Research, Assessment, and Data Needs to Promote Protection of Great Lakes Nearshore Fisheries Habitat

Prepared by:

Reuben R. Goforth, Ph.D. and Stephanie M. Carman

Michigan Natural Features Inventory
Michigan State University Extension
Stevens T. Mason Building, P.O. Box 30444
Lansing, MI 48909
(517) 373-1552

MNFI Report No. 2003-11

MICHIGAN STATE UNIVERSITY EXTENSION

Great Lakes Fishery Trust

Michigan Natural Features Inventory

Research, Assessment, and Data Needs to Promote Protection of Great Lakes Nearshore Fisheries Habitat

Lake Michigan Center, Grand Valley State University
Muskegon, Michigan
April 1-2, 2003

Prepared by:
Reuben R. Goforth, Ph.D. and Stephanie M. Carman
Michigan Natural Features Inventory
Michigan State University Extension
Stevens T. Mason Building, P.O. Box 30444
Lansing, MI 48909

Sponsored By:

Great Lakes Fishery Trust

May 2003

MNFI Report No. 2003-11

MICHIGAN STATE UNIVERSITY EXTENSION

Michigan Natural Features Inventory

Table of Contents

List of Figures

List of Tables

Executive Summary

Lake Michigan low bluff shoreline near Two Rivers, Wisconsin. Nearshore substrates are dominated by sand, cobbles, and clay. Photo by Reuben Goforth.

A Great Lakes nearshore fisheries habitat workshop was held on April 1-2, 2003, at the Grand Valley State University Lake Michigan Center in Muskegon, Michigan. This workshop, funded by the Great Lakes Fishery Trust (GLFT), sought to identify research, assessment, and data management needs to promote the protection and restoration of Great Lakes nearshore fisheries habitats. The two-day workshop was comprised of one day for contributed presentations by participants and a second day of facilitated breakout group discussions. The overall goal of this workshop was to identify research priorities for funding organizations based on information gaps that currently impede efforts to evaluate, manage, and protect nearshore fishery habitats in the Great Lakes. To achieve this goal, 50 Great Lakes fisheries experts from multiple agencies, academic institutions, and non-governmental organizations discussed the following topics in four one-hour working group sessions:

- ***What are the most critical current and future threats and impediments to assessing, managing, protecting, and restoring Great Lakes nearshore fisheries habitat?***
- ***What are the most critical data/information and research needs required to facilitate the assessment, management, protection, and restoration of Great Lakes nearshore fisheries habitat?***
- ***What are the most appropriate software and storage methods and sampling gears/protocols for assessing, managing, protecting, and restoring Great Lakes nearshore fisheries habitat?***
- ***What are the most critical funding priorities and partnerships that exist or need to be created to effectively assess, manage, protect, and restore Great Lakes nearshore fisheries habitat?***

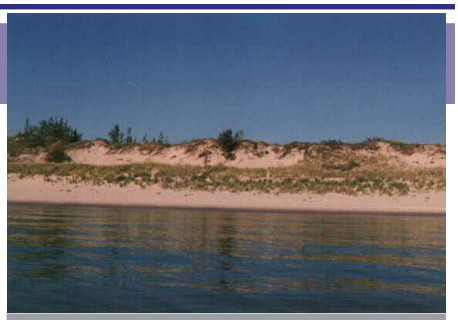
Based on the results of the facilitated discussions, the greatest impediments to Great Lakes nearshore fisheries habitat assessment, management, protection, and restoration are impacts associated with human activities and insufficient ecological understanding of the role of nearshore habitats in fisheries production. While many funding organizations currently have protection and restoration as a funding emphasis, resource experts generally agree that there is insufficient knowledge regarding the availability, condition, function, and dynamics of Great Lakes nearshore habitats to effectively prioritize and evaluate success for protection and restoration targets. As a result, working groups identified several research priorities for funding in the near future, including:

- ***Studies of nearshore ecological function and dynamics***
- ***Determination of the distribution and condition of critical fisheries habitats in nearshore areas***
- ***Determination of appropriate spatiotemporal scales for data collection and resource management***
- ***Development of a nearshore habitat classification system***
- ***Comprehensive mapping of nearshore fisheries habitats***

In order to maximize data distribution and collaboration among diverse members of the Great Lakes fisheries community, widely accepted data standards and a web-based metadata clearinghouse that directs potential data users to data sources throughout the basin need to be created and managed by a central organization.

Diverse threats and knowledge gaps impede effective management and protection of nearshore fisheries habitats. However, by addressing the research priorities and data needs reported in the workshop, these impediments should become diminished. This will enhance efforts by agencies, tribal interests, academia, and conservation organizations to work together to make effective resource decisions that will insure the long-term viability of Great Lakes fisheries.

Introduction



Lake Michigan dune shoreline near Ludington, Michigan. Substrates of adjacent nearshore areas consist of extensive, thick sand sheets. Photo by David Stagliano.

Human beings have dramatically altered the Great Lakes Basin through extensive agricultural practices, construction and maintenance of single family residences, extensive urban development, industrial activities, and commercial navigation (Edsall 1996). The nearshore zone of the Great Lakes, in particular, has been severely impacted by chemical pollution and organic enrichment resulting from intense industrialization and urbanization (Krieger 1984). This is of great concern because nearshore areas factor significantly in the life history of most Great Lakes fishes. For example, more than 75% of Great Lakes fish species' young-of-the-year and approximately 65% of fish species adults use gravel, sand, or silt substrates in nearshore areas (Lane et al. 1996a, Lane et al. 1996b). Despite the importance of nearshore habitats to Great Lakes fisheries, relatively little attention has been given to the study, management, protection, and restoration of these areas until very recently. While we have not yet realized all of the linkages that exist between nearshore habitat alteration and fisheries production, there is no question that these connections exist and may have serious implications for the sustainability of Great Lakes fisheries. We can therefore expect that nearshore fisheries habitat protection and restoration will be required to insure the long-term sustainability of Great Lakes fisheries.

Nearshore ecosystems in the Great Lakes have been poorly studied historically, likely due to the logistical difficulties involved in conducting surveys and a general perception of these areas as "wet deserts" that support few organisms of interest. Therefore, responses of fish and associated biological communities to natural and human induced environmental changes in nearshore areas are generally not well understood. Large knowledge gaps exist, such as the types of associations that exist between fish species and critical habitats, whether Great Lakes fish species and communities are habitat limited, and the roles of spatiotemporal dynamics in determining the availability, stability, and resilience of critical nearshore fisheries habitats. With such formidable obstacles in place, it is difficult to effectively conduct assessments, set management goals, facilitate protection, and prioritize restoration targets for Great Lakes nearshore fisheries habitats. We are only now recognizing the critical roles that nearshore areas play in Great Lakes fishery production, and there is great urgency to initiate the protection and restoration of significant fisheries habitats.

There have been a few studies that have demonstrated linkages between human-induced environmental changes and fisheries of the Great Lakes. For example, increased sedimentation and nutrient enrichment in the Great Lakes have led to spawning habitat loss (e.g., Edsall and Kennedy 1995) and shifts in biological community structure, respectively (e.g., Johnson and Brinkhurst 1971). Direct alterations of shorelines also influence fish populations. For example, shoreline hardening to prevent natural erosion processes alters nearshore littoral transport of materials, eliminates nearshore migration as Great Lakes water levels change, and reduces aquatic habitat diversity (SOLEC 1996). In addition, straightened shorelines lose irregularities in shoreline structure that drive variation in alongshore currents and cause local variation in substrates (SOLEC 1996). While these physical processes and changes are known to exist, responses of Great Lakes fishes to these changes and resulting changes in fisheries production are still poorly known. Given the importance of nearshore areas to Great Lakes fish and associated biological communities, changes in habitat and community structure could have dramatic effects on Great Lakes fisheries production over time.

Yellow Perch, *Perca flavescens*. Photo by Konrad Schmidt.

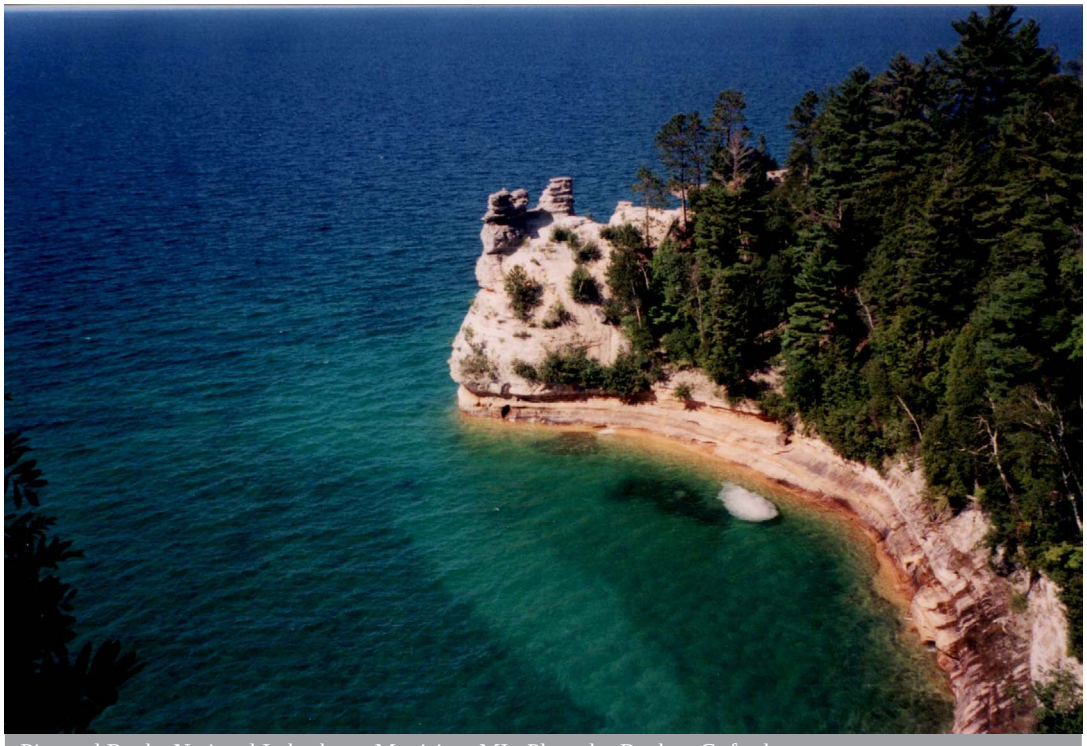
Continued habitat loss and an inability to prioritize the most significant nearshore habitats for protection and restoration loom large as significant threats and impediments to Great Lakes fisheries. At

the same time, significant information gaps and insufficient ecological understanding also impede efforts to identify, assess, and inventory critical Great Lakes nearshore fisheries habitats. It is therefore crucial to pinpoint the specific impediments, threats, and information gaps that exist currently, or that may be significant in the future, so that timely, appropriate research goals and strategies can be developed to fill information gaps and minimize obstacles.

