment tools (e.g., Hilborn and Walters 1992) to derive improved estimates of allowable harvest which reduce the risk of overexploitation in the future.

10. **Determine the relationship between harvest and rehabilitation**

success. The goal of rehabilitation efforts in the Great Lakes is not only to return the ecosystem to a more healthy state, but also to attain a condition that allows sustainable exploitation by man (Christie et al. 1987). Trade-offs exist, however, during the period of transition from a degraded to a rehabilitated state. While fish stocks are recovering, harvest must be regulated in a way that does not compromise the recovery. A better understanding of the quantitative nature of this trade-off is needed.

11. **Determine the effects of exotics on sustainable production.** This issue is essentially an aspect of the second research need identified under **Exotics** (Develop an understanding of established exotics with a view to their management). A successful sustainable-harvest policy cannot ignore the potential impact of exotics on the productivity of other species.

12. **Assess food web effects on sustainable production.** The production of economically valuable fish in an aquatic ecosystem is related to production of organisms upon which these fish feed. These feeding interactions (the food web) can therefore be important in determining sustainable levels of production. For example, much debate currently exists as to whether the pelagic food webs in Lakes Ontario and Michigan can sustain present levels of piscivore production. The existence of this debate underscores the need for an improved understanding of food-web effects.

13. **Evaluate social, economic, and biological trade- offs between stocked and natural fish production.** The economically valuable fisheries of the Great Lakes include both stocked populations supported entirely by hatcheries and natural populations that are self-sustaining in the absence of excessive harvest. These fisheries provide different social, economic, and biological benefits. Understanding these benefits and the trade-offs among them is needed to equitably plan rehabilitation efforts.

14. **Develop techniques for identification and control of fish diseases and evaluate their social, economic, and biological consequences for sustainable production.** The control of fish diseases has become an important part of fisheries management in the Great Lakes, largely because of the heavy dependence on hatcheries for many of the more important fisheries. Little is known about the ecological consequences of the introduction of disease from hatcheries into natural populations. Insofar as diseases increase mortality in fish populations, diseases obviously have an impact on sustainable production. The quantitative effects of the spread of disease in both stocked and wild fish populations, including the relative fitness of diseased fish, need to be better understood.

Habitat

Healthy ecosystems require an adequate supply of high-quality physical and chemical habitats to ensure the successful growth, survival, and reproduction of the organisms that make up the ecosystem. Very often, declines in ecosystem health can be directly attributed to losses of

critical habitat. Certainly, this factor has been implicated with declines of Great Lakes fishes, such as with the Lake Ontario Atlantic salmon, or with many nearshore fish species that once flourished in now absent wetlands. Ironically, lake management plans commonly assume that habitat management can be used to sustain and enhance fishery resources, yet many managers question the current understanding of aquatic habitat (Sly and Busch 1992). Needed research on habitat can be grouped into four categories:

15. **Develop a system of habitat classification appropriate for determining Great Lakes ecosystem health.** The fulfillment of this need was begun with the workshop on Classification and Inventory of Great Lakes Aquatic Habitats (Sly and Busch 1992), but much remains to be done. Habitat descriptors need to be chosen that indicate the state of habitat quality and ecosystem health at a variety of spatial scales, ranging from local embayments or shoals to an entire Great Lake.

16. **Identify species that indicate ecosystem health in terms of habitat.** Indicator species can be used as an index of habitat quality in systems that would otherwise be too difficult or expensive to measure directly (Landres et al. 1988). Finding species that are truly indicators of habitat quality is important.

17. **Inventory habitats deemed important to ecosystem health.** This topic is the implementation side of research-need number 13. Once appropriate habitat descriptors have been agreed upon, an inventory should to be completed to determine where and how much quality habitat is available and to identify areas where remediation is required.

18. **Improve understanding of the relationship between specific habitat characteristics and the abundance of dependent species.** Habitat is of interest primarily because of its presumed importance to fish (or other organisms). Very often, however, the link between habitat and a particular species is at best qualitative. Rarely known, for example, is how much habitat of a particular type is sufficient. Yet, without this knowledge establishment of habitat restoration targets becomes disturbingly arbitrary.

19. **Determine the relative importance of physical habitat, nutrient levels, and biotic factors as agents controlling the capacity of the Great Lakes or areas therein for fish production.** This research combines elements of Research Priority 6 (relation of biodiversity to fish production) and Research Priority 18 (relation of habitat to fish abundance) in that it addresses the relative contribution of biotic and abiotic forces to the productive capacity (*sensu* no-net-loss habitat policy; DFO 1986) of an area. Understanding this issue is pivotal to setting priorities for ecosystem rehabilitation. If biotic factors such as distorted particle-size distributions (Sprules et al. 1991) are a dominant influence on production, habitat manipulations may not result in benefits until community composition is consistent with restored ecosystem health.

