GREAT LAKES FISHERY COMMISSION

Project Completion Report[1]

Examining the role of biodiversity in managing Great Lakes fishery resources

by:

Larry Crowder[2], Baird Callicott[3], Edward Crossman[4], Becky Cudmore[5], Lisa Eby[2], and Karen Mumford[5]

[2] Stephen Toth Professor of Marine Biology
Nicholas School of the Environment
Duke University Marine Laboratory
135 Duke Marine Lab Road
Beaufort, NC 28516-9721

[3] Department of Philosophy and Religion Studies
University of North Texas
P.O. Box 13526
Denton, TX 76203-6526

[4] Department of Ichthyology and Herpetology
Royal Ontario Museum
100 Queen's Park
Toronto, Ontario M5S 2C6

[5] CGRER
200 IATL
University of Iowa
Iowa City, IA 52242

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BOARD OF TECHNICAL EXPERTS
RESEARCH TASK PROJECT COMPLETION REPORT

Project Title
Examining the role of biodiversity in managing Great Lakes fishery resources

Principal Investigator(s)	Project Initiation Date
L. Crowder, B. Callicott, and E. Crossman	1 July 1995

Project Completion Date
30 June 1998 (extensions: values and zoogeography, Dec. 1998; ecology, Feb. 1999)

Project Objectives
1. Historical biodiversity and biogeography: species checklist (yr 1), extirpations and introductions (yr 1,2), historical fishery dynamics (yr 1,2), and organization of species and stocks (yr 2). (Crossman)
2. Food web and ecosystem implications: conserving biodiversity in aquatic systems (yr 1), implication of changes in biodiversity of the Great Lakes (yr 1,2), and feedback to stakeholders (yr 3). (Crowder)
3. Conceptual and values clarification and identification of ethics: concept clarification (yr 1), values clarification (yr 1,2), science/management relationship (yr 1,2), and concept and values clarification feedback (yr 2). (Callicott)
4. Synthesis of historical biodiversity and biogeography, food web and ecosystem implications, and conceptual and values clarification (yr 3). (Crowder, Crossman and Callicott)

Abstract

Our project began with three distinct objectives, each under the guidance of one of the PIs. As the research developed, we began to cross-link our efforts as appropriate. For example, as we documented fish species gains and losses, we began to examine the food webs and ecosystem implications of these changes. As concepts were clarified or basic scientific relationships between biodiversity and function were reviewed, we combined our insights and sought to make them specific to the Great Lakes. Finally as all the efforts began to merge, we examined the time course of changes in the biodiversity and function of Great Lakes fishery ecosystems in the context of changing human values, the increasing diversity of constituents (and their values) and the complexity of govenance structures. The workshops were an integral part of this evolving synthesis. Each workshop sought to integrate two or more of the initial research efforts and to present them to a widening audience for evaluation and critique. The first workshop involved primarily academics interested in conservation concepts and the implications of changing biodiversity for aquatic systems. The second included both academics and fisheries managers from across the Great Lakes. The final synthesis was presented at a "workshop for citizens" which included a wide range of constituents and involved presentations and facilitated discussions. The proceedings of the "citizen's workshop" are in press and will be distributed to interested parties by the GLFC. The Biodiversity Task members continue to prepare a GLFC Technical Report summarizing the results of the Task for publication in spring 1999. We already have published a number of peer-reviewed papers and expect to continue publishing portions of this work over the next year. We present the main results of each of the project objectives below.

Historical biodiversity and biogeography plus trend over time for various inpacts (Crossman and Cudmore)

We have documented the historical changes in species diversity and the factors which have influenced these changes. As part of the above, we made contact with involved agencies and individuals around the Great Lakes in order to: 1) have them check information prepared by us, 2) request that each send to us specific information required in the preparation of various deliverables, 3) organize and interpret documents found in literature searches, and those forwarded by Great Lakes agencies prior to use in preparation of deliverables, 4) distribute individual draft deliverables (e.g. checklists) to individuals seeking the information for their responsibilities (e.g. protocol for aquaculture on Great Lakes, preparation of CDROMs by University of Guelph on Great Lakes aquatic flora and fauna, for consideration of species by the Committee on the Status of Species at Risk in Ontario (COSSARO), for reference by USFWS, Green Bay WI, for use at Notre Dame University in the study of dispersal of fishes).

Completed deliverables by objective include the following (*= current and possible future publications):

Objective 1.1 Species checklist

1. *Established species (native and non-native) checklist by lake (Cudmore and Crossman)
2. Endemism and Type Localities (Crossman)
3. Compilation of legislation regarding the biodiversity of the fishes of the Great Lakes (Pedersen, Hébert, Crossman and Cudmore)
4. Some Human Classifications of Species of Great Lakes' Fishes (Crossman)

Objective 1.2 Extirpations and introductions

1. List of Extirpated/Extinct species (Crossman and Cudmore)
2. *Introduced species (reported and established) checklist by lake with vectors used (Crossman and Cudmore)
3. List of potential invaders into Canada and the Great Lakes with Global Warming (Crossman and Cudmore)
4. List of species invasive into the Canadian waters of the Great Lakes (Crossman and Cudmore)
5. *Invasive Capabilities and 'Original Fish Fauna' (Crossman)
6. Direct and Indirect Impacts of Aquaculture on the Fish Resources of the Great Lakes (Crossman)

Objective 1.3 Historical fishery dynamics

1. Impact of Historical Native Fisheries on the Biodiversity of the Fishes of the Great Lakes (Hébert, Crossman and Cudmore)
2. History of the Great Lakes Commercial Fishery and its Impacts on the Biodiversity of the Fishes of the Great Lakes (Cudmore)
3. Commercial landings - data collected and sent to Stuart Ludsin (The Ohio State University) for compilation on GLFC's website as per Randy Eshenroder's request. Compiled 1990s Canadian landings and US Lake Superior Tribal commercial landings compiled (Cudmore)
4. Recreational fishery - scattered catch and effort data
5. Recreational fishing tournament data compiled with respect to possible impact on the biodiversity of the fishes of the Great Lakes (possibly to be included in GLFC Technical Report)
6. Charter boat data compiled with respect to possible impact on biodiversity (possibly to be included in GLFC Technical Report)

Objective 1.4 Organization of species and stocks

1. Substrate as an example of habitat (possibly to be included in GLFC Technical Report)
2. Stocks (possibly to be included in GLFC Technical Report)
3. Horizontal and vertical distribution of species (possibly to be included in GLFC Technical Report)
4. Contaminants - some time trend analysis of contaminant levels in fishes (Pedersen, Crossman and Cudmore) (possibly to be included in GLFC Technical Report)

Recommendations

The following recommendations (in no particular order) were derived from our experience in attempting to gather and compile information and data from agencies around the Great Lakes.

⇒ The knowledge of the distribution (horizontal and vertical) of the fishes of the Great Lakes is very poorly known. The only exceptions might be the limited number of species included in studies of the status of the forage base, largely for salmonids, and the indirect knowledge by assessment and commercial fishing of the locations of some stocks of some species of commercial and recreational significance. The biodiversity, and future changes in it, cannot be properly monitored without more thorough knowledge of the real extent of distribution of a larger representation of the fauna. Distributional studies should be emphasized and coordinated.

⇒ Future considerations and study of biodiversity of the Great Lakes should not exclude segments of the fauna which are directly interlinked with the fishes as was decided by GLFC for this task.

⇒ Attempt to convince governments, especially the federal governments, that it is unwise to over-emphasize one segment of a problem to the exclusion of others. This applies even though the other may not, as yet, have created an impact equal to that of those segments emphasized. The highly publicized ruffe and one of two gobies, have exerted a demonstrable impact on natives species, but they constitute less than half of the non-indigenous species which have arrived in the Great Lakes with ballast water. In more general terms, the same imbalance of publicity applies to at least six other vectors involved in the appearance in the Great Lakes of non-indigenous species.

⇒ The Task members decided to include lakes Nipigon and St. Clair as Great Lakes, in contrasts to the usual reference to five Great Lakes. Information gathered in our work, and the growing commitment to the concept of ecosystem management suggest this idea of seven Great Lakes deserves continuation.

⇒ The biology, etc., of the fishes of the Great Lakes are not organized according to political boundaries. With the exception of a few cases, the study, documentation, and management of the fishes are being carried out with too much emphasis on state, provincial and national boundaries.

⇒ The status and nature of information needed for meaningful future monitoring of the environment, populations, biodiversity, and that needed to make management decisions, is extremely poor. This state is largely the result of the virtual independent, uncoordinated action of approximately 12 to 15 provincial, state and federal political units. In regard to the two statements above, New York (Department of Environmental Conservation) and Ontario (Ministry of Natural Resources) should be congratulated for the degree to which they have accomplished this coordination in Lake Ontario.

⇒ Many attempts by us to coordinate information on impacts over time on fish populations were seriously hampered or blocked by the divergence in the ways in which information had been gathered, analyzed, and made available. For example, catch and effort of the recreational fishery are recorded and reported by different agencies in ways which literally prevent the development of lakewide trends over time in catch/unit effort.

⇒ The GLFC should assume the responsibility for the coordination of the ways in which data are gathered and interpreted by all agencies involved.

⇒ The GLFC should assume the responsibility for receiving, checking, and storing the information, and making it available to resource managers, research scientists, and other authorized users around the Great Lakes.

⇒ All resource agencies, universities, independent scientists, and resource user organizations around the lakes should commit themselves to cooperating in ways that will make this coordination possible, and useful to all. For example, in the present attempt to acquire information on various objectives of the Task, the response from Ohio and Indiana were very low whereas that from New York, Michigan and Ontario was high.

⇒ More emphasis must be placed on the gathering of annual or regular information on all aspects of the extraction impact on the fishes. That includes the commercial, tribal and recreational fisheries. The role of the charter boat industry in the recreation fishery is a particular case. Too little is known, or available, on the true extent of the effect of the extraction by these fisheries, and on the relative direct and indirect, economic and social benefits of them.

Food web and ecosystem implications (Crowder and Eby)

Objective 2.1 Conserving biodiversity in aquatic systems

We have completed a literature review on the conceptual, theoretical and empirical studies on conserving biological diversity in freshwater systems. We examined the conceptual relationships and evaluated the small amount of experimental evidence for the relationships between species diversity and ecosystem functional characteristics including productivity, nutrient recycling, stability, resilience, and resistance. Although there has been a great deal of theoretical work on these ideas, very few experiments have been done to examine these questions. The strongest experimental evidence is from terrestrial plant ecology (Tilman et al. 1996, 1997) and some freshwater mesocosm work (McGrady-Steed et al. 1997).

Highlights of the literature review follow:

Productivity and biological diversity: Overall, there is a positive, asymptotic relationship between productivity and diversity. Within a trophic level, impacts of dominant species (species composition) may overwhelm the effects of diversity (Tilman et al. 1996, 1997, Hooper and Vitousek 1997). In many cases a more diverse community is more likely to have one or more species that strongly influence the functioning of the ecosystem, but generally increased diversity leads to increased efficiency in nutrient use and productivity (Tilman et al. 1996). Interactions between productivity and diversity at multiple trophic levels are also positive, as productivity increases an increased number of trophic levels can be supported in the system (e.g. Oksanen et al. 1981, Power 1990).

Persistence, resistance, stability and biological diversity: Initially both Elton (1958) and MacArthur (1955) argued for a relationship between diversity and stability. Theoretical models (Gardner and Ashby 1970, May 1971, 1974) found that the more components and greater the connections between components, the less likely the models were to be stable. Further modeling work found increased diversity may stabilize system characteristics but decreases the stability of individual species (King and Pimm 1983). In grassland and aquatic systems during periods of stress, compensatory responses between species (functional complementary) supress changes in ecosystem process rates or total community biomass while community structure shifted to a more tolerant assemblage (Tilman et al. 1996, Schindler 1990). Components of aquatic communities with less functional redundancy are most vulnerable to disruption of the food web structure and ecosystem function (Schindler 1990).

Resistance to invasion by exotics and biological diversity: Much of the work on invasibility and biological diversity has been theoretical modeling work (Post and Pimm 1983, Pimm 1989). Most of their work demonstrates that communities with fewer species had a greater likelihood of being invaded, although this relationship does have an asymptote and the final number of species depended on the connectance of the community. Overall, for a set number of species in the community, one with a higher connectedness is more difficult to invade. In many terrestrial systems, the relationships of communities with higher species richness allowed fewer invaders (Moulton and Pimm 1986, Fox and Fox 1986, Tallamy 1983, Brown 1989). Successful establishment of exotic fishes appear most in communities of low diversity (Taylor et al. 1984), but these are the systems and environments where most of the attempts have been made (Moyle 1985, 1986). It is difficult to come to any broad conclusions from these examples, every database has its confounding factors (e.g. disturbance, proximity to humans, invasion attempts) and there are an equal number of examples where generalities fall short (Lodge 1993). The only experiment examining this question is from a series of aquatic microbial communities with differing levels of diversity. The more diverse microcosms were more resistant to invasion (McGrady-Steed et al.1997). Nevertheless, every system is invasible.

Conclusions

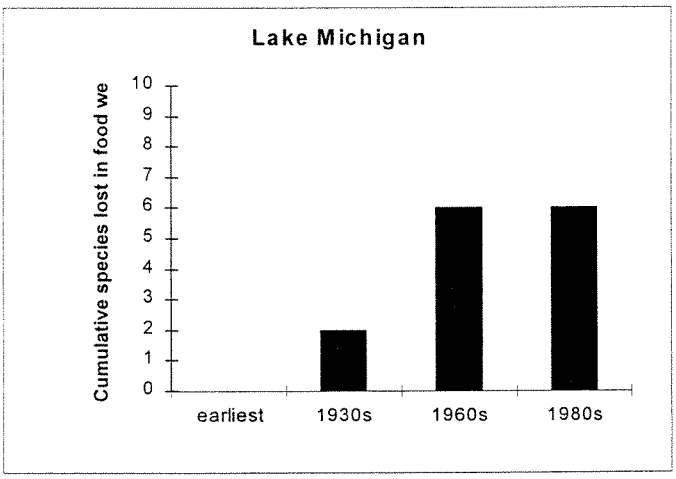
Widespread conceptual generalities about the importance of biodiversity to systems are primary theoretical or anecdotal. In ecosystems there are so many disturbances and stresses, it is difficult to attribute anything to just one aspect, such as changes in species diversity. Reductions in species diversity appear to reduce the system's ability to buffer itself from environmental changes and stressors. By accelerating the rate and magnitude of change in the environment while at the same time homogenizing our ecosystems (e.g. by modifying hydrology or species composition), we are reducing the ability of the systems to cope with stress or perturbations while increasing the assaults on the system. In addition, ecologists are only beginning to understand the role of certain species as "keystone species", "ecosystem engineers", or "strong interactors" whose loss would severly impact the ecosystem processes (e.g. Paine 1980, Power et al. 1996, and Naiman et al. 1988).

A similar, but more elaborate literature review and concept descriptions were presented at our first workshop "Biodiversity and Sustainability in Aquatic Systems". Since that time we have decided to more extensively address a management perspective on biodiversity including issues such as, differences between the perspectives and scale of ecological results and management considerations, conservation of pristine systems, and goals in the sustainable use of altered ecosystems. For example, one major difference between many of the ecological studies investigating diversity and the needs of managers is that managers are concerned about particular species. Many of the results indicating increased productivity or stability with biodiversity are measurements at the community level, species biomass actually varied more with greater diversity. Compensatory responses of different species resulted in dominant species shifts and biomass flips. Fisheries are not valued (socially or economically) on community biomass but by species. A replacement in the Great Lakes dominant offshore deep-dwelling predator from lake trout (*Salvelinus namaycush*) to burbot (*Lota lota*) may be an unacceptable alternative for the Great Lakes fisheries community.

Objective 2.2 Implications of changes in biodiversity of the Great Lakes

We examined the structural and functional characteristics of the Great Lakes' food webs through time. Our approach was at the food web level, but we also considered population and ecosystem implications as well. First, we compiled literature to create two databases. One is a bibliographic database (Endnote) and the other (MS Access) includes diet information for the fish communities. Fish community changes, species interactions, and diet studies from the primary literature and research (technical) reports from most of the US agencies and OMNR have been included. Then with available data, we reconstructed food webs for the coldwater community for Lakes Michigan, Ontario, Superior, Huron, and of the cold- and cool-water community in western Lake Erie, Lake Nipigon, and Saginaw Bay. These food webs exemplified both the structural changes in the system, as well as, the degree of diet information available for these systems through time.

Changes in the Great Lakes Foodwebs:



To date 26 fish species and subspecies have been eliminated from one or more of the lakes. There are approximately 27 exotic fish species that have naturally reproducing populations (Cudmore and Crossman, pers comm.).

Figure 1.

In examining the structure of the food webs, we ran into an information bottleneck. The distribution and food habits of every species in the Great Lakes is not well described. Therefore in our evaluation of changes in the food webs, we limited our analyses to areas where information was available. For Lakes Michigan, Ontario, Huron, and Superior, we examined the coldwater food web. For Western Lake Erie, Saginaw Bay and Lake Nipigon, more complete food webs (cool- and coldwater) were examined.

For example, in Lake Michigan loss (or severe depletion) of species began at the turn of the century with the lake sturgeon. By the 1960s, Lake Michigan had virtually lost its native coregonin assemblage (Figure 1). The assemblage of ciscoes in the Great Lakes could be proclaimed as the most important loss for the Great Lakes. Not only were many of these species endemic to the Great Lakes, but no species have come in and fill the role of these species.

Along with these losses have come many invasive or introduced exotic fishes, many of which are playing a very large role in the system (e.g. stocked or purposely introduced salmonids, alewife, and smelt). Within the Lake Michigan coldwater food web, currently exotics comprise 38% of the species. Lake Nipigon has the lowest percent of exotics in their food web with 5% and Lake Ontario has the most (45%). Obviously these percentages are influenced by how the boundaries are drawn around the food web.

These gains and losses have substantially altered the fish community leading to changes in the food web and community structure of the lakes. For example, the ratio of planktivorous fish to piscivorous fish have decreased drastically in every lake (Figure 2). For example the food webs in Lake Michigan historically had about 16 planktivorous fish and 2 piscivores (ratio of 8). Currently in the Lake Michigan food web, the ratio of planktivores to piscivores is 1.3.

Figure 2.

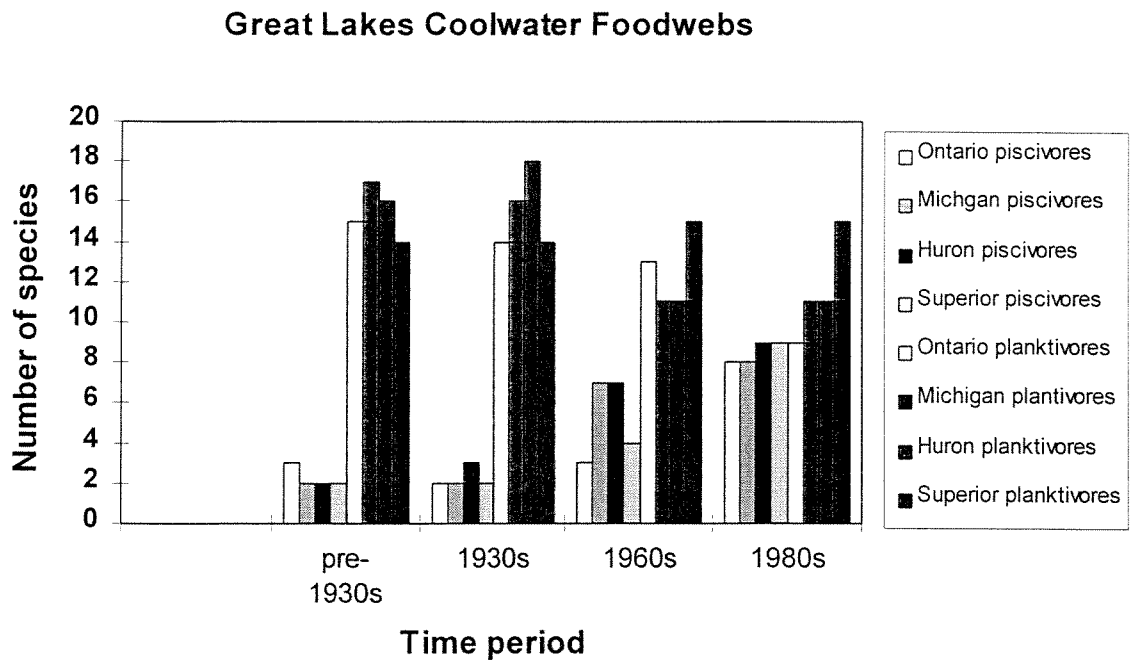
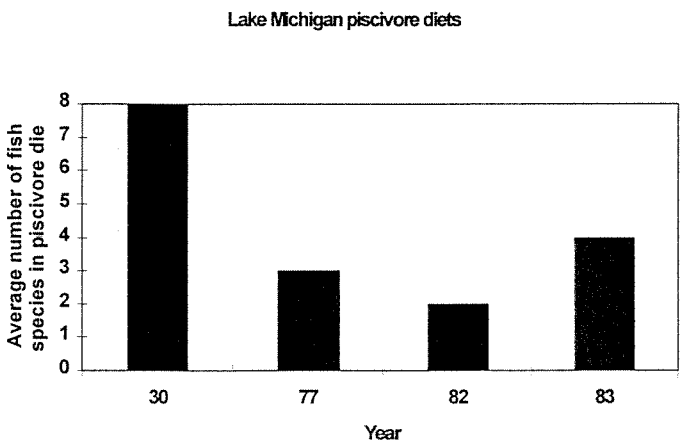


Figure 3.