Realizing varied research goals will only benefit fisheries resources if the resulting data is compatible among projects and can be synthesized and incorporated into management strategies from a holistic perspective. Data dissemination and communication are significant components of this process. Thus , an appropriate data storage framework needs to be created to promote wide distribution of data and collaboration among Great Lakes experts. Nearshore fisheries habitats can only be better understood, managed, protected, and restored by prioritizing research needs, conducting appropriate studies, and creating a complementary, widely usable data storage structure that promotes wide collaboration among Great Lakes fisheries experts.

While grantors, such as the Great Lakes Fishery Trust (GLFT), have the capacity to provide funding to support such efforts, prioritization of research needs and identification of an appropriate data structure can only be determined by the community of agency personnel, academics, tribal governments, conservationists, and other Great Lakes interests that posseses the necessary on-the-ground experience and expertise in Great Lakes fishery science. Great Lakes fisheries expertise is distributed over a wide geographic area that encompasses eight U.S. states (Pennsylvania, Minnesota, Wisconsin, Illinois, Indiana, Michigan, Ohio, and New York) and one Canadian province (Ontario). Great Lakes nearshore habitat is also a relatively recent focus in Great Lakes science and management. Therefore, the best approach to effectively identify information gaps, research priorities, and obstacles to overcome is to convene a workshop during which experts can gather to contribute, discuss, debate, and prioritize issues related to nearshore fisheries habitat.

The mission of the GLFT is to provide funding to enhance, protect, and rehabilitate Great Lakes fisheries. Within the purview of this mission, the GLFT provided funding to support a workshop to identify research, assessment, and data needs to promote the management, protection, and restoration of Great Lakes fisheries habitats. This document provides the results of this workshop, held on April 1-2, 2003, at the Grand Valley State University Lake Michigan Center in Muskegon, Michigan.



Pictured Rocks National Lakeshore, Munising, MI. Photo by Reuben Goforth.

Workshop Organization, Goals, and Objectives

Planning for this workshop evolved from discussions between Dr. Reuben Goforth (Aquatic Ecology Program Leader, Michigan Natural Features Inventory) and Jack Bails (GLFT Manager) regarding the need for greater understanding of Great Lakes nearshore habitats. Dr. Goforth worked with Mark Coscarelli (Assistant GLFT Manager) to devise a workplan for a workshop to be approved by the GLFT's Science Advisory Team (SAT). A seven-member steering committee was formed, including Sharon Hanshue (Michigan Department of Natural Resources, Fisheries Division), Archie Martell (Little River Band of Ottawa Indians), Karen Rodriguez (U.S. Environmental Protection Agency, Great Lakes National Program Office), Dr. Tom Coon (Michigan State University), Mark Holey (U.S. Fish and Wildlife Service), Mark Coscarelli, and Dr. Reuben Goforth. The steering committee developed a set of goals and objectives, a workshop agenda, and a time and place for the workshop to be held. Based on steering committee recommendations, Michigan Natural Features Inventory (MNFI) aquatic ecology staff members organized and facilitated the workshop by completing the following tasks:

1) Compiling a comprehensive list of Great Lakes experts to be invited to participate in a pre-workshop survey and the workshop
2) Compiling a comprehensive Great Lakes nearshore fisheries habitat bibliography to be distributed to workshop participants and included in the workshop proceedings
3) Developing, administering, and synthesizing the results of a pre-workshop survey to identify the most critical issues to be included in the workshop discussions
4) Identifying and securing a venue for conducting the workshop
5) Synthesizing the workshop results and publishing a proceedings to capture and present these results to a wide audience of Great Lakes interests, including grantors seeking guidance in identifying Great Lakes funding priorities
6) Presenting the results of the workshop within a professional forum, the inaugural conference on coastal and estuarine restoration, Saving Our Coastal Heritage, in Baltimore, MD.

The central goal of the workshop was to identify information gaps that currently impede efforts to evaluate, manage, and protect nearshore fishery habitats in the Great Lakes. A set of objectives was developed to meet this goal, including:

1) Identify impediments to nearshore fisheries habitat assessment, management, and protection
2) Identify existing and potential threats to nearshore fisheries habitat integrity
3) Identify the range of nearshore fisheries habitat information and research needs for protection and management of these resources
4) Identify the most efficient ways to gather, store, distribute, and manage fishery habitat information for use among agencies, organizations, public and private interests, and the research community
5) Identify data needs and protocols for monitoring and mapping nearshore fisheries habitats
6) Identify existing methodologies for describing and conducting studies of Great Lakes nearshore habitats; identify gaps in methodologies and seek new technologies to help fill those gaps
7) Identify partnerships among researchers, agency personnel, managers, and public/private interests that integrate diverse expertise to develop innovative approaches for the study, management and protection of Great Lakes nearshore habitats
8) Produce a workshop proceedings for the Great Lakes research community that will inform and guide future funding decisions.

The workshop was conceived as a two-day effort, with a first day of contributed oral and poster presentations by workshop participants and a second day of facilitated workgroup discussions. Specific topics for these discussions were based on survey responses. Four one-hour working group sessions allowed Great Lakes experts to discuss and prioritize issues related to nearshore fisheries habitats. Random assignment of participants to groups for each working session insured that discussion groups would represent diverse areas of expertise and that the participants would have the opportunity to interact with as many different colleagues as possible.

Following completion of the workshop, MNFI aquatic ecology staff reviewed group discussion notes and synthesized these notes for presentation in a published proceedings. In addition to GLFT SAT members, trustees, and staff members, the proceedings were distributed to participants of the workshop, other Great Lakes funding organizations, and other interested parties.

Survey Response

The pre-workshop survey was broadly offered to potential respondents via both personal mailings and Internet postings. Thus, it was considered to be an open survey with an undetermined total number of potential respondents. Twenty-nine Great Lakes professionals provided feedback, including representatives from a wide range of backgrounds and interests. Most respondents were associated with federal agencies (USA and Canada), state/provincial governments, and academia (Figure 1a). Only one representative each from tribal governments and non-profit organizations responded.

The primary habitat focus of respondents was largely associated with Great Lakes coastal wetlands, Great Lakes nearshore areas, or a combination of both general habitat types. A few respondents also indicated Great Lakes Basin tributary rivers and offshore waters as their primary focus areas.

The primary research and/or management interests of survey respondents were highly varied and comprised 15 main categories (Figure 1b). The most common interests were associated with spawning habitat, habitat restoration, fish movements, fish population dynamics, land use change, trophic interactions, conservation activities, and exotic species biology and ecology (Figure 1b), although no research/management class was especially well-represented in the pool of respondents.

Principal fish species of interest to survey respondents also covered a relatively wide range, although several groups did emerge as more common foci (Figure 1c). Walleye, salmonids, yellow perch, and non-game fish in general emerged as the most common foci among survey respondents (Figure 1c). Other fish species/groups that were indicated as foci for respondents included alewife, channel catfish, smallmouth bass, pikes and pickerels, whitefish, and lake sturgeon.

Because survey participants represented a wide range of expertise, they generally did not provide responses to all survey questions. Hence, the number of respondents to specific issues was quite variable, ranging from nearly all survey respondents to about 60 percent of all survey respondents. Regardless, the level of response across all survey questions was sufficient to provide a good scope of the issues related to the assessment, management, protection, and restoration of Great Lakes nearshore fisheries habitat.

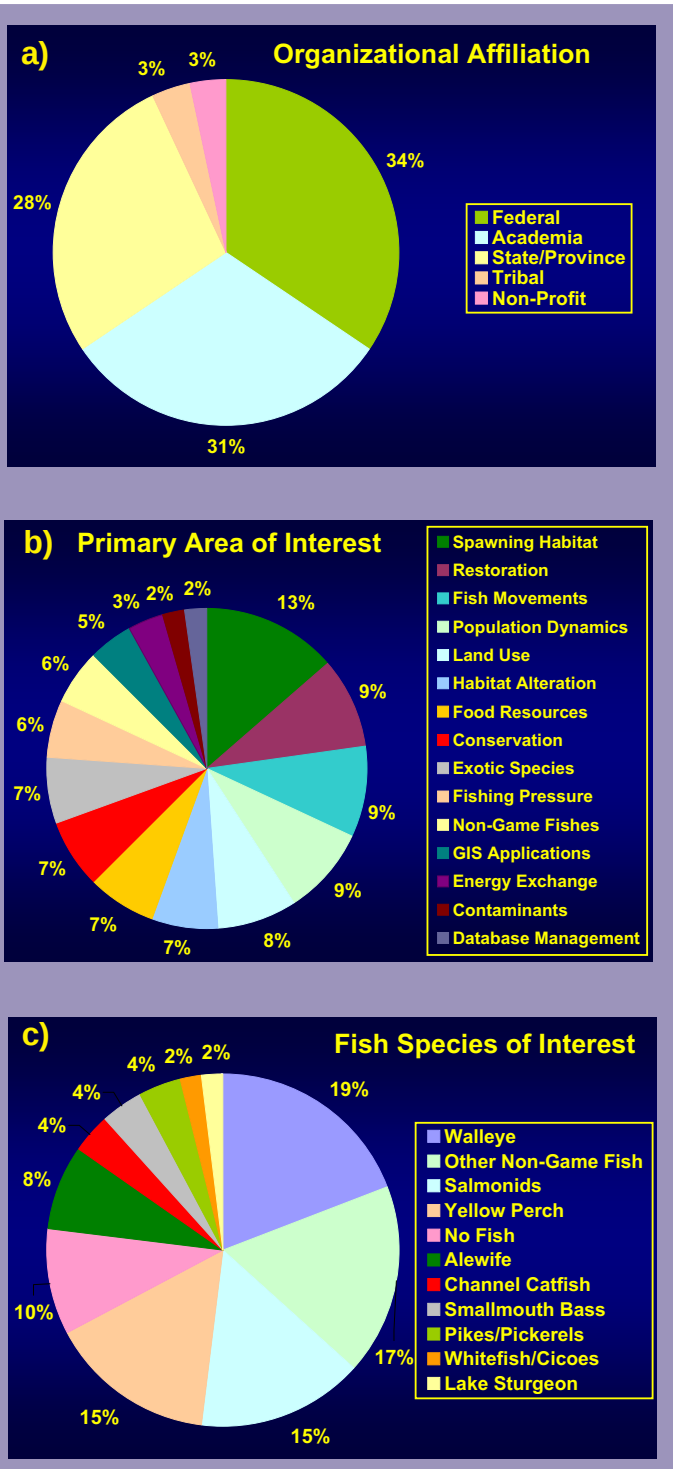


Figure 1. Organizational associations (a), primary research/managment interests (b), and primary fish species of interest (c) for the 29 respondents to the pre-workshop survey.