Contaminants

Webster's Dictionary defines a contaminant as a substance that makes another substance unclean or impure. In the Great Lakes the best-known contaminants include persistent toxic chemicals such as PCBs, DDT, toxaphene, mirex, chlorobenzes, and chlorinated dioxins (Hallet 1988). These persistent compounds can lead to degraded ecosystem health by affecting the growth, survival, and especially the reproductive success of organisms. Especially affected are the top predators (piscivorous fish and birds), due to the phenomenon of biomagnification, which results in greatly increased concentrations of these substances in upper levels of the food chain. Also important is the effect, both real and perceived, of high levels of contaminants on the health of humans consuming fish caught in the Great Lakes.

20. **Determine fate and transport of contaminants in the Great Lakes.** Documenting the sources of contaminants and understanding their fate once they have entered the lakes is obviously a fundamental element of research. This work has traditionally been directed primarily by water-quality management agencies; nevertheless, identification of this problem is important for understanding ecosystem health from a fisheries standpoint.

21. **Improve understanding of the ecological consequences of contaminant levels in Great Lakes fishes.** Contaminants have been shown to biomagnify from one trophic level to another, leading to highly elevated concentrations in top predators (Evans and McNaught 1988). Contaminants have been linked to lowered reproductive success of Great Lakes salmonids through the induction of mortality in developing eggs or in fry (Mac 1988; Mac et al. 1985). One issue not clearly understood and that needs to be addressed is the role (if any) played by contaminants in changing the productivity of fishery resources (Willford 1988).

22. **Improve understanding of social and economic consequences of contaminants.** Humans have been shown to serve as multigenerational end-point receptors for contaminants in the Great Lakes. This phenomenon has given rise to many questions regarding human-health issues, and has made people more wary of consuming Great Lakes fish (Humphrey 1988). The health issue and change of lifestyles due to advisories are important social issues that need to be considered (Knuth 1990), and have prompted coordination of management of contaminants in fisheries. As well, contaminant-related consumption advisories and closure of certain fisheries appear to have had significant impacts on local Great Lakes economies (Willford 1988).

RESEARCH IN SUPPORT OF THE INTEGRATED MANAGEMENT OF SEA LAMPREY VISION STATEMENT

The GLFC views sea lamprey management as an activity that should be complementary to and coordinated with other fishery management activities to produce sustainable benefits to society. The sea lamprey invasion of the Great Lakes was a key factor leading to the demise of lake trout and several other species/populations in the Great Lakes. The control program initiated by the GLFC has been successful in reducing sea lamprey populations in the Great Lakes (Smith and Tibbles 1980). These reductions enabled a reestablishment of piscivores in the offshore waters. Research needs in support of the existing control program are organized around refining the cost/benefit analysis of control practices for (1) allocation of resources among elements of current control technologies (sterile-male-release, within-stream barriers, lampricides), (2) allocation of resources among lakes, and (3) identification of low cost/benefit components of the control process that may benefit most from continued research and development.

23. **Develop a valuation scheme to quantify the benefits of sea lamprey control.** Valuation is a critical part of the cost/benefit analysis as it puts a number to the benefit part of the ratio. The main question is: how much is a fish that is killed by a sea lamprey worth? The issue has been quite controversial since both market and non-market values must be included in a valuation scheme.

24. **Develop an optimization framework for allocation of resources among elements of the control program.** Decision-making tools are required that maximize benefits of the control program by finding the best mix of control technologies to be implemented given a constrained-budget scenario.

25. **Develop improved cost effectiveness of existing control practices.** Improved assessment technologies for lentic and lotic populations of sea lamprey, better representation of habitat, and optimization of the treatment cycle and the mix of control technologies will lead to a more cost-effective way of implementing the control program.

Strong social pressure exists for the GLFC to move the control program from primarily chemical control to a state that is less reliant on chemicals. As a result, the GLFC has incorporated in its vision statement a goal of developing new control technologies not based on use of pesticides.

26. **Conduct basic research on sea lamprey biology as a foundation for development and application of new control technologies.** Knowledge of basic sea lamprey biology is necessary to develop and implement an integrated management approach (Sawyer 1980).

27. **Conduct research on aspects of sea lamprey biology intended to identify specific opportunities for new control strategies.** Several aspects of lamprey biology may give rise to new control technologies. Some of these areas include pheromone communication (Teeter 1980), sterilization (Hanson and Manion 1980), and the role of barriers in blocking access to spawning habitat (Hunn and Youngs 1980).

28. **Develop and assess new control technologies.** New technologies must be taken from the drawing board to actual implementation. These technologies should reduce the GLFC's reliance on chemical control.

RESEARCH IN SUPPORT OF THE INSTITUTIONAL/STAKEHOLDER PARTNERSHIPS VISION STATEMENT

This statement focuses on partnerships that are critical to an ecosystem approach for management of the Great Lakes. The GLFC (1992) defines a partnership as "an association or alliance among different groups of people or institutions and agencies to administer and deliver more effective programs or to seek solutions to problems." The integrity of the Great Lakes ecosystem "requires political systems that are responsive to the social, economic, and environmental systems that sustain them" (Cowan et al. 1990). The GLFC believes that healthy and effective partnerships are essential for the achievement of the other two vision statements.