Along with these changes of an increasing number of piscivore per planktivore, we also found the diversity in the diets of the top predators in the system decreased over this time period (Figure 3). In the 1930s, lake trout were consuming about 8 different types of prey in Lake Michigan (Van Oosten 1938), currently all of the top predators in the lake have on average 3 prey species in their stomachs, predominately alewife (Hagar 1984, Stewart and Ibarra 1991).

In addition to describing structural changes, we examined system implications of these changes. From the previously described work we combined our review of the ecological literature, the Great Lakes literature, and the structural changes in the Great Lakes to come up with a series of hypotheses about the functional implications for changes in biodiversity and the fish community changes. At the second workshop these hypotheses were presented with examples from the Great Lakes where we could find a case study to support the hypotheses. During the workshop, a few more implications were discussed that were included into the project list. A few examples of system implications associated with changes in species diversity that have been demonstrated in the Great Lakes ecosystems include:

1) Diversity is related to the ability of the system to buffer from changes. For example in Lake Michigan the alewife crash alllowed for an increase in bloater recruitment. The lake experienced strong biomass flips from an alewife dominated to a bloater dominated forage fish community. Although bloaters do not fill the same role as the primary prey for salmonids, there is predation on the younger, pelagic bloaters by the salmonid assemblage. In Lake Ontario where there was a less diverse forage fish community, when alewife declined there was nothing to compensate for the loss.

2) Food web structure and species present can change where productivity gets expressed. Stocking of salmonids and the subsequent decrease in the alewife population changed the size structure of the zooplankton population impacting water clarity (Scavia et al. 1986). In addition, invasion by the zebra mussel has been proposed to be shifting energy from the water column in the pelagia to the benthic food web (e.g. Fahnenstiel et al. 1995).

3) Loss of species results in decreased diversity of trophic chains. The loss of the coregonin complex in most of the Great Lakes has resulted in a loss of flows from the offshore, deepwater environment. No species or group of species have entered the offshore, deepwater zone of the lake to replace the coregonin complex, thus the production occurring in this area that once became fish is no longer flowing into the food web (Eshenroder 1998).

Our impacts are also changing the food web and ecosystem in ways that we have not previously experienced and little theory is available to make predictions. For example, theory and examples exist to examine how fishing down food webs (loss of top predators) impacts the system, but very little work has been done on "top heavy" food webs that have been created in the Great Lakes through intensive stocking of top predators. In addition, there has been alot of work examining the eutrophication process, but little work examining the impact of decreasing nutrients into the system.

Conceptual and values clarification and identification of ethics (Callicott and Mumford)

Objective 3.1 Concepts Clarification

A normative conservation concept is an overarching goal of conservation or natural-resource management efforts. In the early twentieth century, Gifford Pinchot articulated the "wise use" norm for conservation- "the greatest good of the greatest number for the longest time" - that became institutionalized in governmental management agencies. Closely connected with this norm is another: maximum (or optimum) sustained yield of various natural resources, each managed separately. With the emergence of conservation biology, a self-styled "transdiscipline" in the late twentieth century, a new conservation norm became prominent: biodiversity (which is short for biological diversity). In an influential article, entitled, "What is Conservation Biology?," Michael Soule stated flatly and axiomatically (that is, without further argument or justification) that "biodiversity is good" and it should therefore be "preserved." Biodiversity thus became the supreme norm for conservation biology.

The purpose of this whole research task- commonly called the "biodiversity task"- is to explore the importance of biodiversity for managing Great Lakes fisheries. The main purpose of this part of the task is to provide a working definition of the concept of biodiversity. While biodiversity is perhaps the most salient new normative conservation concept to have emerged, it is not, however, the only one. In addition we have identified the following: biological integrity, ecological restoration, ecological services, ecological rehabilitation, ecological sustainability, sustainable development, ecosystem health, ecosystem management, process management, adaptive management, and keystone species. Some of these other conservation norms- biological integrity, ecological restoration, ecological rehabilitation, ecological sustainability, ecosystem health, ecosystem management, process management, and keystone species- are as relevant to Great Lakes fishery management as is biodiversity. Therefore we provide working definitions and discussions of those as well.

Our definitions are stipulative, not descriptive. That is, we did not attempt to survey and catalog the several ways these normative terms are used, calculate the most frequent usage, and recommend that as the standard technical definition. Rather, we explored a large representative and influential literature on these concepts. Then, within the limits of their etymologies, lexical definitions, and common usage, we crafted interpretations useful to fishery management policy applications in the Great Lakes. We field tested these definitions in the GLFC sponsored workshops and in presentations (mostly by Callicott) to a variety of audiences (as detailed below). In addition to defining them, we explore an ordering intellectual structure, characterized by two complementary traditional approaches to ecology and one newer more integrative approach, in which these normative concepts in conservation are embedded. These approaches to ecology are (1) evolutionary ecology, (2) ecosystem ecology, and (3) the flux of nature paradigm in ecology.

The following are our working definitions of current normative concepts in conservation. An academic presentation and discussion of them is forthcoming as J. Baird Callicott, Larry B. Crowder, and Karen Mumford, "Current Normative Concepts in Conservation," Conservation Biology vol. 13, no 1 (1999): in press. A presentation, discussion and application to Great Lakes fishery management will appear in the Final Technical Report now in draft. The literature cited for each is to a source which epitomizes our recommended usage.

Norms informed by the evolutionary ecology paradigm:

Biodiversity - Variety at every spatial scale and hierarchical level of biological organization: genes within populations, populations within species, species within biotic communities, biotic communities within landscapes, landscapes within biomes, biomes within the biosphere (Noss 1990).

Biological Integrity - Native species populations in their historic variety and numbers naturally interacting in naturally structured biotic communities (Angermeier and Karr 1994).

Ecological Restoration - The process of returning, as nearly as possible, a biotic community to a condition of biological integrity (Society for Ecological Restoration 1997).

Norms informed by the ecosystem ecology paradigm:

Ecosystem Health - The occurrence of normal ecosystem processes and functions (Rapport 1995).

Ecological rehabilitation - The process of returning, as nearly as possible, an ecosystem to a state of health (Michigan Department of Natural Resources 1994).

Ecosystem management - Managing for ecosystem health with resource extraction an ancillary goal (Grumbine 1997).

Ecological sustainability - Meeting human needs without compromising the health of ecosystems (Callicott & Mumford 1997).

Norms informed by the flux of nature paradigm in ecology:

Process management - Sensitivity to the way ecological processes impact species populations (Pickett and Ostfeld 1995).

Keystone species - A species whose impact on its biotic community and ecosystem is large, and disproportionately large relative to its abundance (Power et al. 1996).

Adaptive management - Treating management goals and techniques as hypotheses that are confirmed or falsified by success or failure (Walters 1986).

Objective 3.2 Values Clarification

The Laurentian Great Lakes have undergone significant biophysical and chemical change since European settlement (Ashworth, 1986; Francis et al. 1979). Although many studies document the biophysical and chemical changes over time, few studies identify the social dimensions of these changes; specifically, how human values affect the management, use, and subsequent changes occurring in the Great Lakes ecosystem. Values expressed or held toward nature, the Great Lakes, and natural resource management influence how the lakes are used and the level of support for strategies or goals carried out by fishery and natural resource managers (Krueger at al. 1986). Understanding values is critical given the diversity of governmental and non-governmental organizations involved in management of the Great Lakes. In addition, increased citizen participation, broadened societal views toward the environment, and expanding scientific understanding are influencing the range and types of values that agencies must incorporate into management goals and strategies (Dunlap 1992, Eshenroder et al. 1995, Gresswell and Liss 1995).

The purposes of this component of the Biodiversity Task are twofold: (1) to characterize the current range of values expressed by governmental and non-governmental organizations in the Great Lakes; and (2) to document changes or shifts in value orientations and actions of selected organizations. This research is being conducted in the context of normative conservation concepts such as ecosystem health and biological integrity and changes in biological diversity and associated food web dynamics in the Great Lakes. Results from this analysis will be integrated with findings from these studies to chronicle the interaction between human values, conservation concepts and changes in the Great Lakes ecosystem. This report summarizes general findings described more fully in upcoming manuscripts and the final technical report.

Methods

Qualitative methods: Most social assessments conducted in the Great Lakes survey the level of participation and expenditures on fishing or confirm public support for existing fisheries and water resource management programs (Loftus 1987). These surveys do not examine the broader range of held values which drive use and management of natural areas (Brown 1987). Because of the exploratory nature of this research and limited number of assessments of value orientations of organizations, a qualitative content analysis approach seemed best suited to the examination of organizational documents (Miles and Huberman, 1994). Qualitative content analysis of documents produced by various organizations in the Great Lakes is the primary methodological approach used to examine current and past value orientations. The qualitative approach allows themes, concepts, and in this case, values to emerge from the actual words within documents instead of imposing a pre-determined assessment strategy. In addition, some quantitative information can be collected from the documents to provide additional insight on issues of importance to Great Lakes organizations.

Documents: We chose to analyze printed materials because they provide an effective means to analyze social trends over time. Surveys, interviews, and case studies shed light on current values and social concerns but not on the evolution of values nor as a basis for projecting trends into the future (Bengston and Xu 1995). Analysis of documents allows the collection of historical information without relying on human memory which can be inaccurate or inconsistent for some types of information (Connelly and Brown 1995). Document analysis can also be effective for assessing current value and ethical orientations because the method is unobtrusive. Neither the sender nor the receiver of the text is aware that the text is being analyzed. Hence measurement will not bias the expression of values (Bengston and Xu 1995). Due to the volume of written material, we were not able to review documents from all governmental and non-governmental organizations. Selection of organizations and documents was dependent on availability and access to documents and willingness of organizational staff to assist in providing, locating, and shipping materials to us for review.

Coding: For this analysis, a coding scheme was developed to classify words and strings of text into categories of values (such as economic, aesthetic, etc.). Coding allows a vast amount of text to be reduced to an understandable level for analysis and summarization (Miles and Huberman 1994). Because value statements are rarely direct and require interpretation, a guide was created for each value category.

The values guide provided a consistent means to code the values expressed within the documents. We reviewed a subset of documents from a range of organizations and created a coding scheme and guide for values based on the actual text of organizational documents. Phrases and statements within the documents were coded and classified under specific value categories. A collaborator is reviewing approximately 10% of the documents examined to ensure that value expressions were being consistently coded and identified and to verify whether or not the values identified are accurate. In addition, preliminary values findings have been shared with Great Lakes fishery managers and biologists as well as with individuals representing various tribes and non-governmental organizations to check the validity of the findings and to determine whether these groups and organizations agree with the findings.

Analysis of current values: A wide variety of governmental and nongovernmental organizations were contacted and asked to provide their most current mission, goal, or objective statement as well as monthly newsletters, newspapers, management reports, policy statements, etc. written between 1995 and 1997. These documents were reviewed to identify the current range of values and issues expressed by organizations in the Great Lakes.

Analysis of historical and shifting values: A time series of documents was collected from select existing and former organizations in the Great Lakes representing state/provincial, federal, tribal, commercial, and sport fishing interests. Types of organizational documents reviewed include annual reports, newspapers, newsletters, management reports, lake management plans, mission statements, testimony before governmental bodies, etc. In addition, tribal stories, legends, and statements recorded by explorers, anthropologists, historians, and tribal members, and journals of early explorers were reviewed to identify values expressed by aboriginal peoples and early European explorers.

General Results

Analysis of current values: Review of documents from current governmental and nongovernmental organizations led to the development of a values typology. In the typology, values are sorted into categories and sub-categories which eventually lead to a "terminal" value (i.e. no additional values are categorized underneath). The values typology is developed from two root categories- anthropocentric and non-anthropocentric. Anthropocentric values are human-centered values- meaning that people value the Great Lakes or its fishes because of the benefits or gifts they receive- food, beauty, income, etc. For non-

anthropocentric values, the Great Lakes and its fishes have value beyond meeting the interests and needs of humans. Anthropocentric values are further categorized as material, non-material, or moral. Terminal values then emerge under these sub-categories. Material values are those people confer to the Great Lakes or its fishes based on the physical or material benefits or gifts received- -such as food or income whereas non-material values indicate the intangible benefits, gifts, or meaning received such as aesthetic pleasure, recreation, or way of life.

As organizations expressed their values toward the Great Lakes or nature, they also expressed thoughts about their responsibilities toward humans. These statements were coded and categorized under anthropocentric moral values such as responsibility to community or to democratic processes.

Three non-anthropocentric terminal values emerged from review of current organizational documents. First, intrinsic values were expressed-- meaning the Great Lakes and its communities are valued for their own sake and not because they have instrumental value to humans. Second, ecological values were expressed which focus on the ecological role species or communities play within natural systems. Moral values were expressed which involved human responsibility to nonhuman entities.

Analysis of historical and shifting values

Value orientations shifted over time as exemplified by the results of a review of management documents from New York State Dept. of Environmental Conservation and Ontario Ministry of Natural Resources. Not only did values shift but the "object of value" or what was of value shifted. From the 1800s to the 1950s, commercial and gamefish stocks were of great value and importance. Commercial and game fishes were valued because they provided food, jobs, and income. In addition, gamefishes were valued for non-material reasons such as for sport and recreation. Between the 1960s and 1990s, game and commercial stocks were still of importance but management agencies also began to value non-commercially important species, fish communities, ecosystems, and watersheds. Values toward the Great Lakes and its fishes expanded to include sport and recreational health benefits, a source of cultural identity and way of life for First Nations and Native Americans, and intrinsic value. These trends reflect broadened understanding of the ecological structure and function of the Great Lakes and the rich variety of human interactions and needs associated with the lakes.

Management strategies also shifted over time in concert with values. Strategies are now focused on watersheds and ecosystems as well as on stocks and populations. More inclusive management strategies are emerging which involve the public and various governmental agencies. These findings suggest that values will play an important role in shaping and influencing the use and management of the Great Lakes and its fishes.

Synthesis (Crowder, Crossman, Callicott, Cudmore, Eby and Mumford)

Synthesis was our major objective (**Objective 4**) of the third year of the grant. Three presentations that synthesized the different aspects of the project were given. At the manager workshop, we presented an integrated picture of the Lake Ontario stocking issues from 1800s - present. This story has helped us develop several conceptual diagrams for how the different sections of the Biodiversity Task (Callicott, Crossman, Crowder) come together for an integrated, historical perspective of Great Lakes fish resources. For the third workshop, we presented a second integrated picture of changes in management perspectives, as well as, ecological and social changes in Lake Erie. A talk was presented at the 1998 ASLO/ESA meeting "Historical and recent changes in the Lake Ontario fisheries ecosystem: stakeholders, stocking, and science" by Larry B. Crowder, Lisa Eby, Karen Mumford, Becky Cudmore. A paper intended for North American Journal of Fisheries Management is currently being drafted. This last spring, Amy Schick (CEM student at Duke Uinversity) completed her masters project which was an integrated story of both the ecological and institutional changes in Lake Erie's fish community and fisheries management. Future integrated papers and reports have been outlined, including, an integrated final project GLFC technical report.

Workshops

The grant called from a series of workshops to help pull together the information for this grant and get feedback regarding our analysis and conclusions. The first workshop, "Biodiversity and Sustainability of Aquatic Systems" was held on June 26-28, 1996 in Wingspread Racine, WI. Academics, mostly professionals with experience in the field of conservation biology from the University of Montana, Virginia Tech University, University of North Texas, University of Washington, University of Notre Dame, Savannah River Ecology Lab, University of Guelph, and Ohio State University. The purpose of the workshop was to critically discuss the preliminary studies of current concepts in conservation, such as, biodiversity,

ecological sustainability, and ecosystem health, and changing values in resource management incluing intrinsic value and duties to future generations in relation to management of freshwater ecosystems. This first workshop was helpful in evaluating and further developing the current concepts.

The second workshop was held September 24-26, 1997 in Windsor ON. Twenty-two managers and biologists from agencies (representation from Canada and US and every lake) including Wisconsin DNR, Illinois DNR, NYDEC, USFWS, OMNR, and DFO, were involved. The purpose of the workshop was to gain feedback from managers and biologists on data and findings gathered to date of the Biodiversity Task. The structure of the workshop five plenary sessions, four had break-out group discussions associated with the material presented. There was a plenary session on current normative conservation concepts that opened the workshop. Each task presented its findings for feedback from the managers. A presentation that integrated the three sections of the task was the final plenary talk of the workshop.

Our third and final workshop that was described in the grant was a stakeholder workshop. The objectives of this workshop were to gain citizen insights on biological diversity as related to Great Lakes fishes, receive feedback on findings of the task to date, and create a forum for discussing the implications of biological diversity for management and use of Great Lakes fishes. The workshop was held April 22-24, 1998 in Ann Arbor, MI. Twenty-nine people representing tribal, commercial and sportfishing interests, environmental organizations, and water users (hydroelectric) attended from all over the Great Lakes region. Participants were drawn from both Canada and the United States, representing all of the Great Lakes. Task members presented short plenary talks describing our research, but most of the time was spent in small breakout groups where participants addressed a series of focus questions. The workshop was successful in pulling together a wide range of Great Lakes citizens to discuss issues of biodiversity in fisheries management. Participant interest and input expanded our understanding of issues surrounding biological diversity and highlighted challenges facing us as the task members develop strategies and plans to address Great Lakes fish biodiversity and its role in future management. Details of these recommendations will be presented in our GLFC technical report. We received positive feedback from workshop attendees and greatly appreciate the contribution of the participants, facilitators, and notetakers as well as the assistance and participation of the GLFC. We have drafted a proceedings document (Callicott et al. 1998) which GLFC will distribute to participants from the workshop and other interested parties.

At all three workshops we received positive responses regarding the objectives of the research task and the ideas presented.

Project Conclusions

Biodiversity has changed significantly in Great Lakes. Both the losses and gains of species have heavily impacted the fish community and fisheries of the Great Lakes Basin. Ecological implications for changes in species diversity on system productivity, buffering capacity, variation in system prcesses is becoming more generally accepted on broad scale although the experimental data are sparse. Before applying these concepts to a fisheries system uncritically, we need to specifically examine the mismatches between the needs of fisheries managers and theory, such as community stability versus species-specific management and the influence of subsidies or control cost issues on the current ecological theory (i.e. as in agriculture, a monoculture may have the highest potential productivity if one doesn't care about how much fertilizer or pesticide is used).

Most of the fish species in the Great Lakes have not been monitored. In fact, the nearshore warm-water community is the most diverse but overall has had the least attention. Biodiversity is difficult and may be impossible to monitor. Although biodiversity may not be a concept that completely alters management, maintaining a diverse native species base may be beneficial as a broad objective to help make decisions about stocking , habitat loss or water quality.. This concept seems to be very useful as tie between management objectives, conservation concerns, and preserving ecosystem function.

History has demonstrated that the Great Lakes ecosystem acts on a basin-wide scale for fish movement, particularly the spread of exotic species. Exotic species that have been introduced or have invaded in one lake spread throughout all of the lakes. Any decisions about managing for biodiversity must involve committments by managers in the entire basin. An achievable starting point may be to try to limit Great Lakes to current species (no losses or gains).

Managing biodiversity in the Great Lakes will be a daunting task because both the ecological systems and the social systems we use to manage them are complex and not well understood. But is is critical to acknowledge that successful management will require both enhanced monitoring and increased understanding of both structural and functional aspects of our fishery ecosystems. In addition, scientists need to take into account the increasing diversity of contituents who have a stake in the management of these ecosystems and the complexity of the government and management structures we have in place to do

the job. If we can achieve the integration suggested by this task, we should be able to improve fisheries management in the Great Lakes for the next millenium.

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Awards

Karen Mumford received an award for outstanding female fisheries graduate student at the 127th annual meeting of the American Fisheries Society, Monterey, CA, August 26, 1997 for her values identification and analysis work related to the GLFC biodiversity task.

Presentations (* presenter)

Callicott, J.B. and K. Mumford*. "Sustainability as a Conservation Concept". Presented to Sustainability Symposium at the Society for Conservation Biology conference, Fort Collins, CO, June 11, 1995

Callicott, J.B.* and K. Mumford. "The New Concepts in Conservation" and "Sustainability as a Conservation Concept". Presented as white papers for the GLFC-sponsored June 26-28, 1996 biodiversity and sustainability in aquatic systems workshop at Wingspread Conference Center in Racine, WI..

Callicott, J.B.* and K. Mumford. "Ethics and Values for a Sustainable Great Lakes" presented for the Sustainability and Great Lakes Fisheries: Paradox or Promise?" Symposium at the annual American Fisheries Society conference, Dearborn, MI, August 27, 1996.

Callicott, J.B.*, L. Crowder, and K. Mumford. "Current Concepts in Conservation". 35th Potter Lecture at Washington State University, Pullman, WA, February 7, 1997.