Pre-Workshop Survey Results

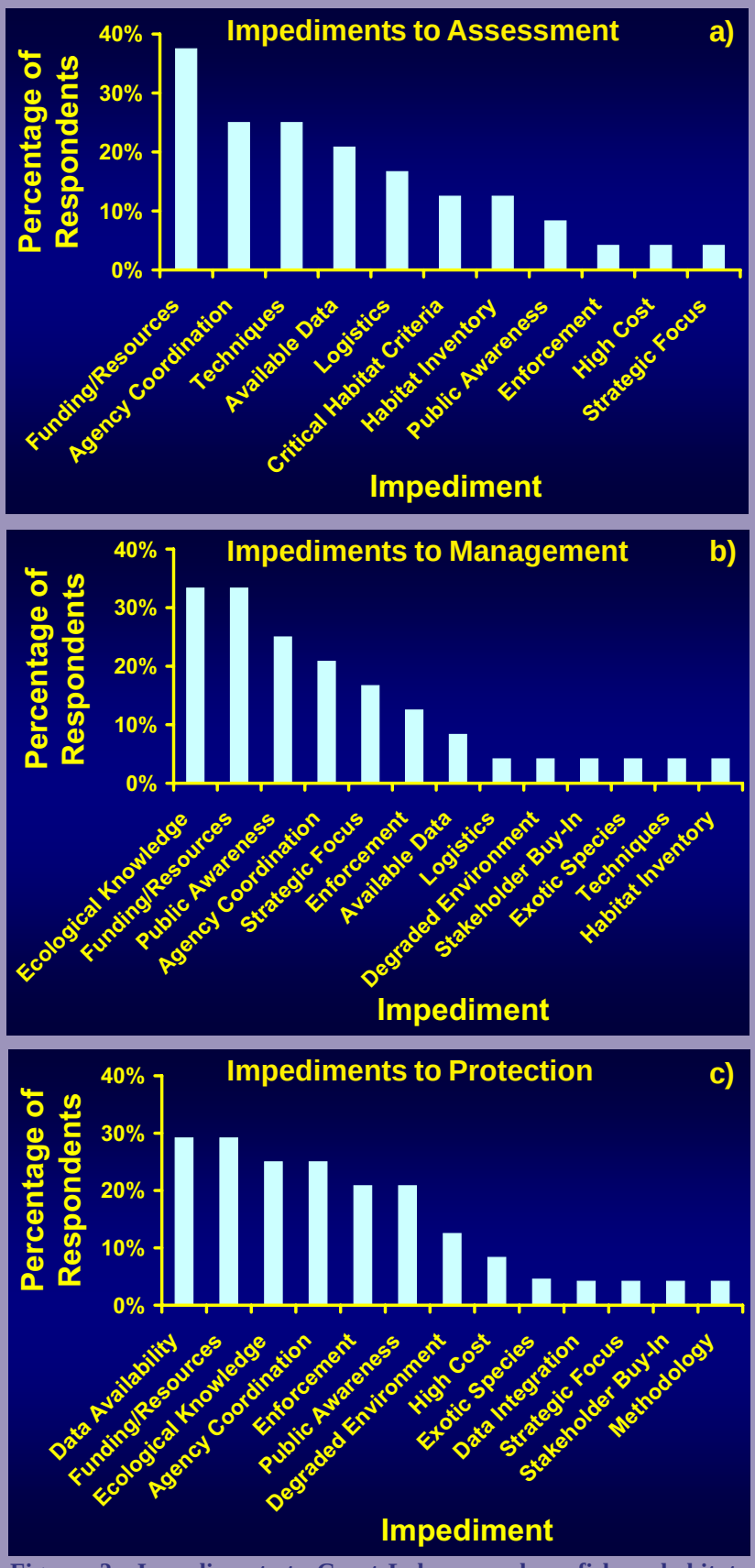


Figure 2. Impediments to Great Lakes nearshore fishery habitat assessment (a), management (b), and restoration and protection (c) identified by 24 pre-workshop survey respondents.

Impediments to Habitat Management, Assessment, Protection, and Restoration

Survey respondents identified a wide range of impediments to Great Lakes nearshore fishery habitat assessment, management, and restoration and protection. Several classes of impediments were common to all three, including insufficient funding, limited agency coordination, limited data, insufficient regulatory oversight, no strategic focus, and low public awareness and support (Figure 2).

Insufficient funding, limited agency coordination, lack of assessment techniques, limited data, and difficult logistics of working in nearshore areas were the most commonly indentified impediments to nearshore fisheries habitat assessement (Figure 2a). Other classes of impediments to assessment included limited understanding of critical habitats, absence of habitat inventory, limited public support, insufficient regulatory enforcement, high cost of assessments, and a lack of strategic focus.

Insufficient ecological understanding, limited funding and resources, limited public interest, and poor agency coordination were the most prevalent impediments to nearshore fisheries management identified in the survey (Figure 2b). Other notable impediments to management included a lack of strategic focus, insufficient regulatory enforcement, and a lack of data to support the development of management strategies.

The most commonly identified impediments to Great Lakes nearshore fisheries habitat protection and restoration included limited data availability, insufficient funding and resources, insufficient ecological understanding, poor agency coordination, limited regulatory enforcement, and low public awareness (Figure 2c). Environmental degradation, exotic species, and high cost of restoration/protection were other notable impediments identified in the survey.

A particularly notable result is the disconnect between the high levels of available funding to conduct restoration despite Great Lakes experts' strongly expressed need for funding to support habitat research and assessment. Such assessments are critical for effectively identifying and prioritizing targets for protection and restoration. Increased availability of funding to develop assessment techniques and to conduct habitat assessments and inventories would help to bridge this gap and would enhance efforts to prioritize the most critical nearshore fisheries habitats for protection and/or restoration.

Existing and Future Threats to Great Lakes Nearshore Fisheries Habitats

Nearly all of the 26 survey participants who identified current and future threats to Great Lakes nearshore fisheries habitats indicated that environmental degradation is and will continue to be the greatest threat to these habitats (Figure 3). With regard to general classes of current threats, the survey participants indicated very strongly that environmental degradation is the most critical threat to nearshore habitats, although 35 percent of participants also identified exotic species introductions and influences on the Great Lakes ecosystem as a significant threat (Figure 3a). Other general classes of current threats identified were poor regulatory oversight, low public awareness and appreciation, and global climate change.

Many specific types of environmental degradation considered as significant current threats to nearshore fisheries habitat were identified by survey respondents (Figure 3b). The most prevalent type of environmental degradation reported by survey participants was development (62 percent of respondents), including residential, recreational, commercial and industrial development of Great Lakes coastal areas. The next most frequently identified types of environmental degradation were general pollution (23 percent of respondents), nonpoint source pollution (19 percent of respondents),

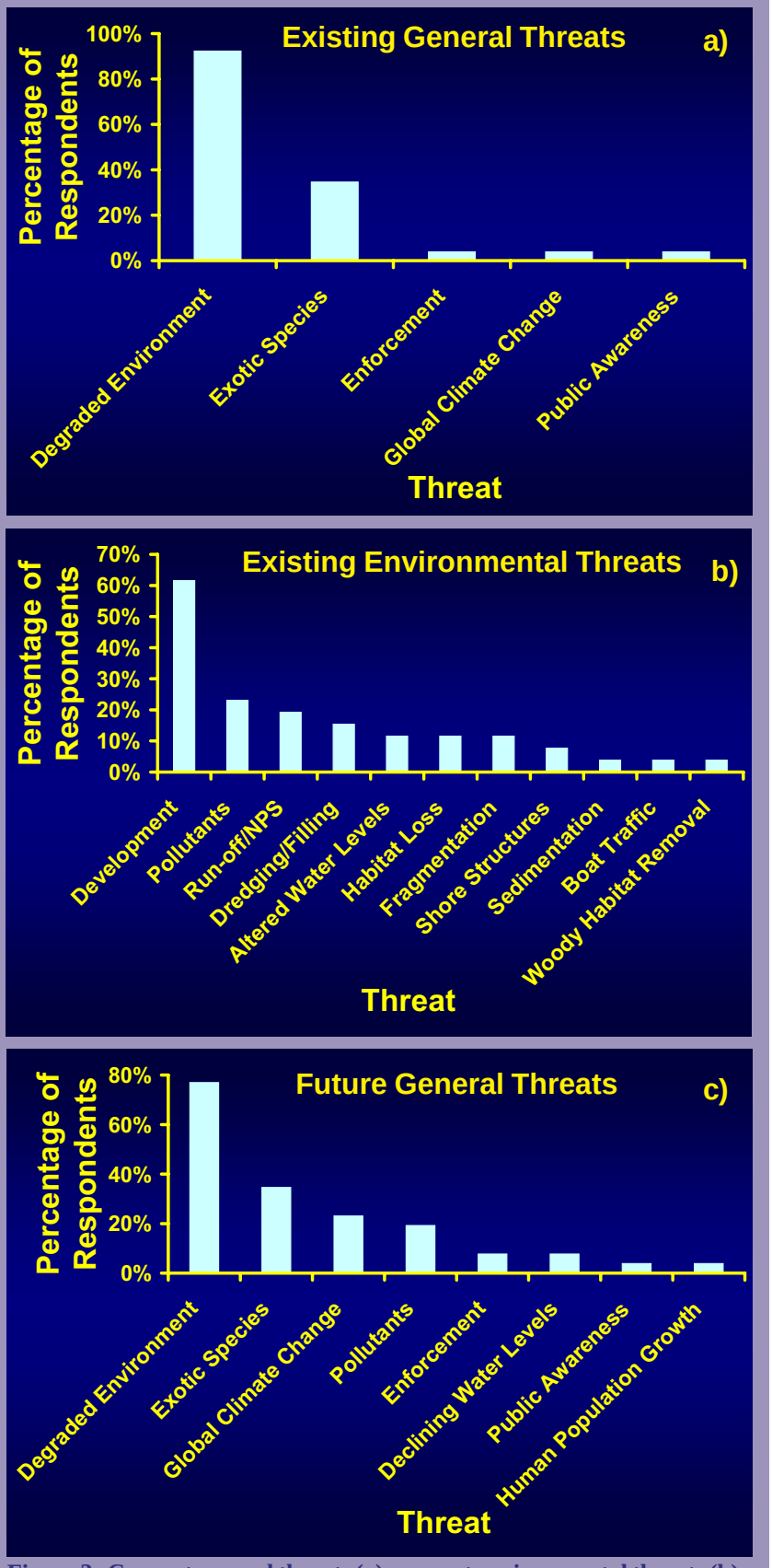
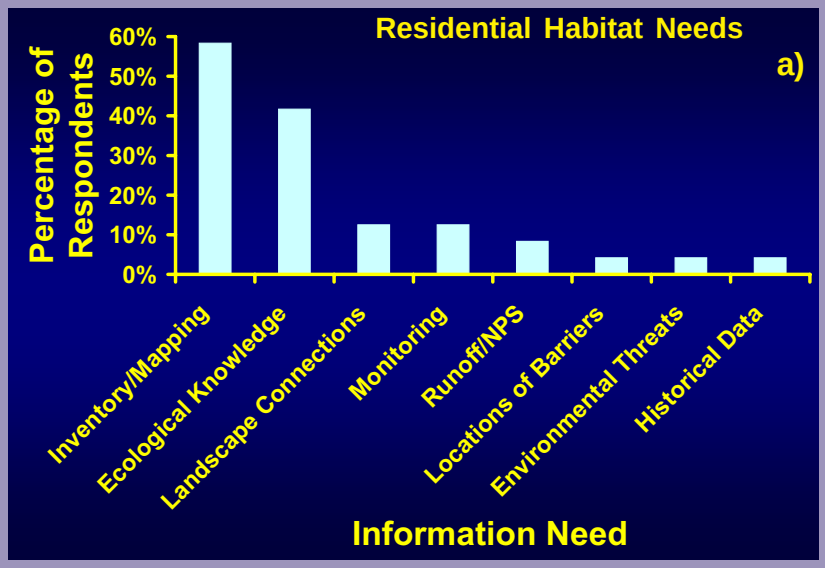
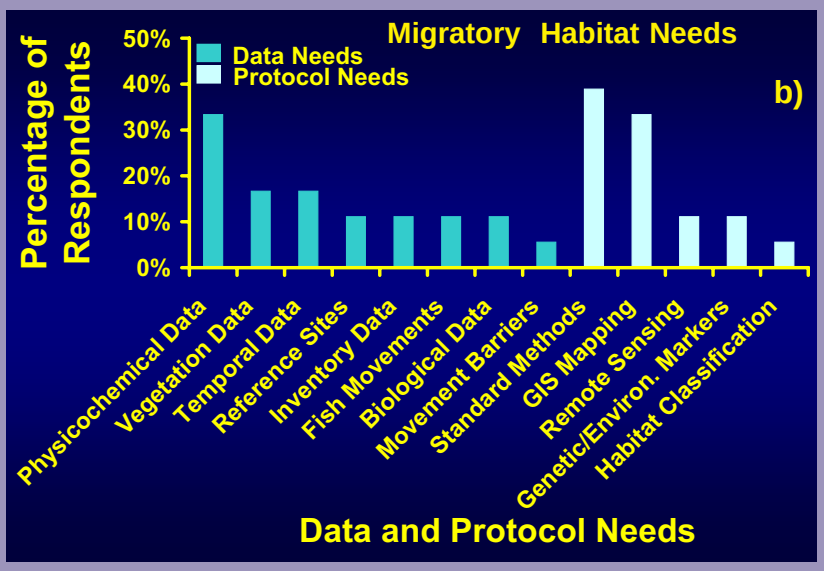