Develop means to identify and characterize the interests of stakeholders affected by the quality and productivity of the Great Lakes ecosystem

Stakeholders are people affected by the quality and productivity of the Great Lakes ecosystem regardless of their perception of their relationship to the Great Lakes (GLFC 1992). In order to establish partnerships, the groups involved need to be identified and characterized.

29. **Develop means of determining the size and distribution of stakeholder groups.** Since all stakeholders are affected by management goals set for the Great Lakes, knowledge of who these goals will affect and how stakeholders will affect their achievement is important. These factors should be kept in mind when setting management policy or when seeking support for management plans. Techniques for the identification of stakeholder groups exist; they need to be identified, evaluated, and adapted to serve the GLFC's specific needs.

30. **Develop means to measure and compare the interests, needs, and expectations of different stakeholder groups.** The needs, interests, and expectations of different groups should be considered when planning a

management strategy since success will be affected by the cooperation and support of these groups. Few management programs can be implemented without resolving the issues presented by the various stakeholder groups (Peyton 1987).

Develop means to identify economic consequences of alternative allocation decisions

31. **Develop economic criteria for the allocation of aquatic resources.** First priorities are clarification of what and how much is being allocated to various stakeholders and assessment of the rate of resource depletion during specific time periods. This evaluation should be in the context of trade-offs between added economic benefits and increased biological stress. As economic benefits depend on the process of allocation to stakeholders, identification of stakeholders and the amounts that they gain or lose in the reallocation process should be established.

32. **Identify and examine means whereby stakeholders pay for benefits generated from their allocation of aquatic resources.** The allocation of a quota of resources will depend, in part, on whether the recipients of the quotas are required to pay for what they use. At present only nominal license fees exist for most fisheries. If a fisher were required to pay for the fish extracted as well, a market in quota rights would be formally established. If stakeholders paid catch fees, demand will tend to decline and governments would gain revenue.

33. **Develop the means to identify and evaluate a multi-account framework so that values are comparable across stakeholder groups.** This area of research will be particularly difficult because any measure of value from economic or social science will fail to perfectly describe a means of comparison between groups and avoid controversy. However difficult, this research is no less important.

Develop means to identify the social consequences of alternative allocation decisions

The GLFC should assess how stakeholders will be affected by alternative resource-allocation decisions. Social and cultural consequences of allocation decisions should be assessed in addition to economic consequences. Although these consequences are difficult to quantify, they are important. Depending on the situations and the type of stakeholders involved, those who "lose" in these decisions may be very active in creating conflict in natural-resource issues, or they may be powerless to affect changes that are detrimental to their interests and well being. The identification of the full range of social consequences of allocation decisions will aid managers in equitable allocation and in issue management.

34. **Identify and evaluate strategies for conflict resolution relative to allocation decisions.** Conflict due to allocation decisions must be negotiated. Currently, ways to negotiate, outside of using the judicial system, are lacking. Finding other methods of conflict resolution would help in building effective partnerships (MacDonnell 1988).

35. **Identify and evaluate mechanisms by which stakeholders receiving an allocation of aquatic resources return benefits to the ecosystem.** The negative consequences of conflict resolution can cause some stakeholders to relinquish their interests in Great Lakes management. Many of the consumptive users currently identified as stakeholders, for example, may seek substitute recreational pursuits as their Great Lakes' interests are diminished. If this substitution happens, the ecosystem would lose benefits to the extent that these stakeholder segments provide a core of support for conservation biology in the Great Lakes. This research also addresses the question of how the stakeholders perceive stewardship of the ecosystem and how they will respond to management goals and objectives. For example, does the negative response by some organizations to the GLFC's strategic vision truly represent widely held values of stakeholders? Existing data show that a large proportion of Great Lakes salmonid anglers place a higher priority on ecosystem quality rather than on recreation (Peyton, unpublished report to Michigan Sea Grant, 1991).

Foster communication among stakeholders to achieve effective stakeholder partnerships

The GLFC defines a partnership as "an association or alliance among different groups of people or institutions and agencies to administer and deliver more effective programs or to seek solutions to problems." Clear and effective communication between different stakeholders is essential to the formation of effective partnerships. In the interest of issue management, stakeholders should be informed about alternative views of other groups. Currently, communication between stakeholders and agencies during critical-issue resolution exists. However, in order to foster effective stakeholder partnerships, communication among stakeholders should exist as well.

36. **Develop means to assess information needs among stakeholders.** To foster effective communication, the GLFC should understand what the different stakeholders know and what they need to know.

37. **Develop means to identify communication networks within stakeholder groups and potential networks among stakeholder groups.** Existing protocols should be adapted to capitalize on current or potential networks. An understanding of who stakeholders trust and rely on for natural resource-management information will enable resource managers to target their actions to make more use of developed and effective communication networks (e.g. Shanks 1992)

38. **Develop and/or evaluate education and communication strategies.** Once information needs and potential communication networks are identified, evaluation efforts should assess how well existing or newly developed communication programs meet information needs and what measurable impacts programs have had.

Integrate the institutional/partnership vision statement with the other vision statements during the implementation of the strategic vision

39. Include an assessment of what is technically, economically, and socially feasible to attain in any research effort to aid the implementation of the GLFC's vision

Contributors

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