Callicott, J.B.*, L. Crowder, and K. Mumford. "Current Normative Concepts in Conservation". Faculty biodiversity seminar at Oregon State University, Corvallis, OR, May 22, 1997.

Callicott, J.B.*, L. Crowder, and K. Mumford. "Current Normative Concepts in Conservation". Presented to the national summer course in Conservation Biology and Policy at the Duke University Marine Lab, Beaufort, NC, July 29, 1997.

Callicott, J.B.* "Conservation Values and Ethics". In: Meffe and Carroll, Principles of Conservation, Second Edition". Presented to the national summer course in Conservation Biology and Policy at the Duke University Marine Lab, Beaufort, NC, July 29, 1997.

Callicott, J.B.* "Ethical and Philosophical Aspects of Human Uses of Nonhuman Organisms" Paper for the Human Interactions with Aquatic Organisms: Philosophy, Values, and Social Change symposium at the 127th annual meeting of the American Fisheries Society, Monterey, CA, August 26, 1997.

Callicott, J.B.*, L. Crowder, and K. Mumford. "Current Normative Concepts in Conservation". Keynote address to the College of Natural Resources annual symposium at Texas A&M University February 20, 1998.

Callicott, J.B.* "Conservation Concepts: Buzzwords or Helpful Tools?". Presented to the Biodiversity Workshop for Select Great Lakes Stakeholders, sponsored by the Great Lakes Fishery Commission Great Lakes Fishery Commission, Ann Arbor, Michigan, April 23, 1998.

Crossman, E.J.* and B.C. Cudmore. "American Species Invasive into Canada: A Political Exotic Problem". Invited paper for a symposium, "Borders and Biodiversity", at the American Society of Ichthyologists and Herpetologists. Guelph ON, 1998.

Crossman, E.J.* and B.C. Cudmore. "Update on Introduced Fishes in the Great Lakes". Invited paper at the University of Guelph's seminar series, 1997.

Crossman, E.J.* and B.C. Cudmore. "Biodiversity of the Fishes of the Laurentian Great Lakes". Congress of European Ichthyologists, Trieste Italy, 1997.

Crossman, E.J.* and B.C. Cudmore. "Exotic Organisms in the Great Lakes, with Emphasis on Fishes". American Fisheries Society Annual Meeting, Dearborn, MI. Invited paper given in a symposium "Aquacultural Practices and Biological Integrity of the Great Lakes", 1997.

Crowder, L.B.* and L.Eby. "Biodiversityand function of aquatic ecosystems". Presented as a white paper for the GLFC-sponsored June 26-28, 1996 biodiversity and sustainability in aquatic systems workshop at Wingspread Conference Center in Racine, WI..

Crowder, L.B.*, L. Eby, K. Mumford, B. Cudmore. "Historical and recent changes in the Lake Ontario fisheries ecosystem: stakeholders, stocking, and science" Presentation ASLO/ESA meeting, St. Louis, June 1998.

Crowder, L.B.* "Putting it all together: diversity, change, and uncertainty". Presentation GLFC Biodiversity Workshop. Ann Arbor MI, April 1998.

Cudmore, B.C.* "Changes in the Biodiversity of the Fishes of the Great Lakes". Invited paper at the American Society of Ichthyologists and Herpetologists. Guelph ON, 1998.

Cudmore, B.C.*and E.J. Crossman. "Vectors for Invasive Species into the Great Lakes". Accepted paper for Midwest Fish and Wildlife Conference, Milwaukee WI, 1997.

Cudmore, B.C.* and E.J. Crossman. "Missing? Your Input: Checklist of the Extant, Established Fishes of the Great Lakes". Poster Presentation at the American Fisheries Society - Southern Ontario Chapter Annual Meeting, Dorset ON, 1997.

Eby, L. A.* "Ins and outs: implications for species, systems, and people". Presentation GLFC Biodiversity Workshop. Ann Arbor MI, April 1998.

Mumford, K.* "Human Values: Diversity and Direction". Ppresented to the Biodiversity Workshop for Select Great Lakes Stakeholders, sponsored by the Great Lakes Fishery Commission Great Lakes Fishery Commission, Ann Arbor, Michigan, April 23, 1998.

Mumford, K. and J.B. Callicott*. "A Hierarchical Theory of Value Applied to the Great Lakes and their Fishes". Presented to the Program for Ethics, Science, and the Environment seminar, Oregon State University, Corvallis, OR, October 16, 1998.

Project Completion Report Expected When
December 31, 1998.

Signature of Principal Investigator(s) **Date**

Great Lakes Fishery Commission

Biodiversity Workshop for Citizens

Conference Proceedings

April 22-24, 1998
Ann Arbor, MI

Proceedings of the

Great Lakes Fishery Commission Biodiversity Workshop for Citizens: Biodiversity Task Presentations and Discussion Summaries

April 22-24, 1998
Ann Arbor, MI

Great Lakes Fishery Commission's Biodiversity Task Group:

J. Baird Callicott[1]
E.J. Crossman[2]
Larry Crowder[3]
Becky Cudmore[2]
Lisa Eby[3]
Karen Mumford[4]

[1] University of North Texas, Dept. of Philosophy and Religion Studies, P.O. Box 13526, Denton, TX 76205-6526, USA.

[2] Royal Ontario Museum, Centre for Biodiversity and Conservation Biology and University of Toronto, 100 Queen's Park, Toronto, ON M5S 2C6, Canada.

[3] Duke University Marine Lab, 135 Duke Marine Rd., Beaufort, NC 28516-9721, USA.

[4] University of Minnesota, Dept. Fisheries and Wildlife and Graduate Program in Conservation Biology, 1980 Folwell Ave., 200 Hodson Hall, St. Paul, MN 55108-6124, USA.

EXECUTIVE SUMMARY

A workshop composed of citizens representing tribal, commercial, recreational, environmental, and management organizations was convened to discuss the implications of biological diversity for management and use of Great Lakes fishes. Background materials and information presentations were provided to participants before and during the workshop on the following topics:

*changes in fish species composition of the Great Lakes

*ecological and ecosystem implications of changing fish community composition

*implications of humans values and conservation concepts as they relate to biological diversity

Small group plenary discussions provided opportunities for individuals to express their views on biological diversity. All participants agreed that biological diversity was important to the long-term health and productivity of the Great Lakes fish community. Some examples of areas where participants also shared agreement and concern include:

*additional non-authorized introductions of non-native fish species and other aquatic life forms pose a significant threat to the Great Lakes and measures are needed to prevent additional introductions

*cooperation and coordination among agencies and opportunities for citizens to substantively contribute to management decisions and actions is necessary to understand fish community changes and the implications of these changes

*understanding what people mean when they use various conservation concepts such as restoration, rehabilitation, biological integrity and ecosystem health is necessary so the intentions of management efforts are more clearly understood

Participants were not in agreement on all issues. Examples of diverging views included:

*the efficacy of continued stocking of non-native Pacific salmon

*the ways in which diverse and conflicting uses of and values toward Great Lakes fishes can be accommodated

Organization of the Proceedings

These proceedings were developed to articulate more clearly, the perspectives of workshop participants and to identify those issues that participants felt were most important to our understanding and management of Great Lakes fish biodiversity. The proceedings begin with an overview of the Great Lakes Fishery Commission Biodiversity Task, which was organized to study the biodiversity of Great Lakes fishes. Next, presentation summaries and responses to these presentations during small group discussions are presented. The

proceedings conclude with a section on important themes and issues which emerged throughout the workshop. Finally, appendices are provided which present a workshop agenda, listing of those who attended and organized the workshop, results of a pre-workshop survey and a briefing paper which was prepared in advance of the workshop.

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OVERVIEW OF THE GREAT LAKES FISHERY COMMISSION'S BIODIVERSITY TASK

Ed Crossman, Royal Ontario Museum

There has been an increasing commitment to the ecosystem concept in regard to the management of the aquatic resources of the Great Lakes. In addition there is the growing realization of the value of the maintenance of biological diversity in any natural system. As a result of these two factors the Great Lakes Fishery Commission (GLFC) Board of Technical Experts (BOTE)[1] proposed that a group of scientists be asked to undertake a three-year task, starting in 1995, which was given the title of "The Role of Biodiversity in the Management of the Fishes of the Great Lakes". The scientists recommended as PIs were Dr. Larry Crowder, of Duke University; Dr. J. Baird Callicott, of The University of North Texas; and Dr. Ed Crossman of the Royal Ontario Museum, and the University of Toronto. The Tasks always provide excellent training for graduate students and those directly affiliated with this one include Lisa Eby of Duke University, Karen Mumford of the University of Minnesota, and Becky Cudmore of the University of Toronto.

The objectives of the Task are as follows: 1) to assess the changes in the composition and structure of the fish community (Crossman and Cudmore), 2) to examine the food webs and the ecological implications of changes in them (Crowder and Eby), and 3) to relate these changes to shifts in human values and conservation concepts (Callicott and Mumford). The goal of the Task was to develop recommendations to Great Lakes resource managers that would incorporate the role of biodiversity in sustainable, consumptive and non consumptive uses of the fishes. The three units of the Task worked largely independently, coordinating results and documents regularly. A major means of coordinating, and of benefiting from the knowledge and experience of others, was a workshop in each of the years of the Task. The workshops, in the order held, involved theorists in ecology and conservation biology; research, assessment, and management biologists; and this one involving citizens representing various governmental and nongovernmental organizations (hereafter referred to as citizens).

[1] The Great Lakes Fishery Commission was established by the Convention on Great Lakes Fisheries between Canada and the United States in 1955.The Commission has two major responsibilities: (1) To develop coordinated programs of research on the Great Lakes, and, on the basis the findings, to recommend measures which will permit the maximum sustained productivity of stocks of fish of common concern; and (2) To formulate and implement a program to eradicate or minimize sea lamprey populations in the Great Lakes. The Board of Technical Experts (BOTE) is the unit of the Great Lakes Fishery Commission which is responsible for developing and administering the Commission's research program. Its membership is made up of individuals from universities, and federal, state, and provincial agencies with interests in research on the Great Lakes. BOTE consists of a Core Group with a major function of recommending to GLFC research ideas (tasks) which are appropriate to GLFC's responsibilities, including the Lamprey Control Program, and more generally the management of the fish populations of the Great Lakes. It also makes recommendations on scientists considered appropriate to the conduct of each task. The scientists, or principal investigators (PIs), are members of BOTE during the term of the task.

INTRODUCTION TO THE WORKSHOP AND DISCUSSION SUMMARIES

The purpose of these proceedings is to provide a record of the presentations and discussions which occurred during the April 1998 biodiversity workshop held in Ann Arbor, MI. The objectives of the workshop were to gain citizen insights on:

* issues of biological diversity as related to the fishes of the Great Lakes
* the findings of the Biodiversity Task to date
* the implications of biological diversity for management and
* use of Great Lakes fishes

An attempt was made to have as many types of citizen groups represented as possible from both Canada and the United States, and from both upper and lower lakes. Participants were chosen based on past collaborations with this project and from suggestions by their peers (for a listing of participants, please refer to the appendix.) Our intention for the workshop was not to gain consensus but to hear the variety of viewpoints and concerns on issues relating to biodiversity of fishes in the Great Lakes. Therefore the workshop was structured with short plenary talks from task members (presentation summaries are provided) and smaller breakout or discussion groups to maximize participant involvement and input.

Discussion summaries were written by workshop organizers based on notes taken by recorders from each breakout group, notes written by individuals from each breakout group, flip charts, and reports provided by members from each breakout group during reporting of group discussions to all workshop participants. Our goal was to present the diversity of participant views in relation to the presentations and breakout group questions.

The view of each participant is important for continued dialogue and understanding of issues affecting Great Lakes fish biodiversity. Our intent was to follow the material from the workshop as closely as possible.

A wide range of views were shared during the workshop. However, the views and ideas in this document do not necessarily represent the views of the workshop organizers nor those of the Great Lakes Fishery Commission. Some of the ideas and opinions expressed in this document may or may not be supported by data or current understanding. Nonetheless, our focus was on presenting the variety of views and ideas expressed by the workshop participants.

We hope you will find these proceedings to be informative and an earnest attempt at presenting the issues and perspectives discussed by participants during the workshop. We thank all the workshop participants who attended. Their interest and input expanded our understanding of biodiversity and highlighted the challenges facing us as we develop

strategies and plans to address Great Lakes fish biodiversity and its role in the future management of populations and fisheries.

Biological diversity (or biodiversity) is the variety at every hierarchical level and scale of biological organization: genes within populations, populations within species, species within communities, communities within landscapes, landscapes within biomes, biomes within the biosphere.

THE INS AND OUTS OF GREAT LAKES FISHES

Becky Cudmore, Royal Ontario Museum/University of Toronto

The scope of the project was limited by the Great Lakes Fishery Commission (GLFC) to the lakes proper and their connecting channels, it did not include the tributaries of the basin. One of the first tasks was to find out what species are currently established in the Great Lakes. By searching through literature and looking at assessment data from many groups and agencies, we determined that 153 species were currently self-reproducing (established) in the lakes. It is important to note that since the figures were made, further study has led to many changes in the numbers presented. The general trends, however, remain the same.

There are many unique groups of fish in the lakes. Two such groups are the Great Lakes' endemics and coregonins (ciscoes). There are six Great Lakes' species and subspecies that are endemic (fishes found only in the Great Lakes and nowhere else in the world). Of these six, three are now globally extinct, while the remaining three are found in low abundance (Figure 1). Of the Great Lake coregonins, three have been lost. Note that the longjaw cisco, although officially listed as extinct, is no longer considered to be a separate species from the shortjaw cisco (Figure 2).

Figure 1:

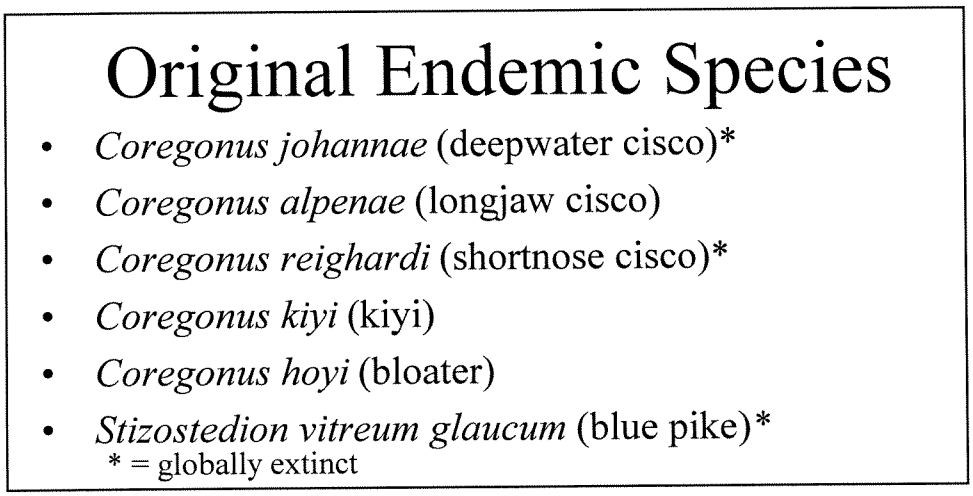
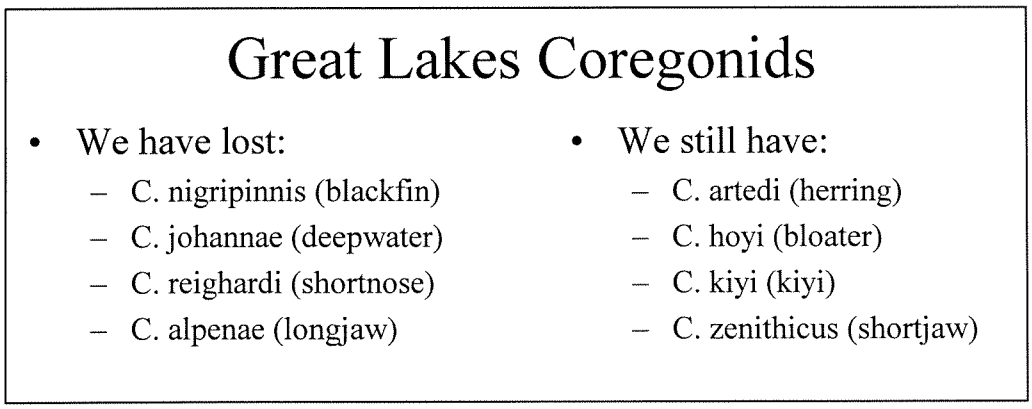


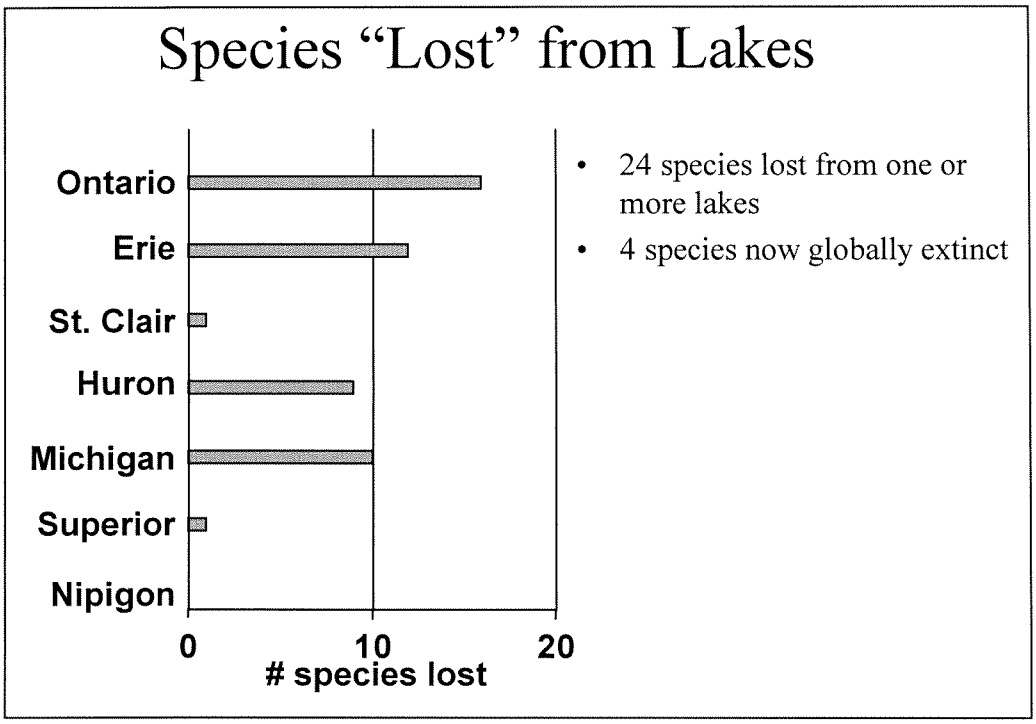
Figure 2:



Looking at the conservation status, as designated by The Nature Conservancy, of the established fishes, 21% are rare to extremely rare. There have been recent increases in abundance in species such as the lake sturgeon, deepwater sculpin, and other native species.

The number of once-established species (native and non-native) lost varies among lakes. The loss of species is highest in Lake Ontario, while of the large lakes, Lake Superior has lost only one non-native (Figure 3).

Figure 3:



Biological invasions can cause ecological disasters and change the biodiversity of the area in which they become established. To date, there have been 50 fishes introduced into the Great Lakes, 26 are currently established (such as the round goby). The other 24 are not likely established, such as the pacu, part of the piranha family. Lake Erie has the highest absolute number of introduced fish (Figure 4).

The origin of the greatest number of established, non-native fishes is outside the Great Lakes basin, from areas such as the Black and Caspian Seas. In comparison, the fishes that are native to some lakes within the basin, but are non-native to other areas, is small. Those species that are native to the American waters of the Great Lakes and migrate across the political boundary into the Canadian waters, are considered 'exotic' in Canada. These species will be viewed very differently and may be subject to very different regulations and policies. There are currently eight species that make up this "invasive into Canada" list (Figure 5).