Figure 3. Current general threats (a), current environmental threats (b), and future general threats (c) to nearshore fisheries habitats identified in the pre-workshop survey.

Pre-Workshop Survey Results





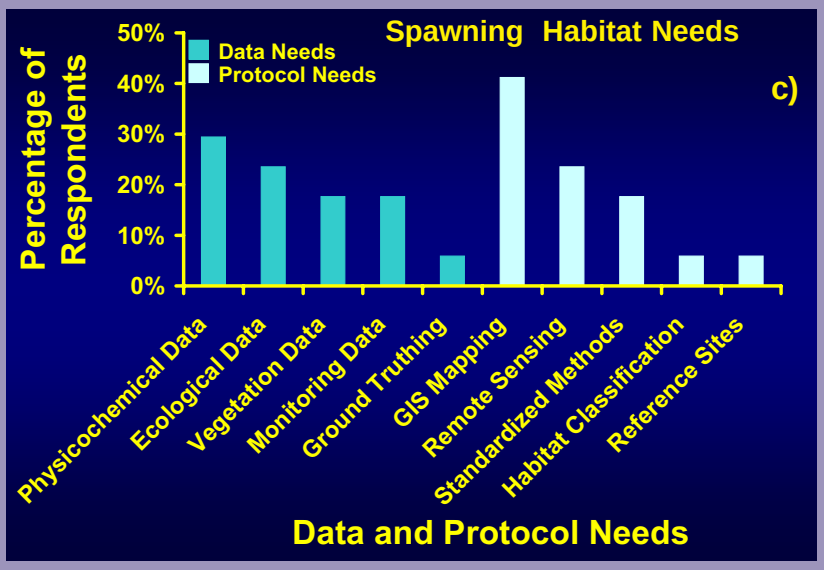


Figure 4. Habitat information and protocol development needs for nearshore residential (a), migratory (b), and spawning (c) fisheries habitats identified by 26 participants in the pre-workshop survey.

and dredging and filling activities in nearshore areas, wetlands, and drowned river mouths (15 precent of respondents). Other, less commonly reported types of environmental degradation reported in the survey are provided in Figure 2b.

Environmental degradation was the most prevalent future threat to nearshore fisheries habitat reported in the survey (77 percent of respondents) (Figure 3c). Introductions and influences of exotic species (35 percent of respondents), global climate change (23 percent), and pollutants (19 percent) were also identified as significant future threats to Great Lakes nearshore fisheries habitats. Other threats, including insufficient regulatory enforcement, declining water levels, low public awareness and support, and human population growth, were also identified by survey participants.

Habitat Information Needs for Great Lakes Nearshore Fisheries Habitats

Habitat inventory and mapping, as well as developing a better ecological understanding of Great Lakes nearshore areas, were the most prevalent habitat information needs identified in the survey (58 percent and 42 percent of respondents, respectively) (Figure 4a). Identifying landscape connections among terrestrial, nearshore, off-shore, and tributary habitats; establishing habitat monitoring programs; and identifying patterns and influences of nonpoint source pollutants were among the other information needs identified by survey respondents.

For migratory fish habitats, the most prominently identified information needs were collection of physicochemical habitat, aquatic vegetation, and temporally continuous data (33 percent, 17 percent, and 17 percent of respondents, respectively) (Figure 4b). Collection of data for reference sites, fish movement data, and habitat inventory data were also considered important needs by survey respondents. Respondents considered the development of

standardized methods for nearshore habitat measurement and increased integration of GIS mapping in management and studies of nearshore habitats to be the most critical protocol needs for migratory fish nearshore habitats (39 percent and 33 percent of respondents, respectively) (Figure 4b). Further development of remote sensing techniques, methods for using environmental and genetic tracers in fish movement studies, and fisheries habitat classifications were also reported as important protocol needs relative to Great Lakes migratory fish work in nearshore areas.

The most commonly reported data needs for nearshore fish spawning habitats were physicochemical habitat data (29 percent of respondents), general ecological data (24 percent of respondents), monitoring data (18 percent of respondents), and vegetation data (18 percent of respondents) (Figure 4c). Ground truthing of remotely sensed data was also reported as an important data need for nearshore fisheries habitats. Development of approaches to enhance GIS mapping (41 percent of respondents), the use of remote sensing technology (24 percent of respondents), and the standardization of data collection (18 percent of respondents) were the most frequently reported protocol needs relative to nearshore spawning habitats (Figure 4c). Protocols for nearshore habitat classification and development of criteria for nearshore habitat reference conditions were also considered to be important for effective spawning habitat management, assessment, and protection.

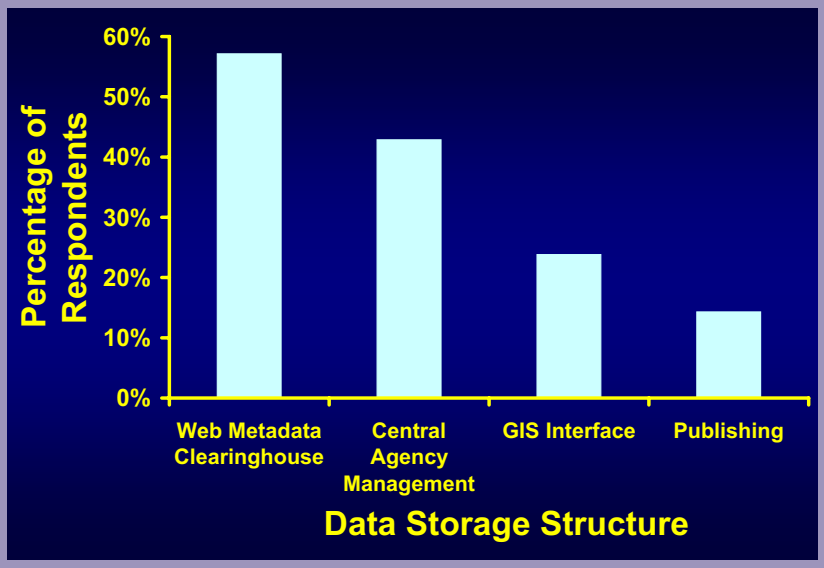


Figure 5. Possible data structures for making Great Lakes nearshore fisheries habitat available to a wide range of users, including agency personnel, academicians, conservation organizations, and other relevant professional groups. Ideas for potential data storage structures were recorded by 24 participants in the pre-workshop survey.

Data Storage and Management for Nearshore Fisheries Habitats

Many survey participants agreed that developing a metadata web clearinghouse for nearshore fisheries habitat data would be the best platform for promoting collaborative data use among Great Lakes experts (57 percent of respondents) (Figure 5). A metadata web clearinghouse would provide information regarding the types of data that are available throughout the basin, including information on the source of the data. This structure would direct potential data users to data sources so that end users can seek access to relevant data from originators of the data. Housing and managing data within a central agency was also a commonly reported structure for providing data to a wide variety of user (43 percent of respondents. Additional ideas for making nearshore fisheries habitat data available to a wide audience included incorporating the data into a GIS format interfaced with the Internet and publication of data in professional journals and technical reports.

Boulder and cobble substrates in the nearshore area of northern Lake Michigan near Manistique, Michigan. Nearly all substrates are densely covered with *Dreissena* sp. Photo by Reuben Goforth.

Workshop Agenda

Grand Valley State University
Lake Michigan Center
Photo Courtesy of Annis Water Resources Institute

Tuesday, April 1

8:30 Registration
Grand Valley State University, Lake Michigan Center

9:00 Welcome and Introduction
Reuben Goforth, Michigan Natural Features Inventory
Mark Coscarelli, Great Lakes Fishery Trust

9:30 Contributed Presentations
John Gannon, International Joint Commission – Linking Habitat Science and Policy: Habitat Issues in the Great Lakes Areas of Concern
Scudder Mackey, Great Lakes Protection Fund – A Conceptual Framework for Nearshore and Coastal Habitats

10:15 Break (refreshments provided)

10:30 Contributed Presentations
Reuben Goforth, Michigan Natural Features Inventory – Resource Values of Great Lakes Nearshore Areas and the Critical Need for their Protection
Neville Ward, Fisheries and Oceans Canada - Expanding Nearshore Fisheries Habitat into Great Lakes Tributaries
Scudder Mackey, Great Lakes Protection Fund – Nearshore Habitat Dynamics
Stephanie Carman, Michigan Natural Features Inventory – Associations between Great Lakes Nearshore Communities and Habitats Influenced by Varied Levels of Shoreline Development

12:00 Lunch (provided)

1:30 Contributed Presentations
Jacqueline Savino, U.S. Geological Survey, Great Lakes Science Center - Nearshore Community Interactions in the West-Central Basin of Lake Erie
Don Uzarski, Grand Valley State University - Fish Habitat Use within and Across Wetland Classes Coastal Wetlands of the Five Great Lakes
Edward Roseman, Michigan State University – Spatial Patterns Emphasize the Importance of Coastal Zones as Nursery Areas for Larval Walleye in Western Lake Erie
Paul Webb, University of Michigan Biological Station – Correlations between Development of Coastal Marsh Fish Communities in Les Cheneaux in the Eastern Upper Peninsula of Michigan

3:00 Break (refreshments provided)

3:20 Contributed Presentations
Sandra Morrison, U.S. Geological Survey, Great Lakes Science Center – Great Lakes Coastal Aquatic Gap Analysis: Preserving Biodiversity in the Great Lakes Basin
Paul Nichol, Ecosystems - Efficient Ways to Gather, Store, Distribute and Manage Fishery Habitat Information for use Among Multiple Agencies, Organizations, Public and Private Interests, and the Research Community

4:20 Summary of Workshop Survey Results

4:45 Poster Session Overview

Tuesday, April 1 (*Cont.*)

6:00 Poster Session and Fish Fry Dinner at Holiday Inn

Great Lakes Coastal Aquatic Gap Analysis - K. Kowalski, S. Morrison, J. McKenna, D. Passino-Reader, C. Castiglione

High-resolution Multibeam Sonar Mapping of Gooseberry Reef, Lake Superior: Its Role in Characterizing Lake Trout Spawning Areas – N. Wattrus

Lake Michigan Rocky Habitat: Always Important, Seldom Studied – J. Janssen, S. Lozano, M. Berg, D. Jude, J. Dettmers

A Prototype Management Tool for Evaluating Potential Fisheries Impacts of Proposed Shoreline and In-water Works in Lake Scugog, Ontario - P. Nichol, D. Bell, T. Cumby, I. Waterhouse, J. Norris.

The Muskegon River Watershed Assembly – G. Nobes

Wednesday, April 2

8:30 Orientation

8:45 Facilitated Discussion Group I

Identifying and Responding to Current and Future Threats and Impediments to Great Lakes Nearshore Fisheries Habitats

9:45 Summary of Discussion Group I

10:15 Break (refreshments provided)

10:30 Facilitated Discussion Group II

Identifying and Prioritizing Information, Data Management, and Research Needs for Management, Protection, and Restoration of Great Lakes Nearshore Fisheries Habitats

11:30 Summary of Discussion Group II

12:00 Lunch (provided)

1:30 Facilitated Discussion Group III

Identifying Hardware, Software, Sampling Gear, and Assessment Needs to Facilitate Effective Nearshore Fisheries Habitat Management, Protection, and Restoration

2:30 Summary of Discussion Group III

3:00 Break (refreshments provided)

3:15 Facilitated Discussion Group IV

Identifying Funding and Partnership Priorities to Facilitate Effective Management, Protection, and Restoration of Great Lakes Nearshore Fisheries Habitat

4:15 Summary of Discussion Group IV

4:40 Closing Remarks

Contributed Oral Presentations

Linking Habitat Science and Policy: Habitat Issues in the Great Lakes Areas of Concern
John Gannon, International Joint Commission

Under the auspices of the Great Lakes Water Quality Agreement and the International joint Commission (IJC), U.S. and Canadian jurisdictions have been developing Remedial Action Plans (RAPs) to restore the ecological integrity in the now 41 designated Areas of Concern (AOCs). The AOCs consist of the harbors, tributary mouths, embayments, and connection channels in the Great Lakes that have been most severely degraded by decades of pollution, habitat loss, and municipal, industrial, and agricultural development. Fish and wildlife habitat loss is one of the 14 beneficial use impairments in the RAPs that is used to identify existing environmental problems, determine and implement measures, monitor and evaluate whether beneficial uses have been restored, and eventually delist the AOC. Progress has been slow largely because of both policy and scientific challenges concerning habitat in AOCs. From a policy perspective, these nearshore areas were known to be extremely important as fish spawning, nursery, and rearing habitat, but because the habitat in many of these areas has been lost and degraded, agencies often have not establishes goals and targets for fish community restoration and associated habitat requirements.

I argue that the habitat concerns along with the invasive species problem offer the greatest potential for policy and scientific collaboration and cooperation between the IJC, Great Lakes Fishery Commission, and Great Lakes Commission. From the scientific perspective, the AOCs and the entire Great Lakes coastal zone for that matter largely have been ignored because: 1) of an emphasis on offshore fisheries and water quality research; 2) the coastal zone is dynamic and difficult to sample quantitatively; and 3) the comparatively new fields of ecological restoration and ecological engineering, originally developed in terrestrial and wetland ecosystems, are only within the last decade being applied to aquatic habitat. I further argue that the time is ripe for a resurgence in nearshore habitat research that for too long has "fallen between the cracks" between traditional fisheries and habitat research. In the AOCs, soft-bottom sediments provide habitat and clean-up of contaminated sediment "hot spots" continues to be important; however, there are also great habitat benefits to be gained in creating restoring hard-bottom substrates (e.g., rocky shoals, submerged bedrock outcrops, and habitat associated with shoreline protection and navigation structures). Linking habitat policy and science in the AOCs requires more attention to fish and wildlife community and associated habitat goal-setting and new scientific emphasis on the structure and function of coastal habitat and the application of habitat restoration techniques in the AOCs.

A Conceptual Framework for Nearshore and Coastal Habitats
Scudder Mackey, Great Lakes Protection Fund

Functioning nearshore and coastal habitats are critical and essential to a healthy Great Lakes ecosystem. Structural Habitats are created by the dynamic interaction of geological, hydrological, and biological processes that result in an organizational pattern that is repeatable in a system and persists through time (Peters and Cross, 1992). These patterns or elements are essential to maintain a renewable resource.

The Great Lakes ecosystem has evolved and adapted to these changing structural habitats through time. A conceptual framework has been developed to identify critical physical parameters that are essential to characterize and map nearshore and coastal habitats. This framework includes energy, substrate, and water mass characteristics within the nearshore and coastal zones of the Great Lakes. Energy in the system can be quantified by hydraulic calculations for both oscillatory and unidirectional flows. Substrate characteristics include bedrock or grain size of sediment, hardness, stability, porosity and permeability, and roughness. Water mass characteristics include depth, temperature, turbidity (light penetration), nutrients, contaminants, and dissolved oxygen. A nearshore "EcoZone" represents the combination of a range of physical characteristics and energy conditions that can be delineated geographically and meet a unique range or combination of physical characteristics and energy conditions for a specific species and/or biological community. Complexities arise due to: (1) a poor understanding of the linkages between nearshore structural habitat and biological communities; (2) the inherently three-dimensional nature of nearshore structural habitat; and (3) the dynamic nature of the nearshore zone – spatially, temporally, and as a function of biotic life stage. This framework provides a systematic way to integrate and

map the distribution of biota (i.e. habitats) across varying energy, substrate, and water mass characteristics as a function of time and space.

Resource Values of Great Lakes Nearshore Areas and the Critical Need for their Protection
Reuben Goforth, Michigan Natural Features Inventory

Although Great Lakes shorelines are generally well known in terms of terrestrial biodiversity and resource values that contribute to aesthetic beauty and recreational/commercial uses, nearshore aquatic biodiversity and habitat are poorly described. Historical lack of interest and logistical complexities associated with studies of nearshore fisheries, associated prey communities, and physicochemical habitats are largely responsible for this paucity of understanding. Yet, nearshore waters reflect significant natural resources that are proportionately far greater in importance than the fairly limited spatial extent of these habitats in the Basin would suggest. These values have great relevance to socioeconomic health and biodiversity integrity (i.e., ecosystem sustainability). However, physicochemical habitat conditions and associated biological communities are highly threatened by multiple stressors related to human activities in the Basin. Multiple ecological consequences can result from these stressors, and a complete understanding of these stressor-response interactions in nearshore areas is lacking, especially with regard to multiple spatial and temporal scales of influence. Several approaches to assessment are emerging, although much more work is required to more effectively manage Great Lakes fisheries habitat, fish populations, and prey communities within an ecosystem context.

Expanding Nearshore Fisheries Habitat into Great Lakes Tributaries
Neville Ward, Fisheries & Oceans Canada, Thunder Bay

Canada's Fisheries Act requires safe passage and sufficient water flows for fish and prevents the harmful alteration, disruption, or destruction (HADD) of fish habitat. Water crossings by national railways, provincial highways, and municipal roads have been found to be barriers to fish migration. Some of these crossings are 'perched' or have water velocities that exceed fish swimming speeds. The railways are presently rehabilitating most of their crossings since the structures have been in place for over 70 years. Since this involves work in water, projects are submitted to Fisheries & Oceans Canada for review under the Fisheries Act. This provides an opportunity to ensure the rehabilitation will accommodate fish passage. The use of downstream riffles to backflood crossings to reduce the 'perched' height or reduce water velocities appears to be the preferred technique. Whether this will enable fish found in nearshore areas to migrate upstream in Lake Superior tributaries and expand their range of habitat will be determined by future monitoring programs.