Figure 4:

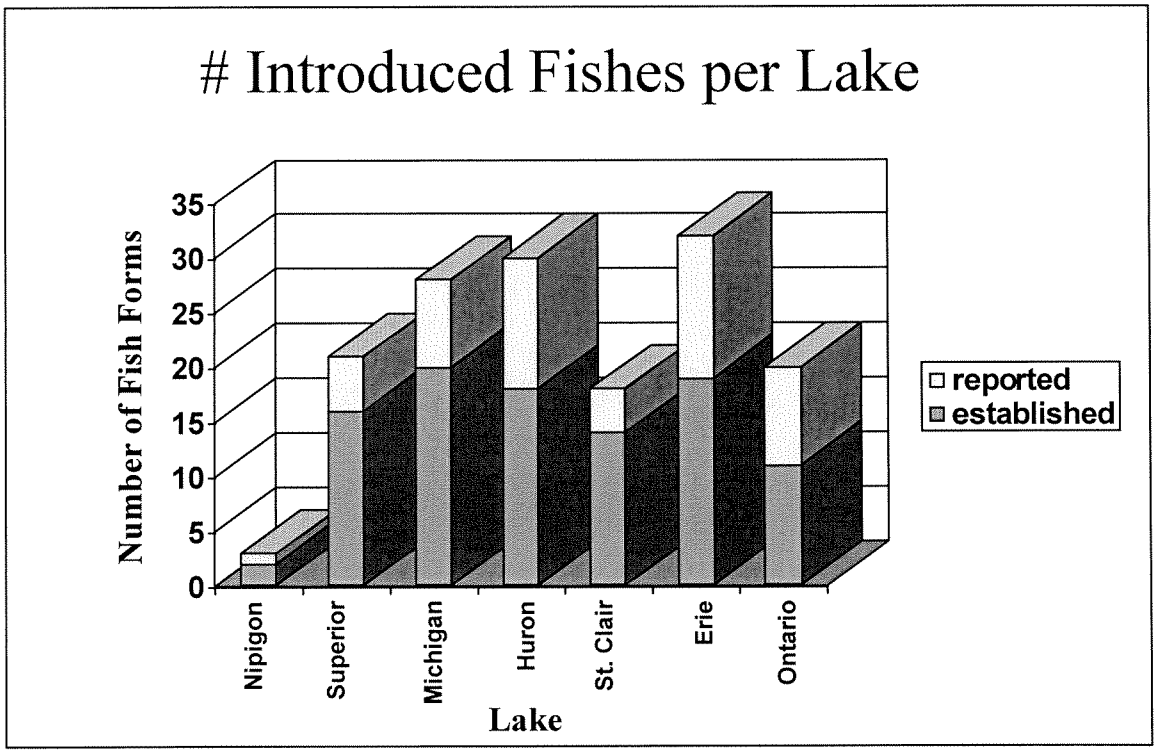


Figure 5:

Invasive into Canada

Species	Lake (Date Arrived)
lake chubsucker	Erie (1949)
bigmouth buffalo	Erie (1947)
spotted sucker	Erie (1962)
northern madtom	St. Clair (1963)
warmouth	Erie (1966)
flathead catfish	Erie (1978)
black buffalo	Erie (1978)
orangespotted sunfish	tribs to Erie (1980)

Most of the non-native species found in the Great Lakes arrived through authorized stocking and natural migration. It should be noted that although ballast water receives much attention, it has been responsible for introducing only seven fish species, a relatively small number compared to the other vectors. The numbers on the list do not add up as one species can use several vectors to arrive and spread within the lakes (Figure 6).

Figure 6:

Number of Fishes by Vector

Vector	# of Fishes
stocking	20
invasive	19
canals	15
aquarium release	7
ballast water	7
bait bucket release	5
aquaculture escape	5
angler release	1
unknown	4

Looking to the future, we should protect against possible non-native introductions by other vectors. Global warming, if current predictions are true, may allow species just south of the Great Lakes to push their range northward as the lakes warm. It has been predicted that 41 species may enter the Great Lakes and Canada. Importing live fish for the food/market industry may provide a vector for the unauthorized introduction of non-native fishes. In 1995, one importer in the greater Toronto area brought in more than one million pounds of fish. The fish are listed by common name only, therefore it is unknown exactly what is coming in. For example, listed separately were grass carp and amur carp. These are two common names for the same species. The increasing popularity of backyard water gardens is bringing many non-native species to the Great Lakes area and the potential for release into the lakes exists.

Comparing published lists of the total number of Great Lakes species, is difficult. The large discrepancy is not the result of the actual number of species, but likely the result of differences in geographic areas (lakes proper vs. basin), definitions of native vs. non-native, and the availability of records. This indicates the importance of standardizing inventory lists in order to effectively monitor changes in biodiversity (Figure 7).

Figure 7:

Changing Biodiversity

Source	# Family	# Genus	# Species
Hubbs 1929	28	96	166
Bailey and Smith 1981	28	71	180
Underhill 1986	26	63	135
Cudmore and Crossman	28	79	153

Overall, "we win (gain) some, we lose some". This is a simple way to describe what has been happening to the species composition of the Great Lakes. We are gaining new species, while losing others. To better monitor these changes, it is necessary to track the abundance of native species. This includes better coordination between political jurisdictions and between interest groups and researchers on the lakes. Great awareness of introduced species is also important, including information on their arrival and spread, as well as their impact. This may allow us to better prevent unwanted non-native species from becoming part if the Great Lakes fish biodiversity.

INS AND OUTS: IMPLICATIONS FOR SPECIES, SYSTEMS, AND PEOPLE

Lisa Eby, Duke University Marine Lab

What are the effects of the species changes that have occurred in the Great Lakes? We reviewed ecological literature, examined examples from other ecosystems, and explored how the species changes have impacted the Great Lakes ecosystem. The species losses and gains have resulted in widespread changes in the Great Lakes from changing fish behavior, interactions with other fish populations, food web structure, energy flow, ecosystem dynamics, and local economies. Unlike some other anthropogenic impacts, species losses and gains are irreversible changes. Here, I briefly review a few examples to demonstrate impacts of species change on other species, food webs, and ecosystems in the Great Lakes.

Invasions of exotic species have had large effects on other species in the Great Lakes system. For example in Lake Michigan, the spread and increase of the exotic sea lamprey populations in the 1940s and 1950s decimated populations of lake whitefish, lake trout, and other large coregonins that were already stressed because of high fishing efforts. The loss of lake trout resulted in an ecosystem with very few top predators that allowed the exotic alewife to become very abundant. At their peak abundance, the alewife became a public nuisance by dying and collecting on beaches and in water intake pipes. In addition, the alewife had detrimental effects on native fishes, such as emerald shiners, yellow perch, and bloater, either through predation on larval stages and/or competition for large zooplankton, their common prey. Direct impacts of species losses due to the invasion of the sea lamprey were widespread in many of the Great Lakes offshore communities. Losses of native species not only impacted commercial fisheries (based on the lake trout, lake whitefish, and the deepwater cisco complex), but led to even more species shifts in the planktivorous fish. The high alewife abundance resulted in stocking of top predators, specifically exotic Pacific salmon, in hopes of controlling the alewife population. These events driven by species losses and gains significantly changed the entire offshore community.

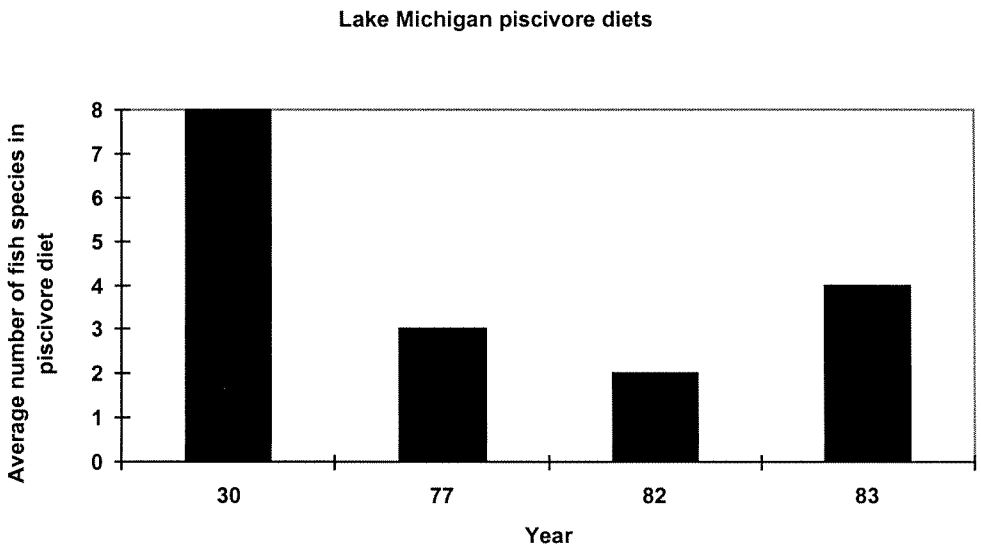
The structure of the offshore food web shifted from having two top predators and 28 planktivorous fish species with several fish utilizing the deep offshore areas, to a food web with about eight top predators, fewer planktivores and most of the energy being funnelled through a small number of species. Do these changes matter? In all of the Great Lakes offshore communities, there are currently more predators dependent on fewer prey species. For example, in Lake Michigan the average number of fish species in piscivore (salmon and trout) diets have decreased from 8 different prey species in the 1930s to only about two to three prey species by the 1980s (Figure 8). The increase in the number of top predators and the decrease in diet diversity has resulted in an increased number of predators feeding on fewer prey species. The implications of these changes are that we have placed ourselves in a precarious situation with a large recreational fishery dependent upon a few prey species (alewife, smelt) that have variable population dynamics. These changes leave little redundancy in the system. Problems with these changes in the offshore community where most top predators are dependent upon a few species, were experienced in Lake Michigan in

the 1980s. Alewife populations dramatically declined resulting in decreases in growth and condition of the salmonid community and the prevalence of disease, particularly bacterial kidney disease (BKD).

In the nearshore zones of the Great Lakes (such as western Lake Erie and many bays) nutrient loading, high algal productivity, and subsequent extended periods of low oxygen in bottom waters decreased populations of sensitive bottom-dwelling invertebrates, such as the mayfly, *Hexagenia limbata*. These sensitive invertebrates, are an important diet items for many fish species, such as yellow perch. Loss of these species has been linked to changes in fish growth and possibly recruitment.

Although there have been many losses and gains in the nearshore food web, the general structure of the food web has not changed as much as in offshore food webs. Long-term data were not found to reconstruct changes in diets through time for nearshore fishes. Some of the most obvious changes in the nearshore community are driven by changes in water quality and the benthic invertebrate populations. The invasion of the zebra mussel has resulted in changes in water quality, the benthic invertebrate community, fish distributions, and potentially how the energy flows up the food web. Zebra mussel dominance may be a sink for some of the energy that would otherwise make its way into fish.

Figure 8:



Species gains and losses may also have consequences for ecosystem dynamics. Productivity in ecosystems is influenced by both species composition and diversity. More diverse ecosystems may more fully utilize potential resources in the system. An example of this is the cisco complex in the Great Lakes. Many species, now locally extinct, lived in deep,

offshore waters of the Great Lakes. Currently, there are few fish living in those areas, truncating the deep offshore food pyramid at the invertebrate level.

How well a system can deal with change or rebound from stressors has been related to species diversity in grassland systems and in temperate lakes. In temperate lakes exposed to acid stress, scientists saw a shift in the dominant species (decreases in acid-sensitive species, increases in less sensitive species). The compensatory response in the species shifts are back-ups that maintain ecosystem function

Conclusions

Not every loss or gain has visible impacts. It is difficult to predict the impacts of species losses and gains. There are some generalities that have come out of the ecological literature, as well as, out of experiences in the Great Lakes and other ecosystems to help guide us. Losses of species (fish or invertebrate) that are an important diet items for many predators may have large impacts. For example, loss of important species; such as *Mysis, Diporeia* or alewife would probably have large impacts on the offshore food web. There have been many examples where losses or gains of top predators have had large effects on lake communities and ecosystems. We have also seen in experiments and other ecosystems that the more redundancy or back-up parts and flows, the more buffering of ecosystem processes. We cannot predict, or be prepared for, every environmental change or stress we pose to a system. Keeping our ecosystems intact (and species diversity and associated redundancy available) is an important insurance against future changes.

BREAKOUT DISCUSSION SUMMARY
The Ins And Outs Of Great Lakes Fishes

Following these two presentations, participants discussed these two questions: (1) *"What are the major changes in the Great Lakes' fish communities and how they have impacted your activities on or involvement in the Great Lakes?"* and (2) *Given these changes, what key problems and opportunities must we face in the future?"*

"What are the major changes in the Great Lakes' fish communities and how have they impacted your activities on or involvement in the Great Lakes?"

The types of changes and impacts that were brought up could be grouped into two categories:

* ecological
* social

Ecological Changes and Impacts
The ecological changes and impacts discussed by participants could be further grouped into the following categories:

* introduction of non-native species
* loss of species
* changes in abundance
* habitat and water quality changes
* disease and overfishing

Introduction of Non-native Species: Quite a lot of discussion centered on the introduction of non-native species. Those species that were non-authorized introductions have led to changes in distribution, composition, fisheries, and surrounding coastal communities. For example, zebra mussels have influenced the sport fishery through changes in water clarity and may have also led to dietary changes in some native species (whitefish). Also, alewife fouled beaches, and smelt led to the introduction of a trawl commercial fishery and may have contributed to the demise of blue pike and its fishery. With the invasion of sea lamprey that decimated lake trout, the creation of the Great Lakes Fishery Commission resulted. Overall, some non-native species have lead to many changes, while the impacts of the introduction of other species, such as the blueback herring, are as yet unknown.

On the other hand, participants were split as to whether species intentionally introduced into the lakes, such as the Pacific salmonids, positively or negatively influenced the Great Lakes and the people living around them. Some argued that with these salmonids came an increased interest in sport fishing and related economic spin-offs such as the growth of the charter industry. Others felt that these species had created an artificial system affecting resident trout by reducing the forage base and competing for limited spawning grounds. In addition, there were concerns that developing and increasing the fisheries associated with exotics have become the states' political goals and created a dependence on cultured fish.

Loss of Species: Many felt that the loss of native species, as well as genes, was very important as there would be a loss within the naturally occurring community. With the loss of some species, particular uses of habitat and the occupation of particular niches (such as the deepwater community) have been lost.

Changes in Abundance: Some specific examples were given to show changes in species abundance over time and how these can be both positive and negative. Emerald shiners have returned to Lake Ontario after being absent since the 1950s. There has also recently been a population explosion of emerald shiners in Lake Erie. In general, participants indicated that in some areas, fewer predators and an increase in water quality and clarity, has led to a return of many species. These returns have many benefits such as the recent resurgence of walleye, which has been good for the sport fishery.

On the other hand, some participants described how changes in the fish community have caused instability in the forage base, which has led to impacts on the sport fishery and predator communities. The constantly fluctuating and "noisier" system is leading to great uncertainty and it becomes more difficult to decide which impacts are positive or negative, depending on the species desired. According to some workshop attendees, the replacement of long-lived species by shorter-lived ones is disrupting biological cycling in the lakes.

Habitat and Water Quality Changes: Dams, pollution, urban sprawl, water quality changes, wetland loss, canal construction, electric power plants and shoreline development have all, to some degree, influenced the offshore and nearshore fishes. Other factors influencing all fishes are impediment of movements, thermal pollution, changes in distribution, and loss of spawning habitat. With reduced nutrients in the lakes, there has been decreased productivity and biomass, which can lead to changes in the fisheries. Toxics can reduce tourism and affect local communities and fisheries due to human health concerns.

Disease and Overfishing: Fish diseases and overfishing affects both offshore and nearshore fishes and fisheries.

Social Changes

The social changes and impacts discussed fell into the following groups:

* fisheries
* management concerns

Fisheries: An increasing number of groups now use fish resources leading to a reduced stocks and resource allocation issues. The increased pressure from user groups causes conflicts. Much concern was expressed regarding the undue influence of strong organizations, which can control management policies. This undue influence may stem from the "user pays" view and doesn't take into account many other sectors using the fishes in a non-consumptive or non-licensed way.

Other changes discussed was the shift from the commercial to the sport fishery which some participants felt contributed to the decline of the chub fishery. It was stated that the methods of taking fish are not selective and that some fishers have changed to become more opportunistic and short-sighted as the demographics of fishers rapidly change.

Management Concerns: Most participants agreed indiscriminate stocking needs to be prevented. More unified management would occur if a central management agency would oversee all US states on the lakes and coordinate research and management of the fishes. There also needs to be more quota management and harvest restrictions. Some participants felt that there was a lack of use of citizen's observations by management agencies.

"Given these changes, what key problems and opportunities must we face in the future?"

Participants put forward future problems that were categorized as follows:

* ecological problems, such as, invasions, habitat loss, pollution, overfishing, etc.
* lack of knowledge about the system and how it works
* perceptions about the state of the system, what it can produce, and vision for future possibilities
* management problems such as, resource allocation, diversity of users/values, and money
* societal trends of decreased support for environmental protection

Some of the key opportunities mentioned included:

* improved communication, interaction and cooperation among different agencies and constituents
* public education
* better monitoring
* better understanding of the state of the system and potential impacts
* potential for not repeating past mistakes

Key problems and issues

Ecological Impacts: Many ecological impacts were described by participants as being important problems that need attention and require solution. Impacts that were specifically mentioned included; intentional and unintentional invasion by exotic species, water quality and quantity issues, habitat loss, toxins, pollution, balance of predator/prey relationships in the lakes, and overfishing. Knowledge gaps about species distributions, stock structure, and how different changes may influence structure and functioning of Great Lakes ecosystems also were discussed. A few participants stated the need to understand the system in a way that we can present future possibilities, costs, benefits and consequences of different management actions to constituencies.

Perceptions: Perceptions, about state of the lakes, vision for the lakes, and assumptions about each other's attitudes and values were all mentioned as problems in the Great Lakes. Several people perceived a mismatch between the state of the ecosystem, what constituents want from the ecosystem, and what can realistically be achieved. Concerns were voiced about the lack of public understanding in how the ecosystem works resulting in unrealistic expectations for what the system can produce and how much control we have to achieve any results. Participants came up with contradictory problems in how current Great Lakes ecosystems are viewed. Some felt that a problem was that people haven't accepted that the lakes have been fundamentally changed. The reasoning here is that there have been changes in the lakes, such as naturalized species, that have inherently changed the lake and we need to consider issues within this new context. This argument concludes that history and society put constraints on what can be accomplished, therefore, we should be focusing our priorities on rehabilitation with a mix of exotic and native species. Others at the workshop held contradictory opinions that the problem was that people today accept the system as it is, without considering its evolutionary context (native species and potential productivity) in setting future expectations and management priorities. They discussed returning the lakes as far as possible to the native state because it is the most efficient and productive state of the ecosystem.

Management: Much discussion of current problems and challenges revolved around the management arena. Many participants stated that they perceived current Great Lakes management to be focused on the short-term. Some argued that more effort should be placed on longer-term goals and system sustainability. Many participants acknowledged constant challenges in managing a system as complex as the Great Lakes. These challenges focused around managing a resource that is always changing, for an increasing number of diverse constituents with different values and concerns. For example, the increase in the number of constituents, their diverse and sometimes conflicting values, desires, and expectations make managing the Great Lakes a great challenge. The problem is a difficult one even before it is placed in a context of an ever-changing system. In addition, several participants reflected upon the large number of fragmented agencies (state, federal, provincial, water quality, and fisheries) with independent goals creating their own conflicts (with objective, actions). For example, water quality agencies seek to reduce nutrient loading while the Lake Ontario and Erie fisheries community debates whether there is insufficient primary productivity available to support the current fish community.

The problems that were discussed relating to management focused around the role of politics and imbalance of economic versus scientific considerations in the decision-making process. Participants voiced concern whether there was a balance of scientific/ecological information with socio-economic concerns in final management decisions and/or whether decisions had been made with the best available ecological data. Some participants felt that money, not concern for the resource, was the primary consideration in final decisions although participants differed in their views as to the extent of the problem. Similarly, many participants voiced discontent about the large role that politics plays in the management process. Several participants felt that many constituents values were underrepresented in the consideration of management alternatives and economic considerations. Examples include

potentially undervaluing minority sectors (such as commercial fishing) as to their contribution to the quality of life for the region.

Resource allocation and regulations were raised as current problems in the Great Lakes. Although, many participants agreed allocation was a problem, several participants stated that even more problems were created when regulations differed among groups. When problems do arise, the tendency for constituents to focus on laying blame versus seeking solutions results in more conflicts and problems. A few participants pointed out areas where they felt more regulation was needed, such as, live fish import and aquaculture.

Societal Trends: General trends in society were also brought up as current problems in the Great Lakes. Decreasing national trends in environmental protection has set the stage for little support for regional efforts. Similarly, reduced federal support for agencies in both the U.S. and Canada hinder research, monitoring, and management efforts in the Great Lakes region. The final problematic national trend is the decreasing youth interest in recreational fishing.

Key Opportunities

In discussing the key opportunities in the future for the Great Lakes, most were optimistic. Much of the discussion focused around benefits of continued constituent interaction, opportunities for better cooperation with management agencies, better coordination among agencies, and better understanding of the system and potential impacts. Participants discussed opportunities to improve monitoring capabilities by working together and using interested groups (commercial fishers, bait fishers, etc.) to help monitor the resource. Some participants mentioned that since we currently recognize several problems, we may be able to improve the situation, specifically coordinating monitoring and research among agencies (e.g. water quality and fisheries), improving public education, and increasing interaction between users. Using current knowledge will provide us with opportunities to learn from, and possibly avoid repeating, mistakes made in the past. Several participants also stated that we had the opportunity to create a sustainable fishery by making the resource a priority (not money or politics). Again, there was a split with some participants stating we have the opportunity to examine the lake and find the best species for function whether it is native or exotic, while others stated we should use this opportunity to focus our efforts on sustainable native fish populations.

CONSERVATION CONCEPTS: BUZZWORDS OR HELPFUL TOOLS?

Baird Callicott, University of North Texas

The practice of conservation is immemorial in human experience, but the philosophy of conservation is recent. The dominant philosophies of conservation during the twentieth century, Preservationism and Resourcism, were guided by norms of wilderness and maximum sustained yield, respectively. These conservation philosophies are no longer tenable: the former was not based on science at all; while the latter was based on pre-ecological science.