Nearshore Habitat Dynamics
Scudder D. Mackey, Ph.D., Great Lakes Protection Fund, Dale Liebenthal, Jonathan Fuller, Ohio Department of Natural Resources

Critical elements that create nearshore structural habitats include energy, substrate, and water mass characteristics that vary as a function of time and space. A method has been developed to systematically classify and map nearshore substrate distributions by combining traditional sampling techniques with sidescan sonar, GPS, and GIS technologies to record and map substrate contacts and morphological features in Great Lakes nearshore zones. Multi-year, geo-referenced sidescan sonar surveys can easily track spatial changes in bottom substrates where a variety of substrates are present. Areas of change can be measured and patterns of change can be identified if the polygons can be correlated through time. In sand-poor areas, movement of individual sand polygons can be used to determine sand movement. In

sand rich areas, polygons enclosing areas of hard substrate exposed though "windows" in a sand sheet can be used to map movement of the sand sheet. During a study of five Great Lakes sites between 1999 and 2000, changes in substrate ranged from 9 to 31 percent per year among the sites. These changes imply that (for these sites) nearshore habitat is continually being created and destroyed which may have significant biological implications. Patterns and relationships emerge that can be used to: (1) quantitatively assess the magnitude and rate of change that occurs within specific nearshore zones; (2) develop predictive models to calculate potential habitat availability; and (3) assess both the short- and long-term biological significance of these changes on the Great Lakes ecosystem.

Associations between Great Lakes Nearshore Communities and Habitats Influenced by Varied Levels of Shoreline Development

Stephanie Carman, Michigan Natural Features Inventory

Nearshore areas of the Great Lakes provide valuable habitat that supports diverse fish and invertebrate communities. Shoreline development directly influences the distributions of nearshore substrates and therefore can have an effect on the nearshore habitats. A better understanding of aquatic community responses to habitat changes is essential for devising effective planning, protection, and restoration strategies as development pressures continue. This study examined the relationship between nearshore substrates and associated aquatic communities. Four sites in Lake Michigan and two in Lake Erie were chosen that represented varied levels of development and substrate composition. Substrates were characterized using SCUBA observations and side-scan sonar imaging. Nearshore fish, plankton, and benthic invertebrate communities were sampled in the summer of 2000. Shores that were artificially armored with riprap and boulders had more fish species present but also tended to have more exotic species. However, the number of benthic invertebrate species tended to be higher in areas with less modified shorelines, especially in nearshore areas with large rocky substrates. Shoreline armoring appears to improve habitat for several species, but may consequentially create a less stable and less diverse community. Nearshore areas with artificial substrates may also be more susceptible to invasion and establishment of exotic species that influence community structure and degrade nearshore ecological integrity.

Nearshore Community Interactions in the West-Central Basin of Lake Erie

Jacqueline Savino, Marc Blouin, Michael Bur, Bruce Davis, Mary Fabrizio, Greg Kennedy, James McKenna, and Thomas Todd, US Geological Survey/Great Lakes Science Center

The nearshore zone may be an important nursery area for Great Lakes fishes. However, more is known about the use of vegetated areas for nursery grounds than for open-water areas. Our sites were at the mouths of three rivers in the relatively high-energy zone of west-central Lake Erie in Ohio. We sampled with a neuston net within a 4 km radius (and in 2-12 m water depth) about each river mouth weekly or biweekly from mid-April through August. Samples are stratified by substrate type. We found similar trends in overall larval fish abundance and collected over 20 fish species each year during three years of collections. Whitefish were the dominant species in April. Emerald shiners were the most abundant species and were available throughout the summer, from early June to the end of August. Rainbow smelt and gizzard shad varied greatly in their abundances by year. In comparison, we found many similar species in collections with a beach seine in 1 m of water. However, the neuston net was more effective in capturing more fish species throughout the season. Next, we want to relate abiotic and biotic factors that we have measured to changes in fish abundance. Knowledge of the factors affecting the occurrence and relative abundance of species would greatly enhance our ability to predict the response of fish populations to perturbations.

Fish Habitat Use within and Across Wetland Classes for Coastal Wetlands of the Five Great Lakes

D.G. Uzarski, D. G.[1], T.M. Burton [2], J. Ingram [3], S. Timmermans [4] and M.J. Cooper [1] [1]Grand Valley State University; [2]Michigan State University; [3]Environment Canada, Ontario Region; [4]Bird Studies Canada

The relative importance of plant zonation in providing fish habitat was determined for 61 Great Lakes coastal wetlands. These wetlands, from all five Great Lakes, spanned nine ecoregions and four wetland types (open-lacustrine, protected-embayment, barrier beach, and drowned river mouth). Fish were sampled using fyke nets, and physical and chemical parameters were determined for inundated plant zones in each wetland. Land use/cover was calculated for one km buffers from digitized imagery and combined with chemical/physical data in principal components analysis. Fish community composition within and among wetlands was compared using correspondence analyses and non-metric multidimensional scaling. Within-site plant zonation was the single most important variable structuring fish communities regardless of lake, ecoregion, or wetland type. An underlying gradient of fish community composition appeared to be related to nutrient concentrations and correlated with vegetation type and/or fetch/pelagic mixing and/or organic sediment accumulation as well as food sources associated with those. Fish communities changed along a continuum from cattail and burreed (*Typha* and *Sparganium*) to floating leaved (*Nuphar/Nymphaea*) to mixed pickerel weed (*Pontederia/ Sagittaria/Peltandra*) to bulrush (*Scirpus*) dominated plant zones. Variability in community composition increased markedly along the continuum from *Typha* to *Scirpus* zones. Fish community composition was most predictable in plant zones protected from waves and pelagic mixing and least predictable in zones subject to wave generated pelagic mixing.

Spatial Patterns Emphasize the Importance of Coastal Zones as Nursery Areas for Larval Walleye in Western Lake Erie

Edward Roseman, Dan Hayes, and Bill Taylor[1], Jeff Tyson[2], Bob Haas[3]. [1]Dept, Fisheries and Wildlife, Michigan State University; [2]Sandusky Fisheries Research Unit, Ohio Dept. Natural Resources; [3]Mt. Clemens Fisheries Station, Michigan Dept. Natural Resources

Lake Erie supports the world's largest naturally reproducing walleye population that, like many natural populations, exhibits significant interannual variability in year-class strength. Recent research revealed the importance of larval vital rates in determining walleye year-class strength in western Lake Erie, indicating that spatial and temporal overlap of larvae with good habitat conditions (e.g., abundant prey, warm waters) promoted walleye growth and survival. To assess the overlap between walleye larvae and associated habitat parameters in western Lake Erie, we evaluated the distribution of walleye larvae with intensive sampling at 30 to 36 sites during spring 1994-1999. We analyzed spatial relationships between pelagic walleye larvae and various habitat attributes using a geographic information system and principal components analysis. Larval walleye density was consistently highest at nearshore sites during all years. Larval walleye density was positively associated with zooplankton density, ichthyoplankton density, and water temperature. Walleye density was negatively associated with water depth and water clarity. Two principal components represented 79.6% of the total variability in site attributes. Principle components analysis supported our spatial analysis by graphically separating sites into distinct groups based on larval walleye density and habitat attributes. These analyses demonstrated repeatable interannual patterns in larval distribution and habitat attributes, emphasizing the importance of nearshore coastal zones as nursery areas for walleye.

Correlations between Development of Coastal Marsh Fish Communities in Les Cheneaux in the Eastern Upper Peninsula of Michigan

Paul Webb, Interim Director, University of Michigan Biological Station and School of Natural Resources and Environment, University of Michigan

Preliminary multi-method observations of fish communities in N. Lake Huron coastal marshes showed the non-game small-bodied species in permanent marsh was most sensitive to human development in Les Cheneaux. This fish community

Contributed Oral Presentations

was quantified in terms of species richness, catch per unit effort, the number of native cyprinid species, and the proportion of tolerant fishes. Human development affecting these communities is largely located along the shorelines where it facilitates run-off and fragments terrestrial and aquatic shoreline communities. We combined measures of shoreline building density and impervious surface area into an index of human activity. This was significantly correlated with measures of fish community structure. Les Cheneaux is considered a fairly pristine system, so that simple measures of fish communities can be used to monitor and demonstrate early habitat deterioration.

Great Lakes Coastal Aquatic Gap Analysis: Preserving Biodiversity in the Great Lakes Basin *Sandra S. Morrison, James E. McKenna, Jr., Chris Castiglione, Kurt P. Kowalski, USGS Great Lakes Science Center*

Gap Analysis is a biogeographic approach to planning and managing for biodiversity. The Gap process uses existing data and GIS to map habitats, species distribution, and land ownership in order to find gaps in the conservation of common species. The recently initiated Great Lakes Coastal Gap project focuses on coastal habitats and nearshore fish assemblages. Pilot studies are underway in western Lake Erie and eastern Lake Ontario and a preliminary coastal habitat classification system has been developed. The results of this project will provide scientists, resource managers, and planners with the information necessary to manage, maintain, and preserve the biodiversity of Great Lakes coastal ecosystems.

Efficient Ways to Gather, Store, Distribute, and Manage Fishery Habitat Information for Use Among Multiple Agencies, Organizations, Public and Private Interests, and the Research Community
Paul Nichol, Ecosystems

Successful implementation of efficient methodologies to gather, store, distribute and manage fishery habitat information for use among multiple agencies, organizations, public and private interests, and the research community is a lofty goal and difficult to achieve. Geographic information system software and relational database applications were utilized in a decade long partnership, which included no less than 9 diverse partner organizations. The primary aim was to collect and analyze fish habitat data, to assess both the importance of specific habitats to fish production and the impacts of human induced changes. This presentation provides an overview of considerations based on the Kawartha Lakes, Ontario Experience, in order to assist others who may share similar objectives.

Contributed Poster Presentations

Great Lakes Coastal Aquatic Gap Analysis
Kurt P. Kowalski, Sandra S. Morrison, James E. McKenna, Jr., Chris Castiglione, Dora R. Passino-Reader, USGS Great Lakes Science Center

Gap Analysis is a biogeographic approach to planning and managing for biodiversity. The Gap process uses existing data and GIS to map habitats, species distribution, and land ownership in order to find gaps in the conservation of common species. The recently initiated Great Lakes Coastal Gap project focuses on coastal habitats and nearshore fish assemblages. Pilot studies are underway in western Lake Erie and eastern Lake Ontario and a preliminary coastal habitat classification system has been developed. The results of this project will provide scientists, resource managers, and planners with the information necessary to manage, maintain, and preserve the biodiversity of Great Lakes coastal ecosystems.

High-resolution Multibeam Sonar Mapping of Gooseberry Reef, Lake Superior: Its Role in Characterizing Lake Trout Spawning Areas

Nigel J. Wattrus, Large Lakes Observatory, University of Minnesota

In a new study, beginning this year in the Apostle Islands, Lake Superior, multibeam sonar surveying will be used as part of a multidisciplinary study that seeks to characterize lake trout spawning and nursery habitat. The project will combine an expansive database collected with high resolution remote sensors of substrate, fish size, fish density, plankton abundance, current speed, current direction, water depth, and temperature with traditionally collected data of each variable that ground truth remotely sensed data and provide biological data from various sites on each shoal. We will construct and analyze a high-resolution Geographic Information Systems (GIS) database of the remotely sensed and site sample data. A pilot study was recently conducted on Gooseberry Reef on the Minnesota North Shore. The results from this survey are presented together with a description of the work to be conducted in the Apostle Islands this year.