A plethora of alternative conservation norms have recently emerged- biological diversity, biological integrity, ecological restoration, ecological services, ecological rehabilitation, ecological sustainability, sustainable development, ecosystem health, ecosystem management, and adaptive management, - most of which are ill-defined. These normative concepts can be better organized and interpreted by reference to two new schools of conservation philosophy, Compositionalism and Functionalism. The former comprehends nature primarily by means of evolutionary ecology and considers Homo sapiens to be separate from nature. The latter comprehends nature primarily by means of ecosystem function and considers Homo sapiens to be a part of nature.

Biological diversity, biological integrity, and ecological restoration belong primarily in the Compositionalist glossary; the rest belong primarily in the Functionalist glossary. The former set are more appropriate norms for reserves; the latter for areas that are humanly inhabited and exploited. In contrast to Preservationism and Resourcism, Compositionalism and Functionalism are complementary, not competitive and mutually exclusive. As the historically divergent ecological sciences- evolutionary ecology and ecosystem ecology- are increasingly synthesized, a more unified philosophy of conservation can be envisioned.

The Compositionalist Glossary

biological diversity - variety at every hierarchical level and scale of biological organization: genes within populations, populations within species, species within communities, communities within landscapes, landscapes within biomes, biomes within the biosphere

biological integrity - native species populations in their historic variety and numbers naturally interacting in naturally structured biotic communities

ecological restoration - the process of returning, as nearly as possible, a biotic community to a condition of biological integrity

The Functionalist Glossary

ecosystem health - the occurrence of normal ecosystem processes and functions

ecological rehabilitation - the process of returning, as nearly as possible, an ecosystem to a state of health

ecosystem management - managing for ecosystem health with commodity extraction an ancillary goal

HUMAN VALUES: DIVERSITY AND DIRECTION

Karen Mumford, University of Minnesota

Considerable research has been directed toward understanding the physical, chemical, and biological changes occurring in the Great Lakes; however, limited work has been conducted to examine the role human values play in influencing the use and management of the Great Lakes and its fish communities. Values indicate what is of worth and why. To identify the range of current values expressed toward the lakes and its fishes, we reviewed documents collected from a cross-section of governmental and non-governmental organizations. Organizations included state, provincial, federal and tribal agencies, environmental organizations, commercial and sport fishing groups, and water users. The types of organizational documents reviewed included newsletters, newspapers, mission statements, management reports, annual reports, policy statements, testimony before governing bodies, etc.

A large number and diverse range of values emerged from review of the documents. We developed a values typology which allowed us to sort and present values in an organized fashion (Figure 9).

The most common values which emerged were anthropocentric or human-centered values. Values under this category included tangible or material values such as valuing the Great Lakes and its fishes as a source of food, income, jobs, trophy fishes, and ecological services (such as water purification).

A broad range of anthropocentric intangible values also emerged. These included valuing the Great Lakes and its fishes for aesthetic, sport, recreational, spiritual or educational reasons. In addition, the Great Lakes were viewed as important because they provide an opportunity to interact with nature and contribute significantly to the cultural identity and way of life for aboriginal people as well as, commercial and sport fishers. As citizens and organizations expressed their values and views toward the Great Lakes, they also expressed parallel and interlinked thoughts about responsibilities to their communities, constituents, democratic processes, and future generations.

Non-anthropocentric values also emerged in some of the documents. These values suggest that the Great Lakes and its fishes are valued for reasons beyond meeting the interests and needs of humans. Documents included statements recognizing the intrinsic or ecological values of the Great Lakes and its fishes.

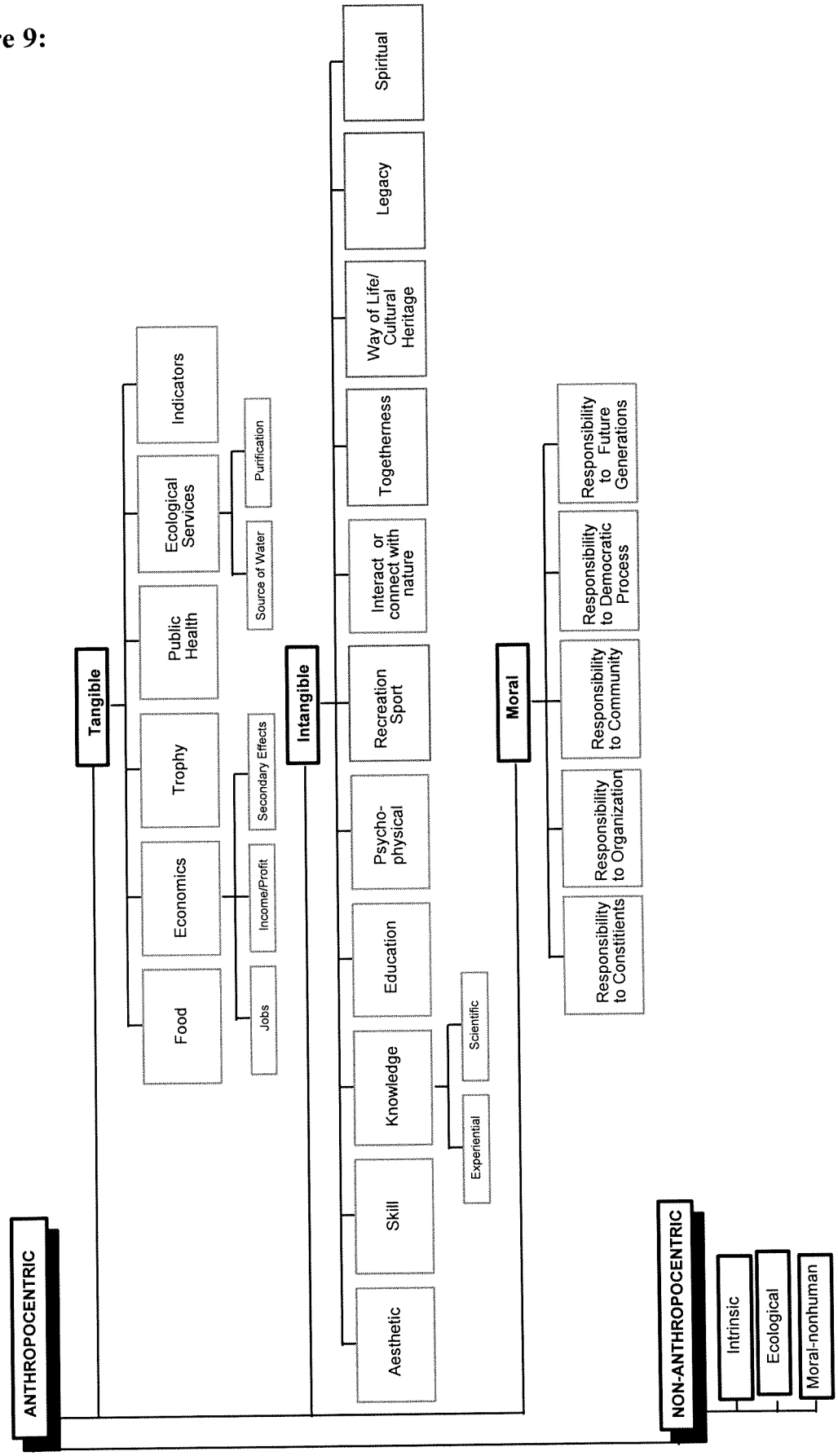
Parallel with tracking the ecological changes in the Great Lakes over time, we also reviewed federal, provincial, and state management documents to determine whether values had shifted or changed over time. Governmental documents were examined from the 1840s to the present to identify value orientations. From the 1800s to the 1950s, commercial and gamefish stocks were of great importance. Commercial and game fishes were valued because they provided food, jobs, and income. In addition, gamefishes were valued for

intangible reasons such as for sport and recreation. Between the 1960s and 1990s, game and commercial stocks were still of importance but management agencies also began to recognize the importance of non-economically important species, fish communities, ecosystems, and watersheds. Values toward the Great Lakes and its fishes expanded to include sport and recreational health benefits, a source of cultural identity and way of life for First Nations and Native Americans, and intrinsic value.

Values play a critical role in shaping and influencing the use and management of the Great Lakes and its fishes. Our attempt to gather and organize the values expressed by various groups and organizations throughout the Great Lakes is intended to aid in actions which support a sustainable fishery and which meet the needs of diverse citizens throughout the basin.

The primary purpose of presenting the values typology was to determine whether workshop participants agreed with our findings to date, whether we had missed or omitted important values and whether our description of values was clear. Suggestions were provided to incorporate the value of species to each other (i.e. as through the food chain, etc.), to characterize the values held by animal rights interests, and to recognize the spiritual nature of nonhuman beings.

Figure 9:


ANTHROPOCENTRIC
Tangible
Food
Economics
Trophy
Public Health
Ecological Services
Indicators
Jobs
Income/Profit
Secondary Effects
Source of Water
Purification
Intangible
Aesthetic
Skill
Knowledge
Education
Psycho-physical
Recreation Sport
Experiential
Scientific
Interact or connect with nature
Togetherness
Way of Life/ Cultural Heritage
Legacy
Spiritual
Moral
Responsibility to Constitients
Responsibility to Organization
Responsibility to Community
Responsibility to Democratic Process
Responsibility to Future Generations
NON-ANTHROPOCENTRIC
Intrinsic
Ecological
Moral-nonhuman

BREAKOUT DISCUSSION SUMMARY
Conservation Concepts And Human Values

Conservation Concepts

The following summarizes views shared by each breakout group following the presentation entitled "Conservation Concepts: Buzzwords or Helpful Tools?" by Dr. J. Baird Callicott. Discussions centered on the following questions: *"Selecting an approach to manage the Great Lakes involves addressing fundamental dilemmas on what to manage and why. What are your views on conservation vs. preservation; native vs. non-native species management; and restoration vs. rehabilitation? Should the entire Great Lakes system be managed in the same way or should each lake be managed differently?"*

What are your views on conservation vs. preservation?

A diversity of views emerged when participants discussed the meaning and application of conservation and preservation. Conservation and preservation were viewed in the following ways:

* Preservation is a form of conservation
* Preservation and conservation differ
* Conservation concepts which fall in between, or are different from, conservation and preservation are needed
* Both terms are confusing and differ only semantically (that is, in name only)

Preservation is a form of conservation: For example, preservation was viewed as a very intense level of conservation necessary for maintaining endangered communities, populations, species, gene pools, etc.

Preservation and conservation are different: Others viewed preservation and conservation as separate and different concepts. Preservation was described as a "hands off" approach in which natural areas were kept isolated from humans- especially from extraction-related activities. Conservation was viewed as wise use of resources for the benefit of humans. Conservation also was viewed as responsible, sustainable use of natural systems emphasizing uses that are compatible with native species as a priority. Others framed conservation on the basis of the transfer of energy through the fish community or ecosystem to the human end users. Conservation seemed more practical, cost-effective, and realistic whereas preservation was viewed as idealistic because "some things can not be preserved." Others argued that elements of both conservation and preservation are necessary.

Different conservation concepts are needed: Some felt that neither concept was appropriate and discussed whether other conservation concepts lie in between the extremes of conservation and preservation, whether a compromise between the two concepts could emerge, and whether we should focus on incorporating elements of both conservation and preservation.

Both terms are confusing and differ only semantically: The concepts of conservation and preservation were also viewed as ambiguous and the discussion as an exercise in semantics. Participants suggested that these concepts were being used to describe the same thing.

What are your views on native vs. non-native species management?

Participants put forward ideas which may be categorized as follows:

* support for native species management, exclusively
* support for or opposition to non-native species management
* support for a mix of native and non-native species management

Support for native species management, exclusively: Some participants supported management exclusively for native species because natives evolved within the lakes and were considered genetically attuned to the environment. Participants supported removal of non-native species, halting unplanned introductions, and prevention of extirpations or extinction of native fish species.

Support for non-native species management: Although most were supportive of native species management, some felt that natives were unable to support the recreational fishing industry. In addition, concerns were shared about higher contaminant loads in native species, such as lake trout, than in non-native Pacific salmon. Support for managing non-natives emerged provided that they are useful, will not impact natives, are well researched, and if they serve an important ecological function. Some viewed native species as ideal, but given the changes in the Great Lakes, felt that non-native species were more practical. Additionally, some supported continued management of non-natives until the system was able to support native species.

Opposition to non-native species management: Several were concerned about the impacts of non-native species to other species and to the ecosystem as a whole. Opposition to non-natives species management emerged because some felt these species benefited certain user groups and not others. Participants were confused by the use of the terms native, non-native, exotic, and naturalized and questioned when a particular species falls into one of these categories.

Support for a mix of native and non-native species management: Several perspectives were put forward in support of managing both native and non-native species. Participants placed priority not on whether populations were native or non-native but whether populations were self-sustaining. This provided support for management of native and non-native species provided they were self- sustaining or naturalized. Agencies should put equal amounts of effort toward native and non-native species.

What are your views on restoration vs. rehabilitation?

A range of views emerged when participants discussed the meaning and application of the concepts rehabilitation and restoration. Rehabilitation and restoration were viewed in the following ways:

* Rehabilitation and restoration are part of the same process or mean the same thing
* Rehabilitation and restoration are different and rehabilitation is more practical than restoration

Rehabilitation and restoration are part of the same process or mean the same thing: Rehabilitation using non-native species may be used in the short-term to move the system toward restoration of native species. In this way, rehabilitation was viewed as moving the system in the direction of restoration. Others felt that restoration and rehabilitation were the same thing and that this discussion was an exercise in semantics.

Rehabilitation and restoration are different and rehabilitation is more practical than restoration: Some viewed restoration as impractical whereas rehabilitation was viewed as more realistic and feasible. Because of changes in species composition due to extirpations, extinctions, introductions, and human-caused changes in fish habitat, restoration did not seem possible. The only option is to support rehabilitation using desired species which may or may not be natives.

Some supported restoring the Great Lakes to their "original" state. Yet several participants were uncertain exactly what that original state was and how far back in time one should go to determine the state to which the lakes should be restored. In addition, it was noted that species may be restored but the original genetic complement may be permanently lost. Others suggested that native species such as lake trout, that once supported a viable and valuable commercial fishery should be restored to past levels. Some supported restoring native species only if they were economically important. Support was given to the idea of restoration only where such actions are feasible. Several expressed the view that Lake Superior was the only lake that could be restored whereas rehabilitation should be the focus on all the other Great Lakes.

Restoration focuses on an "original" state while rehabilitation emphasizes maintaining and improving the functions of the individual ecosystems. Not only did many view rehabilitation as more practical, but they felt that rehabilitation would take into account human uses of the lakes.

Should the entire Great Lakes system be managed in the same way or should each lake be managed differently?

When asked whether the entire Great Lakes system should be managed in the same way or each lake managed differently, participants presented a range of views:

* Manage each lake, basin, section, or fish stock separately
* Manage each lake separately but within a broader Great Lakes-wide philosophy
* Manage all the Great Lakes in the same way

Manage each lake, each section or each stock separately: Support for managing each lake separately was based on recognition of the differences in the physical, chemical, biological, and socioeconomic factors of each lake. Support for watershed-level management emerged. In addition, some felt the need to manage at the level of certain geographic areas (e.g., bays, mouths of rivers) or at the stock or population level. Support emerged for managing some waters for native species and other waters for naturalized non-native species.

Manage each lake separately but within a broader Great Lakes-wide philosophy: Some participants supported managing each lake basin separately, but within the boundaries of a broader Great Lakes wide philosophy. Guiding principles for all the Great Lakes seemed necessary given their connectedness.

Manage all the Great Lakes in the same way: Support emerged for managing all the Great Lakes under similar management objectives. Some felt that all the lakes should be restored. Support for development of management objectives for all the Great Lakes which maximize internal control of the system as self-organizing and self-sustaining and reduced reliance on human intervention emerged.

One group created the following table to synthesize their thoughts on conservation goals and native and non-native species management by lake.

Lake	Restoration or Rehabilitation	Native or non-native species management	Management Goal
Lake Superior	Restoration	Native species	Conservation
Lake Huron	Rehabilitation	Native and Non-native species	Conservation
Lake Michigan	Rehabilitation	Native and Non-native species	Conservation
Lake Erie	Rehabilitation	Native species	Conservation
Lake Ontario	Rehabilitation	Native and Non-native species	Conservation

Human Values

The following summarizes views shared by each breakout group following the presentation entitled "Human Values: Diversity and Direction" by Karen Mumford. Discussions centered on the following questions: *"To be successful, fish management must consider and accommodate a variety of human values. What values influence Great Lakes fish communities and how can the broad range of human values be represented in current fish management efforts?"*

What values influence Great Lakes fish communities?

The following categories of values were expressed by workshop participants and reflect the values that workshop participants felt influenced Great Lakes fish communities.

* Human-centered-materialistic: economic, food, indicators
* Human-centered-non-materialistic: spiritual, cultural identity, legacy, heritage, way of life, quality of life, sport and recreation, aesthetics
* Intrinsic and ecological/biological values
* Additional values not categorized: value of species to one another, weather moderation, animal rights values

Human-centered-materialistic

Economic: Economic values are a major influence on how Great Lakes fishes are used and managed. The Great Lakes and its fishes are valued as a source of employment and income. Funds from sportfishing license sales supports and influences the actions of management agencies. Revenues are generated from commercial and sport fisheries.

Food: Great Lakes fishes were valued as an important source of food

Indicator of Ecosystem or Ecological Health: Certain species such as sturgeon may be restored and never harvested but their presence indicates a healthy ecosystem.

Human-centered-non-materialistic

Spiritual values/cultural identity: Aboriginal people respect and give thanks for taking fish as food for subsistence; their interests often are based on spiritual values. Aboriginal people are offended when nonaboriginal people disregard that fish have spirits and deeper meaning. Recognition of aboriginal values of spirituality and respect inherent in animals themselves is needed. Aboriginal people regard fishing differently from nonaboriginal people in several ways. For example, they have ceremonies associated with harvests and their last names are associated with nature.

Legacy/Heritage/Way of Life: The importance of leaving resources for future generations to use and pass on, to support a way of life, and to protect options to make a living from fishing

were expressed. Concern was voiced that children will not have the same opportunities to use the lakes as current users. If biodiversity is not preserved, then there will be nothing to pass on to future generations. The fishes and fishery also were valued because they played a role in development of communities and community identity. Without fishes and fisheries, communities will disappear. The fishery provides a means to transfer moral, heritage, recreational and economic values on to children.

Quality of Life: The Great Lakes region was valued because of quality of life aspects such as clean air, clean water; and fish.

Sport/Recreation: Fish were valued because they provided opportunities for angling and other recreational activities.

Intrinsic and ecological/biological values

Intrinsic Value: Great Lakes fishes and other organisms were valued just for being part of the system and not for their use, only. Few people hold only intrinsic values- perhaps sturgeon are preserved partially for their intrinsic value as well as for other values. Restocking species such as sturgeon occurs not only because they will generate money but because of their intrinsic value. Some stated that intrinsic values have low priority among users and management organizations.

Biological/Ecological/Evolutionary/System-level/Self-organizing: Values were attached at a higher level of organization- participants valued the hydrology, flora, fauna, communities, and landscapes that created the Great Lakes. Hence, intrinsic value was conferred to the place and the processes where species evolved. Innate value was conferred to the self-organizing coevolved community of fishes adapted to the physiographic conditions of the Great Lakes.

Values between species translates to human values. What's the value of a species to another species? The basis of value is the transfer of energy through the ecosystem to the end users. Biological values were conferred to living organisms for being part of the system and not just for human use.

Additional thoughts on values

Animal Rights Values: More work must be done to identify and present values expressed by animal rights interests.

Non-fish values: People value the Great Lakes for more than just fish. The Great Lakes are valued because they support such activities as recreational boating, swimming, bird watching, commercial shipping; the Great Lakes provide water for human consumption, agriculture, sewage treatment, industries, and use by municipalities. The Great Lakes are also valued for the climate and weather moderating effects which support orchard operations and other farming activities.

General Comments about Values

People place value on different aspects of the Great Lakes such as species or stocks; native or non-native species; communities, and ecosystems. Recreational and commercial fishers value different species; the value of non-native species should not be ignored; some people are more excited to see or catch "wild" fish than a hatchery fish- hence "wild" fish are more highly valued by some. Are non-natives as intrinsically valuable as native species? It was suggested that values differ considerably between older and younger generations.

How can the broad range of human values be represented in current fish management efforts?

To incorporate the broad range of human values into fish management, participants provided perspectives on:

* Actions directed toward the lakes
* Actions directed toward citizens and interest groups
* Challenges to accommodating diverse values

Actions directed toward the Great Lakes: Participants expressed that by sustainably managing the abundance and harvest levels of various fish species and stocks, a variety of values can be accommodated such as legacy, heritage, food, sport and recreation, employment, income, and the value associated with meeting the needs of future generations. Aesthetic value would be accommodated by improving water transparency and clarity, enhancing the coastline, and by keeping certain areas undeveloped and pristine. Actions to meet values associated with maintaining a healthy Great Lakes ecosystem include improving habitat quality, expanding pest control, and managing for self-sustaining systems. Although participants viewed intrinsic values as easily discounted, they did support accommodation of these values through reintroduction of extirpated native species, greater attention to non-game fish, and focus on supporting "wild" self-sustaining populations.

Actions directed toward Great Lakes citizen and interest groups: Communication, education, dialogue, and information sharing among agencies, various groups and interested citizens were considered extremely important given the diversity of groups, values, and interests within the Great Lakes basin. Participants suggested that more forums be held to allow different groups and interested citizens to talk with each other, exchange ideas, and identify common goals and concerns. Such efforts will allow participants to learn about each other and their values. Participants stressed that every value and idea be touched upon and included in discussions instead of just those of majority groups. Minority viewpoints are important and need to be recognized and considered during discussions.

Opportunities for dialogue would also provide a proactive means of addressing problems and establishing goals and objectives. When constructive dialogue does not occur, then the court must be relied upon to establish objectives. Tribal communities are relying more heavily on proactive dialogue than litigation to reach understanding. Small groups of fish managers, and sport, commercial and tribal fishers need opportunities to get together, exchange ideas, and

identify concerns. Support was given for the creation of citizen advisory groups composed of local, multiple interests. These groups could participate in monitoring programs and collect and analyze data together so that all are operating on the same "playing field". Such a collaborative effort would stimulate shared ownership of the data and management process.

Long-range planning and goal setting processes must include all interests and provide a means to consider concerns for the future of the lakes. Such processes may stimulate long-term thinking which was considered very important. Also, plans and management efforts should be developed for different areas around the lakes to take into account the views and values of those within the area. Regional zones could be developed for local level planning efforts. Bottom-up communication would be critical to take into account local values and perspectives. Participants stated that education was crucial. Citizens and interest groups need to have the impacts and consequences of various proposed actions presented so they can make informed decisions with regard to different management options.

Challenges to Accommodating Diverse Values: Participants also discussed challenges and difficulties which must be overcome to incorporate diverse values and interests. Sometimes values will be in conflict. For example, improvements in water clarity through reductions in nutrient loading may have a negative affect on fish productivity. Sailboaters may enjoy clearer waters but anglers may not. How will these types of conflicts be handled? Some agencies may be more responsive to certain values and interests than others. Tradeoffs and compromises may have to occur but how do we determine what to trade and when to compromise? Licensed users who pay more to use the resource may want more power and influence over decisions. How can we balance biological and economic considerations? How is our understanding of the lakes influenced by our values and the things we want from the lakes?

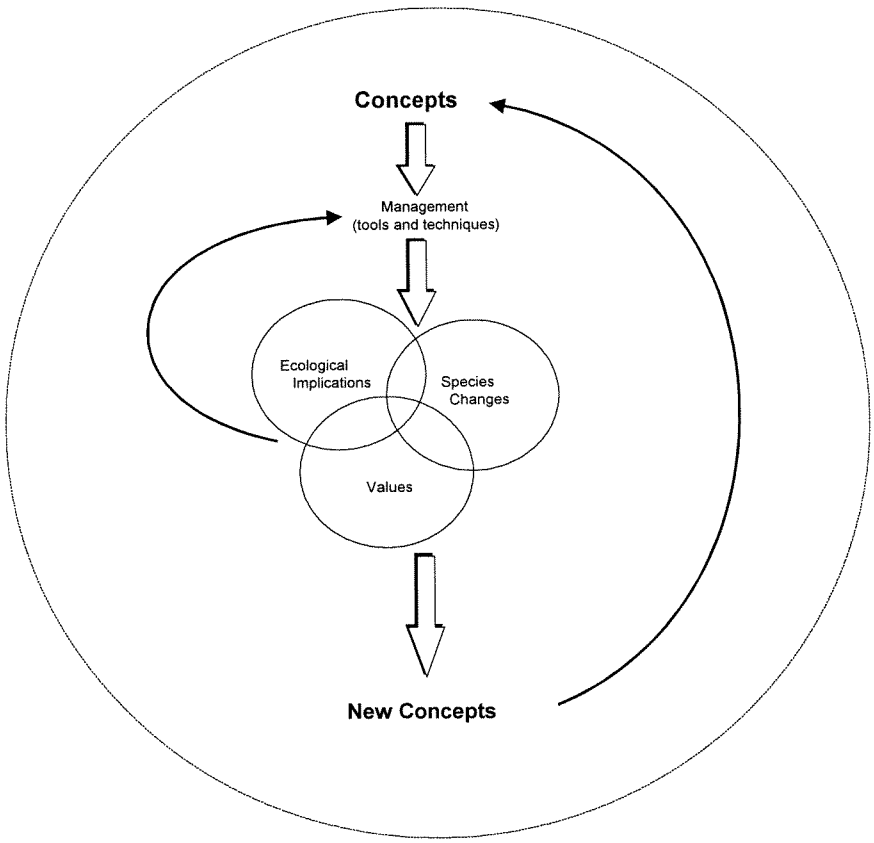
PUTTING IT ALL TOGETHER: DIVERSITY, CHANGE, AND UNCERTAINTY

Larry Crowder, Duke University Marine Lab

"To keep every cog and wheel is the first precaution of intelligent tinkering." Aldo Leopold, 1953 (From Luna Leopold, ed., *Round River: From the Journals of Aldo Leopold*)

Most scientists, managers and constituents now fully recognize that Great Lakes fisheries derive from lake ecosystems that begin in the watershed and end in the creel or fish market. Clearly, fisheries are affected by a wide variety of factors including those that have a direct effect such as harvest by fishers or fish stocking by managers. But fisheries are also affected indirectly by sources of nutrient enrichment or toxins that originate in the watershed (or ever broader, the airshed) due to human activities. Our project sought to integrate changes in the species composition of the Great Lakes fish communities over time with likely implications for ecological function and with the dynamics of human values (Figure 10). Changes in the ecological system can drive shifts in human values (e.g. when severely degraded systems are recognized humans respond) or shifts in human values can drive shifts in the ecological system (e.g. as interests in fishing shift from commercial to recreational, stocking of non-native predators may increase).

Figure 10:



Management seems to be driven by a diversity of human values as well as the current and projected state of the ecosystem. One widely supported management goal is that fisheries be sustainable. But do sustainable fisheries depend upon sustainable ecosystems? In order to sustain the function and health of lake ecosystems, do we have to consider biodiversity? Our findings suggest that biodiversity, which means variety in nature, including genetic variety, numbers of species, and the variety and distribution of habitats, populations and communities of organisms, seems to allow ecosystems to "work" more sustainably. Ecosystem function can sometimes be maintained by "redundant" species; this redundancy is important for ecosystem dynamics. But this is true for most complex systems. Any fisherman knows that one does not go to sea without backup systems for communication, navigation or mobility, at least if he or she wants to get home safely. So it goes with ecosystems-- loss of key species or reduced biodiversity can compromise ecosystem health. Diverse systems also often operate with reduced variability. Protecting biodiversity is also about maintaining options for the future-- we must prevent additional species losses and prevent irreversible species additions. Again, as on a fishing vessel, we must always carry spare parts to maintain our ability to rebuild the system if it falters. It is true that total fishery production depends ultimately on nutrients and sunlight, but fishers prefer to harvest some species over others.

Ecosystem management as a way of thinking entered the Great Lakes management lexicon over 20 years ago, but some scientists, managers and constituents have not fully adopted this perspective. They are most interested in a "piece" of the overall system, like Pacific salmon or potable water. We have come to recognize that humans are part of ecosystems and that ecosystems can be very complex, including nutrients, plankton, benthic organisms, forage fish, fish predators, birds as well as humans. We also acknowledge that changes in the ecosystem (e.g. in species composition, habitat or water quality) can alter its usefulness to particular human interest groups. When scientists or managers detect what they perceive to be problems associated with these changes, they often naïvely expect the public to readily change its behavior to fix the problem. But awareness and values differ among constituents. Furthermore, public policy and governance structures are often as complex as the ecosystems themselves. Managers in one agency manage water quality and those in another manage fishes as if water quality and fisheries were not both properties of the same ecosystem! Most Great Lakes socio-political systems involve several governments (Canada, United States, First Nations, Provinces, States) each with management in sectors (water quality, habitat, fishing, shipping) managed by different agencies. In addition, landscape management often overlooks downstream effects.

"If humans are an integral part of ecosystems, are politicians a separate trophic level?" Peter Larkin, 1993 (From Fisheries 18:6-11)

Our hope for the future depends upon a synthesis of the ecosystem concept and integrated management. This approach acknowledges the complexity of both the fishery ecosystem and the governance structure-- indeed we are trying to manage a complex system with a complex system. We need a balanced perspective that seeks to understand the complexity of the ecosystem and to incorporate the complexity of the social systems into decision making. This decision structure needs to include interaction among constituents, scientists and managers to interpret changes in the ecosystem and to derive management responses based

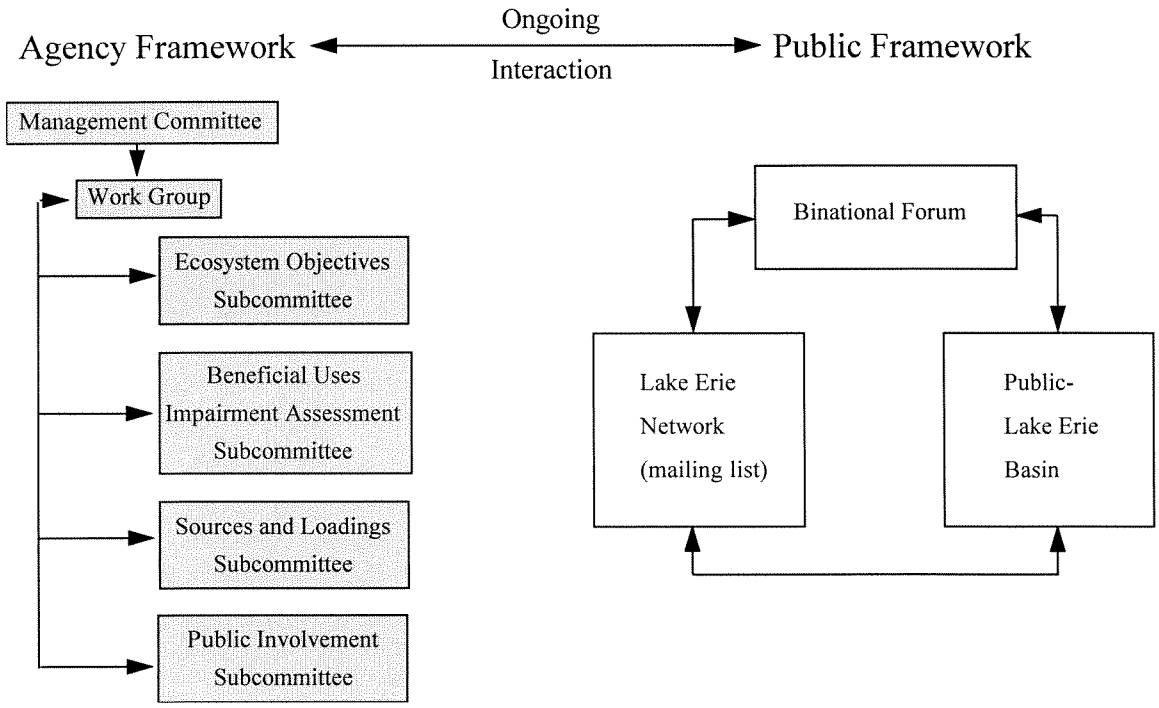
on constituent values. But these management responses need to be integrated across a complex governance system, where responsibilities are shared, diffuse and sometimes in conflict.

Examples of such integration within sectors include the International Joint Commission (water quality), the Great Lakes Fisheries Commission (fisheries) and the Great Lakes Commission (commerce). These coordinating bodies have contributed to dialogue among managers and governments dealing with particular issues. Newly formed cooperatives seek to coordinate management across these sectors. One of the most promising efforts is the Lake Erie Lakewide Management Plan (LaMP) which is developing integrated management plans with input four states and a province and specifically includes Agency and public involvement (Figure 11).

Figure 11:

Lake Erie LaMP

Organizational Chart



Management of any complex system is based upon a "concept" like maximum sustainable yield or ecosystem management. Based upon this concept, managers can employ their "toolkit" to influence the trajectory of the system. Management activities, resource use or other outside forces (e.g., species invasions, economic or social changes) can alter species composition, ecological function or human values. If these alterations are small, management can respond within the context of the existing concept. But if alterations are large (e.g. collapse of the lake trout due to lamprey invasion, rise of recreational fishing), management may require a new conceptual basis in order to manage sustainably.

Management around small variations is pretty much "business as usual" but management under radical change is difficult for managers, scientists and the public. Major changes in biodiversity often fall into this latter category-- managing Great Lakes fisheries after the exotic species invasions of the 1930s-50s (and associated losses of native fishes) was a different ballgame. Because established non-native species are impossible to remove, we must ever after deal with their legacy. The challenge of changing biodiversity and its impacts on Great Lakes ecosystems will require the cooperation and support of constituents, scientists, and managers.

"There is a search today for new approaches and new meanings for managing fishery ecosystems... The first clues to possible solutions... take a broader perspective on the relationships between human communities, aquatic resources and ecosystems." John Kurien, 1998. (From Ecological Applications 8(1) suppl.:52-85)

BREAKOUT DISCUSSION SUMMARY
Putting It All Together:
Diversity, Change And Uncertainty

After the presentation, participants discussed the following questions: *"How does your sector of the Great Lakes fishery community cope with and adapt to the social and ecological changes that occur within the Great Lakes, such as zebra mussel invasions, downturns in the commercial or sport fishery, etc?"* and *"How can maintaining or protecting the biodiversity of the Great Lakes system be implemented to preserve current and future uses of the Great Lakes fishery?"*

"How does your sector of the Great Lakes fishery community cope with and adapt to the social and ecological changes that occur within the Great Lakes, such as zebra mussel invasions, downturns in the commercial or sport fishery, etc?"

Where it was possible to contribute comments to a specific sector we have done so. The amount of information following each section is not meant to be misleading regarding the amount of discussion time provided to each sector. It is also not intended to represent the views of all people associated within each sector, these are just the points brought up by those attending this workshop. Where comments could not be attributed to a sector, they were placed under the general section.

Bait: Bait fishers track species' diets and people's catch with different bait to obtain a variety of information. Changes, from ecology to values, affect activities as to what will sell. Bait fishers need to sell in order to make a living, so they monitor human use.

Electric Utility: Ontario Hydro is changing to provide the public with information and the opportunity to comment on what they are doing. They have moved from impact statements to doing more rehabilitation/restoration "greening" projects. Documents and reports are becoming more visually appealing to the public. The creation of stakeholder advisory groups is important.

Sport: Use money and public relations to attract people back to the lakes and fishing. There is, however, a misperception about no stocking. It is important to make explicit the impacts of all decisions on each sector.

Charter: Current economics affect membership and the client base is driven by economics. Also, ecological trends affect catch and business. They cope by using a lot of advertising. Stocking keeps business good (direct catch or through ecological change). With the declining lake trout stocks some have moved away from the charter business. Some are turning to ecotourism (selling the experiences of fishing, cruising, and diving) and participating in research. More cormorants and changing fish stocks have led to more catch and release (which has not been well received), decreased limits and switching species

(choose most available species). Moratoriums are declared with species depletions. With cleaner water, there is more bottom fishing vs. open water fishing.

Environmental: Cope by spending much time and effort to increase public awareness and education. Increase use of lobbying and speaking out against stocking exotics, etc.

Commercial: To cope with ecological changes, including the difficulty to predict the next harvest, more research is encouraged. Making recommendations to the general public, including what affects each sector is also encouraged. Commercial fishers have responded to changes by using other environmental clues rather than just fish populations. Changes have led to reduced take, differences in species caught (for example, when yellow perch declines switch to lake whitefish/chubs), changes in gear type used, switching fishing areas and adjusting to quota management to improve populations.

Social changes (commercial to sport) have led to a "hang in there" approach and an attempt to work with and create partnerships with other fisheries through changing fishing areas, seasons, species, and the employment of sport people in the off season. In the past, some commercial fishers didn't cope, just tied-up their belts and hung on. Current coping methods are an increased lobbying capacity, more research and data collection to get whole picture once per year, become more active/proactive, down-sizing, and buy-outs. They are getting more involved with research in product developments and harvesting techniques. There is more encouragement to prevent overcapitalization by limited entry, which could also be used by charter industry.

Scientist: It has been the habit to study fish to death and write an epitaph for a succession of previously revered species. Now we seek new paradigms to explain the changes that have occurred, such as shifting from maximum sustained yield to ecosystem management. However, with funding shifts, we can't study on a long-term basis because the community responds to new "hot issues". Most studies are stuck with a 2-3 year limit.

Manager: In coping with all changes it was the case in the past to do nothing and learn from experience. We couldn't do much long term and are creating rhetoric/objectives that are not being implemented.

Aboriginal: There is a governance structure with a well-regulated licensing process. To cope with changes there is more promotion of concerns with the government and increasing dialogue and information sharing with all groups.

General: To cope with all changes, it is best done by co-management, dialogue, and setting up citizen advisory committees at different levels of local government. This can be achieved by working with management agencies, city, county governments, and industry. It is especially important to communicate to Lake Advisory Committees. We can also contact lobbies or local politicians. It is important to make available all information and communicate with user groups more often in workshops such as this. Another method to cope is to take more responsibility for research, data collection, and enforcement functions. Acting defensively and complaining instead of acting proactively should be a thing of the

past. A "wait and see" attitude was used in response to new exotics in the system. Building or altering fish hatcheries to try patching efforts has been a response to loss of fish stocks. Many spoke of the challenges of addressing the issues of concern to animal rights groups, a non-user sector. It was also stated that there is a need to prevent the media from being the primary mode of communication.

"How can maintaining or protecting the biodiversity of the Great Lakes system be implemented to preserve current and future uses of the Great Lakes fishery?"

An immediate reaction to the question from many was that current practices would probably not be enough to protect Great Lakes biodiversity and that a mix of biological and social considerations are necessary for any solution. A large number of both general and specific ideas or approaches were generated in discussion groups. The general responses fell into one of the following categories:

* increasing public education and awareness
* changing perceptions of the system and views for management
* creating dialogue between user groups, management, scientists
* finding solutions to biological concerns
* funding ecological research
* changing the management system and goals

Increase Public Awareness: Many participants felt that the role of public education (of the Great Lakes ecosystem, aquatic ecology, human values) for all sectors in understandable terms is very important. Several participants mentioned the importance of broader marketing or communication of the uniqueness of the Great Lakes system, including the role of the fish community. This includes increasing public awareness of not only commercially valued species, but also focusing on the importance and value of non-economically valued species. There was a call to present future management options/goals, including biodiversity objectives, in a costs/benefit framework that includes not only economic but also ecological considerations.

Increase Dialogue: Most participants stated that an increase in dialogue and responsibility between all user groups, as well as, constituents and management agencies and scientists would be beneficial. Dialogue between constituents (including management and scientists) was emphasized by several participants as a necessary approach to gain respect and understanding between individuals which may help resolve conflicts when they arise. Several participants discussed the possibility for non-governmental agencies to share data collection with government agencies. Many participants felt that they had knowledge about the system that may benefit management, possibly meetings could occur where multi-directional information flow occurs about the state of the system and potential important needs to be addressed. Some people further formalized this idea and suggested establishing public advisory committees (where everyone is represented) that would meet to discuss the state of the resource, needs, and future directions for management.

Ecological Issues: In order for biodiversity to be protected in the Great Lakes, several ecological issues need to be addressed. Participants specifically mentioned several issues including: protection of the forage base, control of exotics (intra- and interlake), protection of habitat, control of pollution, and potentially control of species that have become abundant and a nuisance (i.e. cormorants).

Research Needs: Several participants considered that more research was necessary, although many admitted a lack of funds for monitoring and research. Several questions revolved around a better understanding of the structure and function of ecosystem, the importance of wetlands and habitat loss in its implications for biodiversity and fisheries in the Great Lakes, and an ecological assessment of non-native species. There was also some interest in formalizing the conservation concepts in putting them in practice.

Management Changes: In discussion groups there was some consideration of management changes that would need to take place to protect Great Lakes biodiversity. Discussions revolved around potential for better coordination of all Great Lakes management agencies, increasing the reaction time to emerging problems (such as exotics), improving monitoring and protective mechanisms, restoring the balance of power between user groups, and increasing accountability within the management agencies. Although a daunting task, participants felt that getting federal, state, provincial, tribal, and non-governmental organizations communicating and coordinated in monitoring and regulation would be beneficial. In addition, the need for water quality agencies to meet with and consider fisheries agencies and objectives (and vice versa) is needed. Some participants voiced frustrations about the reaction time of the management agencies, specifically the time it takes from problem recognition to putting changes or protective measures into place. In many instances throughout the workshop, discussions about restoring or equalizing the balance of influence that different constituents groups have in decision-making. Many constituents stated that resource management decisions have become too political, narrowly focused on specific economic gains, and influenced by only one or two user groups. If all constituents were fully considered in decisions, it may result in a larger ecosystem perspective (including more protection for biodiversity), because these groups are so diverse in their concerns, interests and values.