Lake Michigan Rocky Habitat: Always Important, Seldom Studied

John Janssen,Great Lakes WATER Institute, University of Wisconsin-Milwaukee; Stephen Lozano, Great Lakes Environmental Research Laboratory, NOAA; Marty Berg, Biology Dept. Loyola University of Chicago; David Jude, School of Natural Resources, University of Michigan; John Dettmers, Illinois Natural History Survey

Rocky habitat in Lake Michigan has seldom been studied, yet it is abundant, particularly on the west side of Lake Michigan. The habitat has become increasingly important because of dense zebra mussel infestations and enhanced benthic production due to increased water clarity. Rocks provide the best spawning habitat for spawning yellow perch, which is good, and for round gobies, which is bad. Food for fish is relatively abundant. Our poster presents some highlights, including (1) evidence that the rocky habitat is not only preferred by yellow perch, but even by young alewives, for unknown reasons; (2) the rocky habitats on the west side of Lake Michigan may be the source of young yellow perch as far away as the east side of the lake; and (3) the rapidly spreading round gobies are bringing further changes to Lake Michigan. Despite round gobies preferring the same habitat that yellow perch prefer to spawn in, round gobies do not consume yellow perch eggs. The gelatin coating of the eggs has been known to be bad-tasting for a long time.

A Prototype Management Tool for Evaluating Potential Fisheries Impacts of Proposed Shoreline and In-water Works in Lake Scugog, Ontario

P. Nichol, D. Bell, T. Cumby, I. Waterhouse, J. Norris. Ecosystems

Changing agencies' capabilities, roles and responsibilities created an increasing need to develop efficient methods to assess impacts of applications for shoreline and in-water works on fish habitat in a consistent, defensible manner.

A keystone species spawning habitat approach was used to develop a user friendly, Microsoft Access database application. The application allows the user to view predicted keystone fish species spawning classes and acceptable shoreline and in-water works projects for any of the 2117 properties adjacent to the Lake Scugog Shoreline, by property assessment roll number. For each acceptable project, the user can access related fisheries considerations and standardized conditions of approval.

Tabular data objects originated from several sources. Keystone species spawning classes were developed via spatial analysis of lake-wide vegetation and substrate data collected in 1997 as well as historical spawning data. Fisheries considerations and standard conditions were largely based on local fisheries guidelines, developed by the Ontario Ministry of Natural Resources, for use in the Kawartha Lakes Area.

Working Group Guiding Questions

Facilitated Discussion I *Current and Future Threats and Impediments to Assessing, Managing, Protecting, and Restoring Great Lakes Nearshore Fisheries Habitat.*

1) What environmental factors influence nearshore fisheries and how do they influence these resources?
2) How are threats and impediments determined and/or measured?
3) What are the most susceptible components of nearshore fisheries and habitats to existing/future threats?
4) How can threats be ameliorated and/or discontinued?
5) What actions need to be taken to deal with threats to nearshore fisheries habitat?
6) What are the most significant/pressing threats and impediments to nearshore fisheries habitat management, protection, and restoration?
7) What current gaps in understanding exist relative to dealing with threats to nearshore fisheries habitats?

Facilitated Discussion II *Information, Data Management, and Research Needed to Facilitate the Assessment, Management, Protection, and Restoration of Great Lakes Nearshore Fisheries Habitat.*

1) What data exist and are commonly collected?
2) What data are required but are not commonly collected?
3) What methods exist to provide needed data? What data are required that cannot be collected using existing methodologies?
4) What data are absolutely critical for effective fisheries habitat management?
5) What research questions are critical for effective nearshore fisheries habitat assessment, management, restoration, and/or protection?
6) What research exists that deals with significant data issues in Great Lakes nearshore areas?
7) What spatial/temporal contexts are important for studying Great Lakes fishery habitats?
8) What new/emerging technologies exist that can lead to innovative research on Great Lakes nearshore fisheries habitats?

Lake Michigan low bluff shoreline near Two Rivers, Wisconsin. Nearshore substrates are very dynamic in this area and consist of shifting sands with cobbles and boulders interspersed in hardpan clay. Photo by Reuben Goforth.

Working Group Guiding Questions

Northern Lake Huron shoreline in the Les Cheneaux Island complex near Cedarville, Michigan. Photo by Reuben Goforth.

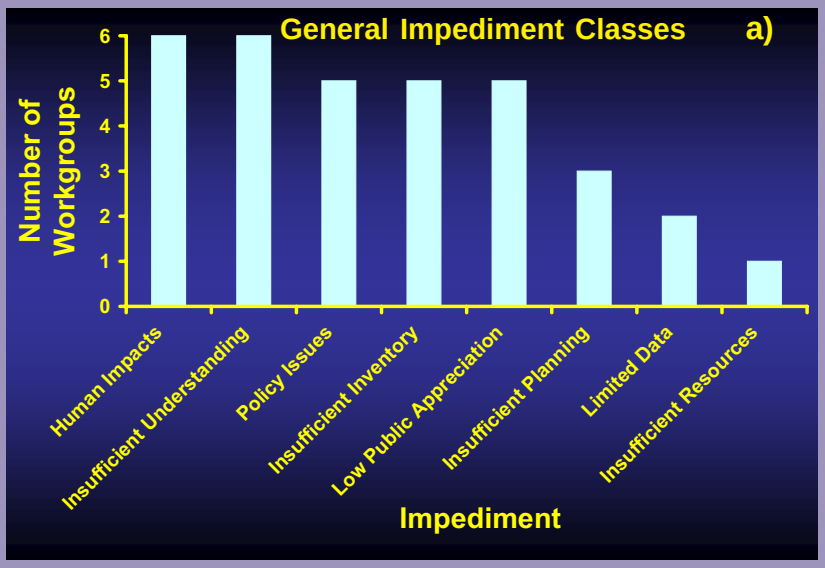
Facilitated Discussion III *Hardware, Software, Sampling Gear, and Assessment Protocol Needed to Facilitate the Assessment, Management, Protection, and Restoration of Great Lakes Nearshore Fisheries Habitat.*

1) What is the most appropriate format for making data available to a wide community of users?
2) What impediments exist to data sharing within the community of Great Lakes interests (researchers, agency personnel, tribal governments, conservation organizations, etc.)?
3) Are there any existing efforts to manage data for a wide range of users? What approach/format is being used?
4) Are there specific Great Lakes interests that would be especially well-suited to management of Great Lakes fisheries habitat data? What are they?
5) What sampling gear and protocols exist or are emerging that facilitate fishery habitat data collection? What gear needs to be developed?
6) What are the limitations of existing approaches to assessing Great Lakes fisheries habitats?
7) What gear and protocols are most effective in providing data that facilitate Great Lakes fisheries habitat management?
8) What gear and protocols exist or need to be developed to identify Great Lakes fisheries habitat protection and/or restoration priorities?

Facilitated Discussion IV *Funding and Partnerships Needed to Facilitate the Assessment, Management, Protection, and Restoration of Great Lakes Nearshore Fisheries Habitat.*

1) What are the most critical priorities for funding with respect to Great Lakes nearshore fisheries habitats?
2) What grantors or other resources are you aware of that would support research, protection, and/or restoration priorities related to Great Lakes fisheries habitats?
3) What are other funding priorities or sources that could be tapped to support efforts to manage, assess, protect, and/or restore Great Lakes nearshore fisheries habitat?
4) What partnerships are you currently involved in related to Great Lakes nearshore fisheries issues?
5) What partnerships are you aware of (but not a part of personally) related to nearshore fisheries issues?
6) What information or knowledge gaps could be filled by innovative partnerships, and what would the composition of those partnerships be?

Workshop Results



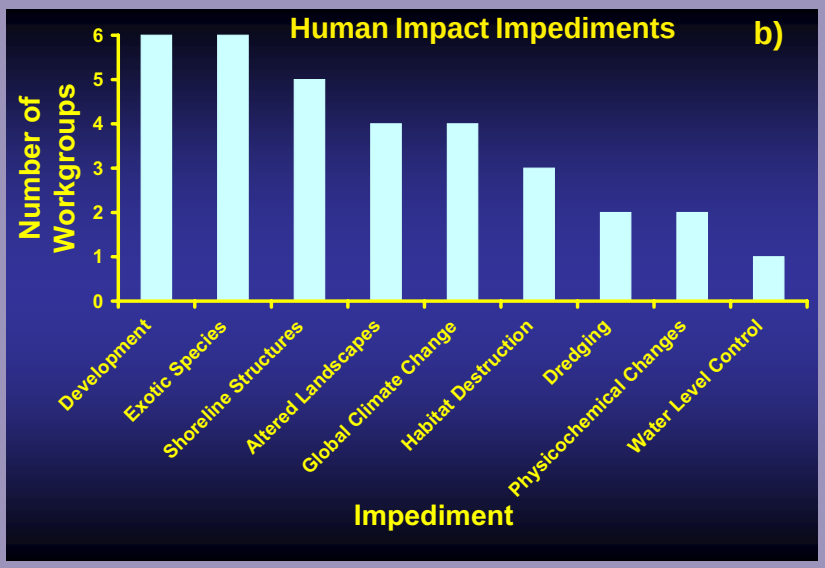


Figure 6. General classes of impediments (a) and specific anthropogenic impediments (b) to Great Lakes nearshore fishery habitat assessment, management, restoration, and protection identified by six working groups comprised of Great Lakes experts.

Facilitated Discussion I Results - Threats and Impediments

During the first working session, workshop participants identified significant impediments to effective nearshore fisheries habitat assessment, management, protection, and restoration. Many specific impediments emerged from these discussions and were grouped into eight general categories of impediments (Table 1 and Figure 6a). All six workgroups identified human impacts and insufficient ecological understanding as significant impediments. Five out of the six workgroups also identified policy issues, insufficient inventory, and a lack of public awareness and appreciation as significant impediments (Figure 6a). Insufficient strategic planning was identified as a significant impediment by three workgroups, while two workgroups identified limited data availability and one workgroup identified insufficient funding and other resources as significant impediments.