Potential management goals/thinking emerged as necessary for a biodiversity objective including: manage for self-sustaining populations, maintain ecosystem health, and create a long-range or long-term vision for the Great Lakes. More equivocal management goals were considered in the different groups such as setting restoration of lake trout as a top priority, explicitly focus our efforts and directions towards a native complex of species (while some participants wanted focus on native and naturalized species). More focus around non-commercially valued species would be necessary with a biodiversity objective. These non-economically valued species may be incorporated more as views expand towards the functional group, food web, watershed scale.

Several specific areas for regulations were mentioned by participants as approaches to conserving Great Lakes biodiversity. These included utilizing current political framework for zoning restrictions. Shorelines that are not yet developed could have future development

restrictions placed on them. A few participants suggested area closures or reserves that would be off-limits to fishing for everyone to help protect species and fish stocks. Some participants acknowledged concerns that some management goals or regulations that are already in place need to be strengthened, enforced, or made basin-wide (not just federal or state/province-specific). Two specific examples mentioned include the IJC zero discharge goal for pollutants and the ballast water exchange to control spread of unintended exotics.

Potential Problems: Potential problems will arise with making biodiversity a fisheries management objective because subsequent actions will conflict with current use. For example, the successful restoration of Atlantic salmon to Lake Ontario would displace the naturalized steelhead in many of its tributaries. Resource overlap of lake trout with exotic salmon (chinook, coho) may also result in conflict if natives are explicitly made a priority. A biodiversity objective focused on purely natives versus natives and naturalized species contrasts the competing uses and values of the system. The future perception of naturalized species was probably one of the most contentious issues at hand in discussions of biodiversity in the Great Lakes One area that more people tend to agree on is a goal of no new accidental or unintentional species introductions. Another consideration that emerged in discussions to make biodiversity a management objective is how that may change research and monitoring needs and whether there is money to apply it as an objective

RECURRING THEMES

Many themes were consistently expressed and emerged throughout the workshop. These recurring themes fell into five categories:

* biological
* social
* informational
* educational
* management/institutional

Biological: There was much concern expressed about non-authorized introductions, both present (zebra mussels, sea lamprey, ruffe) and potential future ones. Many pointed out the impacts that these extant non-native species are having on the fish community, and noted that the impacts of very recent introductions and potential future ones are often unknown. Authorized introduced species often emerged as an issue - both in positive and negative lights. Misinformation about contaminants was another issue brought up, along with the concern of contaminant impacts on subsistence fishers.

Social: The term "stakeholder" is not appropriate for some citizens, groups and organizations and its use should be limited.

Information: The importance of the need to share information between citizen groups often emerged. This could be achieved through more communication and dialogue in workshops for citizen groups, such as this one. Also, allowing various groups to participate in collecting data information, monitoring efforts, and having input into the state of the system and goals. More and efficient use of citizen information by researchers and managers should be encouraged. It was apparent there was frustration at the lack of use, by researchers and managers, of the knowledge of citizen groups who work directly on the lakes. The need for consensus of concepts was also expressed. Many concepts were viewed as similar by some participants, while others viewed these same concepts as completely different. A consensus regarding definitions and terms would help clarify many issues.

Education: It is important to educate the public about the issues and serious nature of the problems in the Great Lakes to increase awareness. Presenting this information to the public should be in usable and understandable terms, possibly through workshops. It would be beneficial if citizen groups had more information about each others activities, values etc. This would go a long way to understanding each others' views and may help towards creating partnerships. Also, the importance in teaching the younger generation, as well as learning from them, was frequently discussed.

Management/Institutional: It was frequently discussed that more bottom-up co-management and decision-making is necessary through local communities which would tailor efforts to meet concerns and report to a general overseeing body. It was also stated that there needs to be more consistency of policies across lake political borders and for management to listen to users and develop dialogue. Providing opportunities for more citizen input in decision-

making and investigate opportunities for co-mangement, including minority views, were both discussed. It was stated that it is important to make explicit the social, economic, and environmental impacts of all feasible future options on each sector using techniques such as cost-benefit analysis, and in doing so, allow the sectors to make more informed decisions regarding outcomes for management. It is important that there be more equity of users influencing policy. Allowing only those that pay licensing fees to call the shots, has led to an unfair influence of only a few citizen groups. Often, the voices of non-user groups or non-licensed user groups fall on deaf ears.

Conclusion: Although there was a wide variety of views expressed throughout the workshop, there were many points that were often discussed and emerged frequently. These recurring themes do not necessarily mean consensus, which was not the goal of this workshop, but indicate areas of interest to a variety of citizen groups.

WORKSHOP WRAP-UP: WHERE ARE WE GOING FROM HERE?

Ed Crossman, Royal Ontario Museum

There are two types of "we" involved in the activity we have just completed. There is we in the broader sense which includes all of us, our families, friends, and colleagues. There is also the we that is limited to the members of the Biodiversity Task Team.

In his presentation, Baird Callicott quoted from an older animal comic strip, "Pogo", which regularly placed in the mouths of so-called "lesser" animals sentiments and wisdom highly appropriate to humans. The hero of the strip, Pogo Possum, said "we have met the enemy and he is us". This is also true of the clash between our demands on aquatic ecosystems and the abuses of them. If we learned anything from our coming together and participation in the various discussions, there is hope that we will be able to buy into all, or some, of the ideas. Perhaps we can become disciples to spread the word to our children, our neighbors, our group constituents, and government representatives at all levels. Two points that were made repeatedly in the workshop are dialogue and discussion are necessary, and there is hope in our young people.

We, as a Task Team, will attempt to utilize the counsel received from participants from this workshop, and from the other workshops, to provide GLFC with our suggestions for a set of recommendations to the Resource Managers. Those recommendations will incorporate the role of biodiversity and will probably include ideas on the need for coordination and compilation of data on the Great Lakes. We have experienced trouble locating, obtaining, or transposing information on a number of topics. The major reason is a result of the involvement on the Great Lakes of several federal agencies, nine state and provincial agencies, and several groups of Native Peoples. Often the same type of information is gathered by several agencies, but in different formats which make it difficult or impossible to combine. You saw at the outset of this workshop the use of three circles to represent the three Units of our Task. We will proceed toward the coordination of the three activities, which was expressed as the overlapping portion of the three circles.

The formal end of the Task is June 30, 1998, but complete documentation, including Task Completion Report, may not be available until 1999. Otherwise the results will be in the form of a mix of GLFC Technical Reports and papers in journals.

The remaining duty for the Task Members is to express our thanks to the various people who made the workshop such an outstanding success. We thank each participant, and hope each has profited personally from the experience of helping the Task Team with ideas and opinions, expressed in breakout sessions, survey form, and appraisal form.

Mike Donahue's skill as a Facilitator was greatly appreciated, and recognized as one of the reasons the workshop functioned so well. Much credit for the effectiveness of the breakout groups is the result of the willingness of busy people to give their time to assist us as facilitators (Larry Crowder, Jim Diana, Dave McLeish, George Spangler and Roy Stein). We

extend our thanks to the notetakers Jen Abdella, Susan Fruchey, Michelle Huffman, Deborah Steinberg, Leslie TeWinkel, and Amy Schick who also donated their time to assist in the process. Possibly it will help them to understand the problems of the Great Lakes and those who utilize them. We appreciate the time Marc Gaden took out of his schedule to come and present his informative and interesting talk to us. We should also thank the Great Lakes Fishery Commission for making it possible to bring us all together to listen, discuss, and to hear one anothers' points of view.

The PIs of the Biodiversity Task extend their thanks to the student members of the three units, Becky Cudmore, Lisa Eby, and Karen Mumford. It was almost totally their efforts and ingenuity that led to the mix of participants and the organization of the very successful workshop.

INTERNATIONAL SEA LAMPREY MANAGEMENT ON THE ST. MARYS RIVER: EVERYONE WINS BUT THE SEA LAMPREY

Guest Speaker: *Marc Gaden, Great Lakes Fishery Commission*

Marc Gaden of the Great Lakes Fishery Commission's Secretariat delivered a slide presentation about the Commission's efforts to control sea lampreys produced in the St. Marys River. Gaden pointed out that the St. Marys River poses some of the biggest challenges the Commission has faced in its 40-year history.

Today, the St. Marys River produces more parasitic sea lampreys than all Great Lakes tributaries combined. Prior to the mid-1970s, the St. Marys River had been an inhospitable place for sea lampreys to live and reproduce. Water quality and habitat improvements during the previous couple of decades have turned the river into a producer of hundreds of thousands of sea lampreys annually. Sea lampreys produced it the St. Marys River migrate into Lake Huron and northern Lake Michigan and prey heavily on many fish species. More fish are destroyed by sea lampreys than all other sources of mortality combined- including natural causes, sport, tribal, and commercial harvest.

The river's tremendous size and flow volume prohibit effective sea lamprey control using conventional methods. Use of the lampricide TFM on the St. Marys River, for instance, would require approximately $12 million and would only eliminate 50% of the sea lampreys- an unacceptable level of control, especially for the cost.

Gaden reported that after years of research and development, the Commission and its agents were able to develop alternatives to TFM; in 1997 this research provided the Commission with the knowledge to commence sea lamprey control on the St. Marys River. The program relies on three techniques working together to significantly reduce sea lampreys produced in the river:

1. Granular Bayluscide: Controlling Sea Lamprey Larvae. Scientists learned that sea lamprey larvae are not dispersed evenly throughout the St. Marys River but rather, are concentrated in a few areas of relatively high abundance. Using helicopters and global positioning technology, a specially formulated lampricide- granular Bayluscide- will be applied to the "hot spots" to kill sea lamprey larvae on the bottom of the river. Granular Bayluscide applications will take place in 1998 and 1999.
2. Trapping: Removing Spawners. The Great Lakes Fishery Commission entered into partnerships with Great Lakes Power and the U.S. Army Corps of Engineers to construct sea lamprey traps on the St. Marys River. Traps remove thousands of spawning sea lampreys and supply males for the sterilization program.
3. The Sterile-Male-Release-Technique: Suppressing Long-Term Spawning Success. Male sea lampreys are trapped, sterilized, and released into the St.

Marys River. The sterilized males compete with normal males for females and thereby reduce the reproductive potential over the long-term.

In 1997, the Commission- with the support of the Lake Committees- redirected most of the sterile males to the St. Marys River. Gaden noted that sea lamprey control on the St. Marys River is consistent with the Commission's Strategic Vision for an integrated sea lamprey control program that relies on partnerships and that promotes a healthy Great Lakes ecosystem. This control effort is cost-effective, it relies heavily on alternative controls, and it will reduce parasitic sea lampreys in Lake Huron and northern Lake Michigan by 85%, a level consistent with Fish Community Objectives. Spawning potential of lake trout and other species is expected to rise dramatically. In formulating the St. Marys River program, Gaden stressed that the Great Lakes Fishery Commission worked closely with state, federal, and tribal partners, and received extensive input from scientists, its committees and boards, and the public. Funds for sea lamprey control on the St. Marys River have been provided by the U.S. and Canadian federal governments and by the State of Michigan.

Appendix A:

Great Lakes Fishery Commission Biodiversity Workshop Agenda
April 22-24, 1998
Ann Arbor, MI

Wednesday, April 22

8:00 - 10:00 PM	Official Welcome Evening social with appetizers and beverages

Thursday April 23

8:30 AM	Introduction- workshop goals and structure *Dr. Mike Donahue*
8:45 AM	Overview of GLFC Biodiversity Project *Dr. E.J. Crossman*
9:00 AM	The Ins and Outs of Great Lakes Fishes *Becky Cudmore*
9:30 AM	Ins and Outs: Implications of Species Changes for Fish, Ecosystems, and People *Lisa Eby*
10:00 AM	(Coffee break)
10:15 AM	Breakout groups
11:30 AM	Reports from the breakout groups
12:30 PM	Lunch (provided)
12:45 PM	Guest Speaker: International Sea Lamprey Management on the St. Marys River: Everyone Wins but the Sea Lamprey *Marc Gaden*, Communications Specialist Great Lakes Fishery Commission
1:30 PM	Conservation Concepts: Buzzwords or Helpful Tools? *Dr. J. Baird Callicott*
2:00 PM	Human Values: Diversity and Direction *Karen Mumford*
2:30 PM	(Break)
2:45 PM	Breakout groups
4:00 PM	Reports from the breakout groups
5:00 PM	Reception: appetizers and cash bar
6:00 PM	Dinner on your own

Great Lakes Fishery Commission Biodiversity Workshop Agenda
April 22-24, 1998
Ann Arbor, MI

Friday April 24

8:30 AM	Welcome back- summary of previous day's activities *Dr. Mike Donahue*
8:45 AM	Putting it all Together: Diversity, Change, and Uncertainty *Dr. Larry Crowder*
9:15 AM	Coffee break and join breakout groups
10:30 AM	Reports from the breakout groups
11:30 AM	Wrap-up- Where are We Going from Here? Thank-you, post-workshop evaluation *Dr. E.J. Crossman*

Appendix B:

Great Lakes Fishery Commission Biodiversity Workshop
Attendee List

Jim Boraski
Bob Collins
Steve Crawford
Jim Diana
Doug Dodge
Mike Donahue
Randy Eschenroder
Andy Frank
Todd Grische
Walter (Skip) Hartman
Dennis Hickey
Paul Jones
Doug Kettle
Glen Maxham
Dave McLeish
Greg Nadjiwon
Cecil Peterson
Frank Prothero
Terry Quinney
Merlynn Russell
Michael Ryan
John Schrouder
George Spangler
Frank Sanza
Roy Stein
Jim Tibbles
John Tilt
Forest Williams
Don Wismer

GLFC Biodiversity Task Group:

Baird Callicott
E. J. Crossman
Larry Crowder
Becky Cudmore
Lisa Eby
Karen Mumford

Appendix C:

Results of Pre-workshop Survey

A pre-workshop survey was sent out to participants to explore some of their views and perspectives towards the Great Lakes and its fish communities. Approximately 58% of the participants responded. Most of the respondents were associated with more than one of the lakes, but we found Lakes Ontario, Erie, Huron, Michigan, and Superior were represented well and evenly. Most of the respondents had been personally involved in the lakes for over 10 years. We inquired about familiarity and importance of particular concepts used in conservation and what they considered to be some of the most important impacts on the Great Lakes and its fishes. All of the conservation concepts that we inquired about were considered to be very important or somewhat important to almost all of the respondents (Table 1).

Table 1. Survey question: How important is each of the following concepts, in your own work or in Great Lakes related activities? Numbers represent the actual number of respondents that indicated the level of importance of each term.

	Not Sure	Very Important	Somewhat Important	Not Important
Biodiversity	0	11	7	0
Biological Integrity	1	11	4	1
Ecological Rehabilitation	1	11	5	1
Ecological Restoration	1	9	7	0
Ecosystem Health	1	16	1	0
Ecosystem Management	1	15	2	0
Sustainability	0	17	1	0

To gain an understanding of the meaning of these concepts to workshop participants, we asked them to define or describe two concepts, biodiversity and sustainability. Of the 20 descriptions of biodiversity provided by respondents, most characterized biodiversity as the "diversity" or "variety" of one or more of the following: genotypes, stocks or populations, species, lifeforms, or ecosystems. Some descriptions included both native and non-native species such as "..healthy stocks of native and naturalized aquatic species..". Others included only native species: "...indigenous species mix excluding introduced species..". Three descriptions included humans as part of biodiversity such as "a wide variety of living organisms including humans..". Other descriptions also included the "interactions" or "interrelations" between life forms or systems as well as functional aspects of biodiversity: "biodiversity...includes not only the form of the living system, but also its functions."

Of the 19 descriptions of the concept of sustainability provided by workshop attendees, seven described sustainability in terms of sustaining long-term beneficial uses of Great Lakes organisms or ecosystems to meet current and future human needs and interests. The following reflects this emphasis, "Sensible harvest and use of our renewable resources for the benefit of the general public." Eight descriptions focused on sustaining the organisms or ecosystems of the Great Lakes into the future without referring to human needs or interests. An example of type of description is a follows, "Healthy and diverse ecosystems exhibiting long-term stability." Four described sustainability as balancing human interactions with protection of Great Lakes ecosystems or organisms. This is exemplified as follows, "..the management of human activities and impacts over time such that they neither irreversibly degrade the environment, nor impede processes, structures, or functions."

When asked to consider what level of impact several factors had on the Great Lakes and/or its fishes, most of the factors we listed received An impact rating of high by at least 50% of the respondents. Stocking, water quality, over-fishing received the most votes as having a high impact, followed closely by exotic species, extinctions, and changes in food availability (Table 2). Of the impacts considered, exotic species was ranked #1 by more people as having the greatest impact. Other impacts ranked #1 or #2 include water quality/pollution, habitat loss, and changes in food availability. Neither overfishing or extinction were mentioned often as an important impact (Table 3).

Table 2. Survey question: What level of impact do you believe the following factors currently have on the Great Lakes and/or its fishes? Numbers represent the actual number of respondents that indicated the level of impact of each factor.

	Not sure	High impact	Low impact	No impact
Changes in food availability	0	12	7	0
Exotic species	1	11	4	1
Extinction of native species	1	11	5	1
Loss of habitat	1	9	7	0
Overfishing	1	16	1	0
Water quality/pollution	1	15	2	0
Stocking	0	18	1	0

Table 3. Survey question: Of the factors above, please list the top three you believe have the greatest impact? Numbers represent the actual number of respondents that ranked the importance of each factor.

	ranked #1	ranked #2	ranked #3
Food	2	2	3
Exotic	8	4	4
Extinction	1	0	1
Habitat	3	3	3
Overfishing	0	0	2
Pollution	4	5	1
Stocking	0	4	1
Other	0	0	3

When respondents were asked to state in their own words, the ways in which the Great Lakes were meaningful to them, a broad range of values toward the Great Lakes and it fishes and ecosystems were expressed. The values expressed by respondents ranged from material values such as a source of income and jobs to non-material values such as cultural and spiritual importance and intrinsic values. Some of these values and examples of statements expressed by respondents are summarized (Table 4).

Table 4. Examples of values expressed when survey respondents were asked to describe personally, the ways in which the Great Lakes and/or its fishes are important or meaningful.

Values	Respondent description
Material	
Food	It has been a lifeline to my community for generations for **food**, barter and transportation
Economic	The Great Lakes support a commercial fishery that is an important socio-**economic** factor...and is an outlet for **capital** and employment
Jobs	Through many sources it [the Great Lakes] created and sustains **employment**
Ecological services	..fishes of all species and functional groups are key to **proper functioning of the ecosystem to provide the services we need**
Non-material	
Aesthetic	The Great Lakes are **jewels** of North America..I highly value the **aesthetic** appeal
Cultural, spiritual, heritage	The Great Lakes are part of our **cultural, spiritual**, and **natural heritage** as healthy freshwater seas
Recreation	[The Great Lakes] are very important to **recreational fishing**
Ecological	[The Great Lakes] not only supports fishing but it is **important to many of our birds and other animals**
Intrinsic	..it's important to me to be able to know that all natural flora and fauna living in the water, over the lakes, and on the shore are **there for their own sake**.

Appendix D:

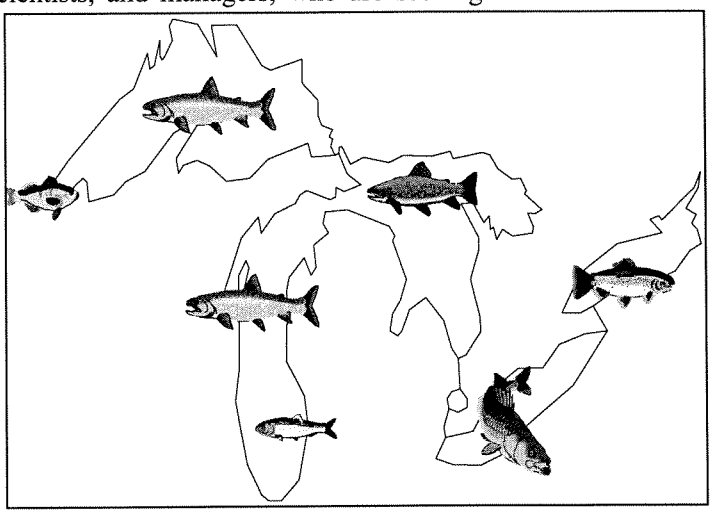
Briefing Paper for Great Lakes Biodiversity Workshop
April 22-24th, Ann Arbor MI

What is the Great Lakes Fishery Commission (GLFC) Biodiversity Task?

In 1995, the Board of Technical Experts of the GLFC sponsored a three-year biodiversity study. The objectives of the study were to assess the changes in the composition of the Great Lakes fish community, examine the food web and ecological implications of these changes, and relate these changes to shifts in human values and management concepts. One of the goals of the study was to develop recommendations to Great Lakes resource managers that would incorporate the role of biodiversity in sustainable, consumptive and non-consumptive uses of the fishes. A significant part of this study involves organizing workshops to incorporate the experience and knowledge of fishery managers and citizens from around the Great Lakes.

Purpose of this Document

In this paper, we review the results to date of our research on the biodiversity of Great Lakes fishes. More specifically we examine the changing composition and structure of Great Lakes fish communities, the implications of such changes on the functions of Great Lakes ecosystems, and the changing ways people value the Lakes and their fishes. We summarize our major findings here and point to both problems and opportunities confronting citizens, scientists, and managers, who are seeking to better understand and enhance Great Lakes fisheries.



Why is biodiversity important?

The term biodiversity means variety in nature, including genetic variety, numbers of species, and the variety and distribution of habitats, populations and communities of organisms. The Great Lakes have experienced losses of native fishes, invasions of non-native organisms, habitat modification, and increased genetic uniformity. Many of these changes have been catastrophic for fish, as well as the citizens in the Great Lakes basin. Diminished biodiversity can influence ecosystem functions, such as the types and number of fish an ecosystem can produce. Thus all of us- citizens, scientists, and fishery managers- should be concerned.

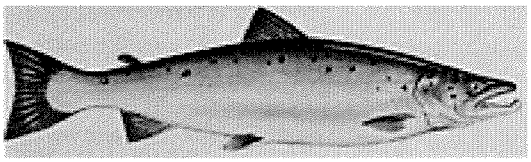
Both governmental and nongovernmental organizations have begun to consider the connection between biodiversity and maintaining sustainable fisheries. We recognized decades ago that fish populations exist in, and interact with, the whole lake ecosystem. Therefore, we need to keep whole ecosystems healthy by recognizing and maintaining the critical components; including water quality, adequate production of forage fish, and habitats necessary for fish to feed, grow, and reproduce. Some species may also be critical components of healthy ecosystems, such as the invertebrate opposum shrimp or the lake trout. If so, we may also need to preserve them and their interactions so that the ecological processes that support our fisheries are maintained.

Biodiversity and Other Useful Concepts

Growing worldwide human population and intensive use of natural resources has led to a pooling of once-separated plants and animals and to an alarming increase in the rate of species extinctions during the twentieth century. Scientists refer to these changes as the loss of biological diversity or biodiversity. At first, **biodiversity** referred primarily to the variety of species, but the concept was soon widened to cover variety at all levels of biological organization, including genes, populations or stocks, species, communities, habitats, and ecosystems.

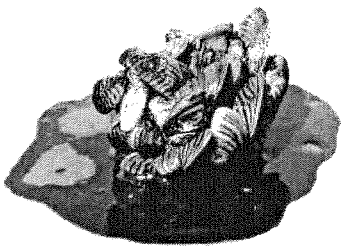
Biodiversity refers to variety at all levels of biological organization, including genes, populations, species, communities, habitats, and ecosystems.

Many scientists limit the concept of biodiversity to genes and species of *native* organisms. Native species are typically the species at risk of disappearing. There are many examples of accidental or purposeful introductions wreaking havoc on the system by directly or indirectly causing the decline of other species in the system and altering habitat. However introduced genes or species might have neutral or even positive effects on host communities. In some cases, the native stocks have been completely eliminated from the Great Lakes. Thus, the only way to restore these species, if desired, is to introduce stocks from different ecosystems. For example, native Atlantic salmon were eliminated in Lake Ontario. Any efforts to restore Atlantic salmon to the lake must therefore rely on non-native stocks.



Picture of Atlantic Salmon from http://www.seagrant.wisc.edu

Other concepts such as ecosystem health, biological integrity, ecological restoration, and ecological rehabilitation express goals of resource management that are related to the concept of biodiversity (Box 1). Biotic communities in which all the native species exist in their characteristic numbers are said to have **biological integrity** and we may manage them so as to maintain native species. Biotic communities in which some native species have been lost or in which non-native species have been introduced may be candidates for **ecological restoration** to a condition of biological integrity. For example, in the Great Lakes ecological restoration would involve exterminating or controlling such non-native species as sea lamprey or zebra mussel and reintroducing the lost native species, such as lake trout.



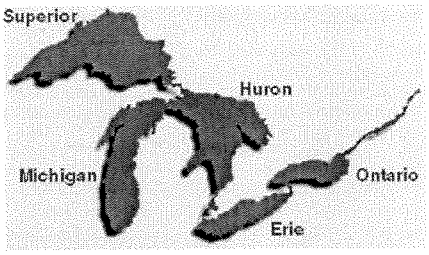
Http://www.great-lakes.net/envt/exotic/zebra.html

Ecological rehabilitation is the process of returning an altered system to a state of health- which may include mixing native and non-native species. Just as human health is indicated by such things as normal temperature and blood pressure, ecosystem health is indicated by such things as long food chains capped by large, long-lived organisms, and complex food webs. The **health of an ecosystem** is not necessarily compromised when one species replaces another, provided that the replacement species performs the same function in the ecosystem. In irreversibly altered ecosystems, in which some native species are globally extinct and some non-native species cannot be eradicated, managers may focus on protecting important ecological processes and functions, instead of protecting or restoring native species.

Box 1. RESOURCE MANAGEMENT CONCEPTS

- **Biological integrity** refers to a naturally structured biological community composed of naturally interacting native species populations in their historic variety and numbers.
- **Ecological restoration** is the process of returning, as nearly as possible, a biological community to a condition of biological integrity.
- **Ecosystem health** is the normal occurrence of such ecological processes as primary production of biomass, energy flow, nutrient cycling, and disturbance regimes.
- **Ecological rehabilitation** is the process of returning an altered ecosystem to a condition of ecological health.
- **Ecosystem management** is the management of ecosystems first and foremost to maintain their health, with commodity extraction as a secondary or ancillary goal.
- **Ecological sustainability** is the use natural resources without compromising the health of ecosystems.

By clarifying and narrowing the interpretations of these concepts, they can be applied more usefully in different settings. In Lake Michigan, many native species and genetically distinct stocks have been lost and many non-native species have been introduced. As a result, the original species composition and structure of the fish community is greatly altered. Therefore, managers may choose to rehabilitate the lake rather than try to restore its biological integrity. In Lake Superior, where the fish community still retains most of its native species and their diverse stocks, the management goal could be biological integrity: protecting and restoring the original composition and structure of the fish community.



picture from http://www.great-lakes.net/places/watsheds/grlakes.html

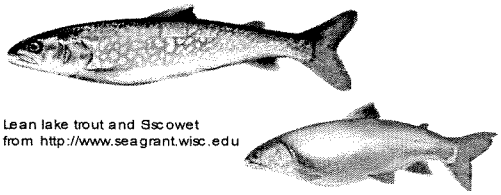
What types of existing policies and initiatives address biological diversity?

Concern about the loss of biodiversity, and the ecological and human implications of this loss have led Great Lakes governmental and non-governmental organizations to develop initiatives to address this issue. Box 2 summarizes several examples of initiatives related to protection of biological diversity. In Michigan, for example, a working committee was created to develop a state-level strategy to conserve biodiversity. The International Joint Commission, a binational organization involving Canada and the U.S., recognized biological diversity as an indicator of ecosystem health and stated that biodiversity was at risk along some shorelines of Lakes Ontario, Erie, and Huron.

BOX 2
Biodiversity Initiatives and Policies from Governmental and Non-governmental Organizations

Organization	Year	Initiative
Federal-provincial-territorial Governments of Canada	1992	Canadian Biodiversity Strategy
Illinois Dept. of Natural Resources	1994	Illinois Critical Assessment Program
Nature Conservancy	1994	The Conservation of Biological Diversity in the Great Lakes Ecosystem
Wisconsin Dept.of Natural Resources	1995	Wisconsin's Biodiversity as a Management Issue
Great Lakes Fishery Commission	1995	The Role of Biodiversity in the Management of the Fishes of the Great Lakes
State of Michigan	1992	Public Act No.59 Biodiversity Conservation Act
International Joint Commission	1996	Eighth Biennial Report stating biodiversity as an indicator of ecosystem health
National Wildlife Federation	1993	Lake Superior Biodiversity Project

Some non-governmental organizations identified key biological resources and threats and examined the scientific, socioeconomic, and political aspects associated with the protection of biodiversity. Input from citizens was incorporated into these initiatives. Various groups, such as Native Americans, First Nations, anglers, industry, commercial fishing interests, and watershed organizations participated in work to restore habitats and native species and to assist in research and assessment.



Lean lake trout and Siscowet
from http://www.seagrant.wisc.edu

Changes in Great Lakes fish communities

Great Lakes fish communities have changed considerably over the years due to several factors which are summarized in Box 3. Twenty-seven of the 52 exotic fish species new to the Great Lakes, developed naturally reproducing populations. To date, 26 fish species and sub-species have been eliminated from one or more of the lakes. These gains and losses have substantially altered the fish community. Each Great Lake has experienced different levels of species gains and losses and are presented in Box 4.

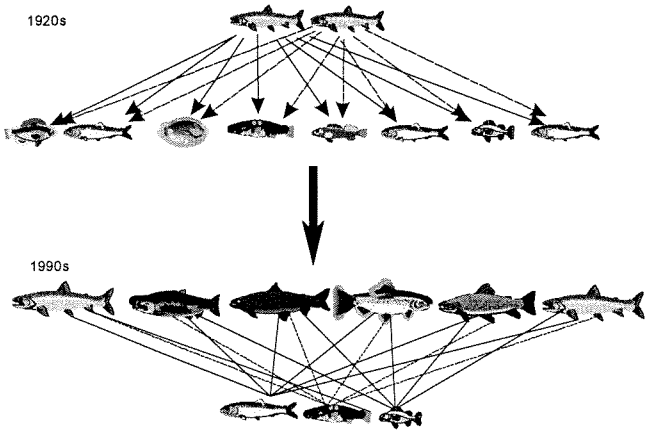
Box 3. FACTORS INFLUENCING BIODIVERSITY

- contaminants
- disease
- exotic species
- fishing
- food web structure
- habitat loss

⇒ future: climate change ?

BOX 4	# of established introduced species and subspecies	# Lost
Nipigon	2 (4.6%)	0
Superior	16 (18.6%)	0
Michigan	21 (16.8%)	11
Huron	18 (15.3%)	9
St. Clair	15 (14.8%)	1
Erie	20 (16.9%)	11
Ontario	11 (10.1%)	15
( )= % of introduced fish of the total established fish in lake		

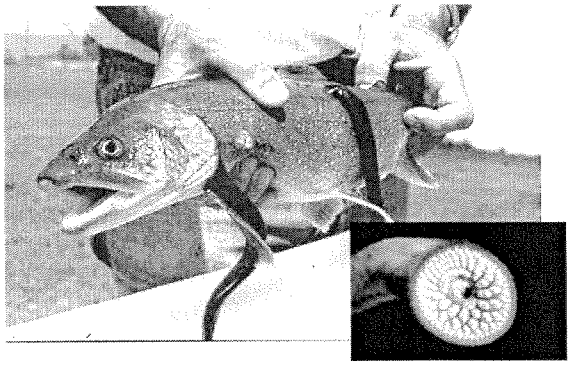
These losses and gains of fish species have led to changes in both the food web and community structure of the Lakes. For example, at the turn of the century the offshore fish community in Lakes Michigan and Ontario had about 20 plankton-eating fish (planktivores) and 2 predatory or fish-eating fish (piscivores). Recently the scales have tipped. Many plankton-eating fish have been eliminated while several new top predators have been introduced.



Along with these changes, top predators currently depend on fewer species of prey fish in the offshore community. Diet studies in the 1920s showed that top predators, such as lake trout and burbot, ate about 8 different types of prey. Currently, top predators eat about 3 different prey species, predominantly the introduced alewife. The fish communities in the nearshore waters of the lakes do not demonstrate these same changes in the food web structure.

What are the effects of these changes?

The number of fish that a lake can produce is limited by several factors, including nutrients. But changes in species composition can influence how many and what types of fish the ecosystem will produce. The loss of several deepwater species, such as deepwater chubs in Lake Michigan, has left deepwater areas devoid of fish. Influential exotics, such as sea lamprey, changed the structure of the communities by drastically reducing large offshore predatory fish (for example, lake trout & burbot) and the larger planktivores (for example, lake whitefish).



Pictures from world-wide web *http://www.greatlakes.net/envt/exotic/lamprey.html*

Changes in the fish community reduces the ability of a lake and its fishes to withstand stress or impacts. Many artificial systems incorporate "engineered redundancy," so that if one component fails, a back-up kicks in. Similar features occur in natural biotic communities and were present in the original fish communities of the Great Lakes. Presently, in Lake Michigan, however, most of the top predators in the offshore community, feed primarily on one forage species- alewife. If alewife populations decline, the top predators have few alternative prey on which to feed - there are no back-ups.

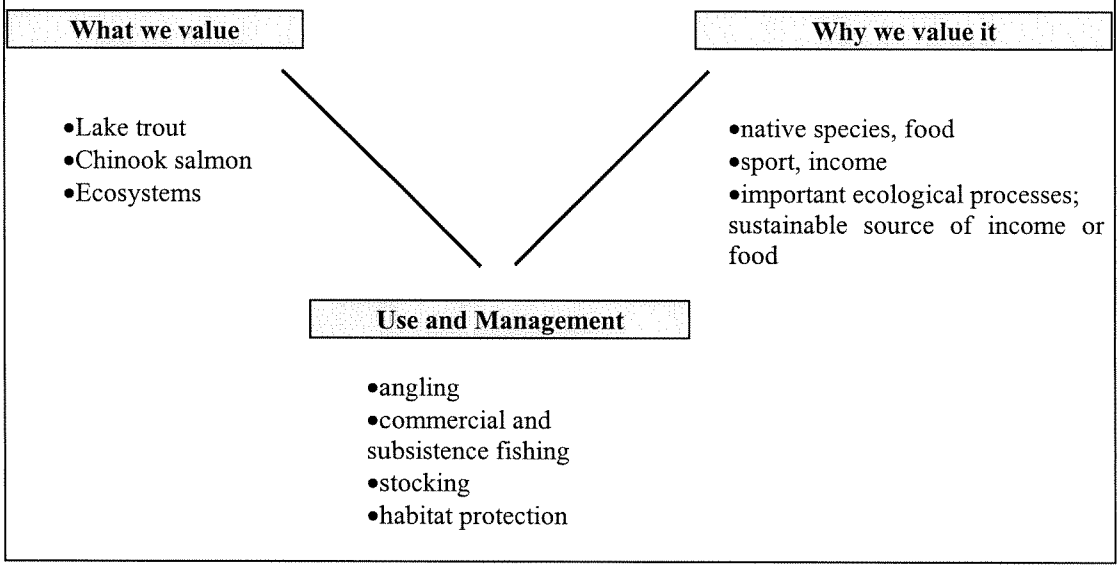
A lake that has diversity at every level in the food web, especially among the forage fish, can sustain fluctuations in one species without causing large changes in the structure of the whole fish community. Unanticipated disturbances, such as unusual weather or an outbreak of an epidemic disease, in lakes with reduced biodiversity may negatively impact the species composition. Maintenance of species diversity is critically important to sustaining a fishery.

Fluctuating biodiversity and its effects make managing a fishery difficult. Anytime a fish community is altered, the conditions and opportunities change for the species living in the system. Fish communities that have reduced biological integrity may be more vulnerable to species invasions. Although new species have been introduced into the Great Lakes for hundreds of years, it has been suggested that the number of successful invasions increased only after the Lake ecosystems had been severely impacted by over fishing, landuse activities, pollution, and other human related activities.

How are human values linked to biodiversity?

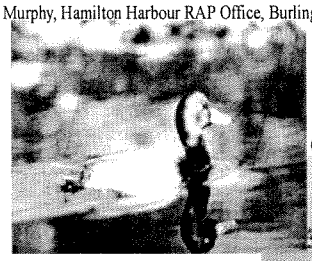
Changes in the way people value the lakes and their fishes have paralleled rapid ecological changes within the Great Lakes. To understand ecological changes, we need to understand the role of human values. Values indicate what is of worth to us and why. For example, lake trout may be of worth because they can be commercially harvested or, because they are a native species. Chinook salmon may be valued because they are challenging to catch and provide income to local communities. Healthy Great Lakes ecosystems may be valued because they will provide sustainable benefits to current and future generations. As reflected in Box 5, what we value and why are linked to how we use and manage the Great Lakes and their fishes.

BOX 5.
An example of the relationship between what we value, why, and how this affects use or management of the Great Lakes and Great Lakes fishes.

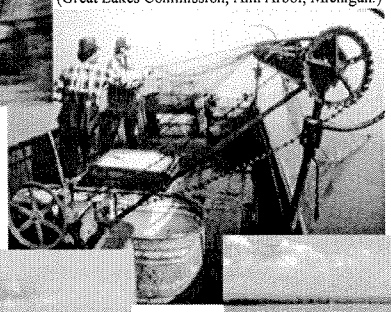


Understanding values is especially important given the diversity and number of governmental and non-governmental organizations involved with the Great Lakes. These various organizations may hold similar or competing values and interests. Identifying values which overlap or converge will aid in development of policies acceptable to a broad range of citizens.

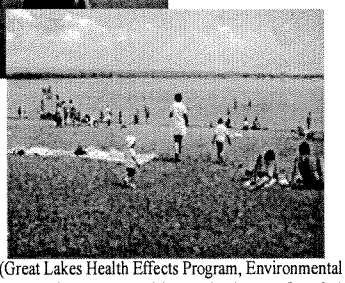
(Harold Murphy, Hamilton Harbour RAP Office, Burlington, Ontario.)



(Great Lakes Commission, Ann Arbor, Michigan.)



(D. Cowell, Geomatics International, Burlington, Ontario.)



(Great Lakes Health Effects Program, Environmental Health Directorate, Health Canada, Ottawa, Ontario.)

We have attempted to classify the variety of values expressed toward the diversity of life in the Great Lakes. For example, the Great Lakes and their fishes are valued materially as a source of food, profits, and jobs. Intangible values are also expressed and include sport or recreation, scientific knowledge gained from study of the Great Lakes plants and animals, and even aesthetic, moral, and spiritual values. Some governmental and non-governmental organizations also express intrinsic values-meaning that the Great Lakes and their fishes or ecosystems are valuable in and of themselves, for their own sakes, and not just because they provide goods or services to people.

The current status of the Great Lakes and its fish community reflects values and actions which have evolved and expanded over many decades. Box 6 summarizes shifting and expanding values and parallel shifts in management over time as expressed in current and historical documents from Great Lakes fishery management agencies. For example, in the 1800s, commercial fish stocks were of prime importance and they were valued as a source of food, jobs, and profits. By the 1960s, what was of value began to expand to include gamefish as well as commercial stocks. By the 1990s, whole fish communities, ecosystems, and watersheds were valued. From the 1960s through the 1990s, the value of the Great Lakes and their fishes expanded to include sport and recreational health benefits, a source of cultural identity and way of life for First Nations and Native Americans, and their intrinsic value.

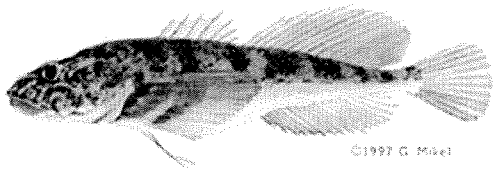
Management goals and actions have also shifted and expanded over time. In the early 1800s, objectives were directed toward propagation of commercial stocks. From the 1960s through the 1990s, they expanded to include stock assessment and yield studies, restoration of native species, introduction of salmonids to control alewife populations and enhance the sport fishery, ecosystem-level management strategies, and watershed management. Cooperative efforts to manage the Great Lakes fisheries with input from various governmental and non-governmental organizations also occurred.

BOX 6
Shifting values and management strategies identified from documents of Great Lakes fishery management agencies.

Era	What is valued	Why it is valued	Management strategy
1800's - 1900's	- commercial fish stocks	- food - jobs - income	- culture and propagation of commercial stocks; - introductions of non-native food fishes
1900's - 1950's	- commercial fish stocks - gamefish	- food - jobs - income - sport - health benefits	- culture and propagation of commercial stocks - management of game fishes; - stock assessment and yield studies
1960's - 1990's	- commercial fish stocks - gamefish - fish communities - ecosystems - watersheds - basin	- food - jobs - income - sport - health benefits - cultural identity & way of life - ecological indicators -intrinsic worth	- stock assessment and yield studies - restoration of native species - introduction of species to control alewife populations and enhance the sportfishery - ecosystem-level strategies to rehabilitate the Great Lakes - protection and improvement of habitat including water quality -management of watersheds and landuse activities - development of cooperative management strategies

Understanding the linkages between societal values and the ecological and management changes in the Great Lakes will be crucial to the long-term protection of Great Lakes biological diversity. Understanding contemporary values may provide the insight needed to develop policies and management approaches which meet the various interests and needs of those in the Great Lakes region. Understanding both current and historical values may also help in developing strategies which will meet future challenges.

A Final Challenge



To date the most predictable feature of Great Lakes ecosystems is that they are unpredictable. Great Lakes social systems are equally complex involving a wide variety of citizens and governmental and non-governmental organizations with diverse and changing values. Currently, the sustainability of some Great Lakes fish populations appears questionable. Other populations have improved only with the help of intensive management actions, such as sea lamprey control. Our challenge for the future is to develop a management strategy that can address the diversity and dynamics of both natural and social systems and can help us respond to change and the challenges of the future.

"To keep every cog and wheel is the first precaution of intelligent tinkering"
-Aldo Leopold

For further information on:
Conservation Concepts and Values
Species Changes
Ecological Implications of Changes

Contact:
Baird Callicott and Karen Mumford
Ed Crossman and Becky Cudmore
Larry Crowder and Lisa Eby