Within the general category of human impacts, all six workgroups identified both development and exotic species as significant impediments (Figure 6b). Specific types of development included residential, commercial, recreational, and industrial activities. Exotic species identified as impediments by workgroups included zebra and quagga mussels (*Dreissena* spp.), round and tubenose gobies (*Neogobius* spp.), Asian carp, Eurasian water milfoil (*Myriophyllum spicatum*), and purple loosestrife (*Lythrum salicaria*). Five workgroups reported shoreline structures (e.g., jetties, groin fields, and hardened shorelines) as a major category of impediments (Figure 6b). Altered landscapes and global climate change were identified as major categories of anthropogenic impediments by four workgroups each (Figure 6b). Habitat loss, dredging, physicochemical changes, and water level control were also identified as human impacts that serve as significant impediments to nearshore fisheries management and protection (Figure 6b).

Eleven major areas of limited ecological understanding that serve as impediments were identified by workgroups (Table 2). The most frequently identified deficiency related to understanding of linkages that exist among nearshore, offshore, terrestrial, wetland, and riverine ecosystems of the Great Lakes Basin (four workgroups). Three workgroups also identified insufficient knowledge of fish associations with specific critical habitats and limited recognition of current and future threats as major gaps in ecological understanding that impede management and protection of nearshore fisheries habitats. Other areas of insufficient ecological understanding identified by workgroups related to nearshore substrate dynamics, spatiotemporal scaling,

Workshop Results

Table 1. Specific impediments (current and future) to assessing, managing, protecting and restoring Great Lakes fisheries habitats that were identified by six working groups comprised of Great Lakes fisheries experts (eight experts per working group). The number of groups reporting each impediment identified during the working session is provided.

Specific Impediment	Number of Groups
Critical and limiting nearshore fisheries habitats unknown	6
Lack of public education, communication and/or awareness	
High levels of physicochemical pollution in the Great Lakes and their tributaries	5
Shoreline modifications (e.g., revetments, groin fields, etc.)	
Development (e.g., residential, commerical, recreational, etc.)	4
Water diversion and water level control	
Aquatic invasive species	
Habitat fragmentation	
Poor understanding of important fish-habitat linkages over multiple scales	
Altered basin/coastal hydrology	3
Alteration and degradation of coastal wetlands and drowned river mouths	
Demand for development of shorelines (most is privately owned)	
Global climate change	
Lowered Great Lakes water levels	
Altered sediment transport and dynamics	
Limited fundamental information and understanding of nearshore science	
Inventory and monitoring efforts nonexistent	
Ineffective policies and enforcement of laws	
Biological pollution	2
Damming of tributary rivers	
Absence of reference conditions in the Great Lakes nearshore areas	
Limited baseline/historical data	
No ecological models or predictive capacity to anticipate future impacts	
No existing classification for nearshore aquatic habitats	
Threats analyse not developed for critical and/or unique habitats	
No strategic vision or focus exists for nearshore fisheries habitat	
Limited methodology and/or data standards for nearshore habitat work	
Current management strategies are largely reactive vs. proactive	
Increased legislative demand for development	
Limited sustainability	
Funding/resources to conduct surveys and inventories	
Altered alongshore currents	1
Altered littoral drift/sediment transport	
Altered nearshore physicochemical properties	
Changes in seiche frequency and magnitude	
Destruction of regionally rare/unique habitats	
Exotics species introductions not federally regulated	
Few multi-disciplinary/multi-agency approaches to management exist	
Inlet river channelization	
Lack of understanding by policy makers	
Legislative changes in ownership of exposed/uncovered lands	
Mining	
No clear understanding of how sediment transport affects fisheries	
No policy exists to protect reference conditions	
Poor understanding of habitat resiliency	

influences of man-made structures on fisheries, nearshore habitat definition, whether nearshore habitats are limiting for Great Lakes fish, nearshore habitat reference conditions and criteria, prediction of changes in response to stressors, and nearshore habitat resiliency (Table 2).

Eight types of policy issues were reported by workgroups as impediments to nearshore fisheries habitat management and protection. The most frequently identified policy issue was related to ineffective laws for riparian, development, and exotic species regulation (three workgroups). Reactive vs. proactive management, legislative demands, and lack of protection for reference conditions were all identified as significant policy-related impediments by two workgroups each. Other policy issues identified by one workgroup each included uninformed policy makers, lack of protection for public shorelines, limited regulatory enforcement, and the lack of federal regulation for exotic species.

Table 2. Areas of limited ecological understanding that currently impede efforts to assess, manage, protect, and restore Great Lakes fisheries habitats as identified by six working groups comprised of Great Lakes fisheries experts (eight experts per working group). The number of groups reporting each deficiency with regard to ecological understanding during the working session is provided.

Deficiency in Great Lakes Nearshore Ecological Understanding	Number of Groups
Poor understanding of linkages among nearshore, riverine, wetland, terrestrial and offshore environments	4
Poor understanding of fish associations with particular habitat types and why these habitats are critical to fish species and communities	3
Poor understanding of current and potential threats	
Poor understanding of the influences of substrates and sediments on fish species and communities	2
Poor understanding of spatiotemporal scales relevant to Great Lakes fish species and communities	
Poor understanding of the influences of shoreline structures and land covers on nearshore habitats and fisheries	
Inability to effectively define nearshore habitat	
Poor understanding of whether habitats are limiting	1
Reference conditions and critiera largely unknown	
Limited predictive capability to anticipate impacts and changes	
Limited understanding of nearshore habitat resiliency	

The largest issue with regard to the insufficient inventory category was the absence of comprehensive historical and current distributional information for nearshore habitats (five workgroups). A complicating factor related to this is that no classification system or assessment protocols have been developed to consistently evaluate and inventory nearshore fisheries habitat throughout the Great Lakes Basin (three workgroups). Workgroups also reported that we do not currently know the location and extent of remaining high quality habitat, and no monitoring or evaluation program for management purposes has been created. Without knowing what habitats exist, where habitats are located, what condition the habitat is in, or how these habitats relate to fisheries production, it is difficult to effectively devise management, protection, and restoration strategies that will lead to recognizable improvements in Great Lakes fisheries production.

Workgroups identified several specific issue that contribute to low public awareness and appreciation of Great Lakes shorelines and associated nearshore fisheries habitats as a significant impediment to management and protection. While the public, in general, wants to have good recreational fisheries opportunities in the Great Lakes, coastal landowners do not recognize that there are connections between their development and management of shorelines and fisheries resources via nearshore habitats. This is compounded by the fact that there is insufficient information transfer from Great Lakes experts to both private landowners and officials who make land use planning decisions. Much of the shoreline is privately owned, so this lack of understanding of the consequences that local land management practices can have both individually and in combination with other activities is of particular concern. There are also insufficient examples of state and federal governments implementing more environmentally friendly, soft engineering practices on public shorelines to serve as a demonstration for private land owners.

Facilitated Discussion II Results - Information and Research Needs

Information and research priorities considered by workgroups as necessary for effective nearshore fisheries habitat management, protection, and restoration fell into four major categories: ecological understanding; classification, assessment, and inventory; public education and involvement; and strategic planning. Within the category of ecological understanding, 11 specific classes of research priorities emerged from workgroup discussions (Table 3). Four of the six workgroups identified evaluation of nearshore ecological function and dynamics as a research priority to support nearshore fisheries habitat management, protection, and restoration. The next most frequently reported research priorities were evaluation of critical nearshore habitat attributes and determination of appropriate spatiotemporal scales for managing and collecting data on nearshore habitats (reported by three workgroups each) (Table 3). Research priorities identified by two of the six workgroups included evaluating limiting nearshore fisheries habitats, determining influences of water level fluctuations on fisheries habitats, developing holistic approaches to management, evaluating tributary river influences on nearshore habitats, and determining the effects of exotic species on nearshore fisheries habitats (Table 3). One out of the six workgroups also identified evaluations of the importance of habitat connectivity, shoreline management, and substrate change in nearshore areas to Great Lakes fisheries production (Table 3).

Table 3. Research priorities for improved ecological understanding to support efforts to assess, manage, protect, and restore Great Lakes fisheries habitats as identified by six working groups comprised of Great Lakes fisheries experts (eight experts per working group). The number of groups reporting each research priority during the working session is provided.

Research Priority	Number of Groups
Evaluation of nearshore ecological function and dynamics	4
Evaluation of critical nearshore habitat existence, function, and distribution related to Great Lakes fishes	3
Determination of appropriate spatiotemporal scales for assessing, managing, protecting, restoring, and collecting data relevant to nearshore fisheries habitats	3
Determination of whether nearshore habitats are limiting for Great Lakes fisheries and the characteristics of limiting habitats	2
Determination of the influences water level fluctuations have on Great Lakes nearshore habitats and associated fisheries	2
Development of holistic approaches to nearshore fishery habitat management	2
Evaluation of Great Lakes tributary river influences on nearshore fisheries habitats	2
Determination of the effects that exotic species have on nearshore fisheries habitats	2
Evaluation of the roles of nearshore habitat connectivity in sustaining Great Lakes fisheries	1
Evaluation of the effects that shoreline management activities, such as shoreline armoring, have on nearshore fisheries habitats	1
Determination of how Great Lakes fisheries are influenced by substrate changes in nearshore areas	1

Several inventory related research and information priorities were also identified by workgroups (Table 4). The most frequently reported inventory research priorities were development of a nearshore habitat classification system and identification of nearshore critical habitat characteristics and criteria, both of which were reported

Table 4. Inventory-related research priorities to support efforts to assess, manage, protect, and restore Great Lakes fisheries habitats as identified by six working groups comprised of Great Lakes fisheries experts (eight experts per working group). The number of groups reporting each inventory priority during the working session is provided.

Research Priority	Number of Groups
Development of a nearshore habitat classitication system	3
Identification of critical habitat characteristics and development of critical habitat criteria	3
Development of nearshore fisheries habitat assessment protocols	2
Identification of existing reference conditions and development of reference condition criteria	2
Determination of historical and current habitat availability and spatial extent	1
Identification of priority sites for protection and restoration	1
Comprehensive mapping of Great Lakes nearshore fisheries habitats	1
Identification of degraded nearshore fisheries habitats	1

by three of the six workgroups (Table 4). Other inventory related research priorities included developing nearshore fisheries habitat assessment protocols, identifying reference conditions, determining current and historical extent of nearshore fisheries habitats, identifying priority sites for protection and restoration, comprehensive mapping of habitats, and identifying degraded habitats (Table 4).

Facilitated Discussion III Results - Hardware, Software, Sampling Gear, and Assessment Protocol Needs

Five workgroups discussed software and storage methods, as well as sampling methods and protocols, needed to more effectively manage and protect nearshore fisheries habitats. However, the emphasis of these discussions was largely centered on data storage and sharing. This may partially reflect the critical need for greater coordination and collaboration among Great Lakes workers expressed by most workgroups. Enhanced data sharing would contribute greatly to increased coordination of efforts and could potentially maximize the research returns and leverage provided by diverse, but coordinated efforts, effectively providing more "bang for the buck." The benefits of having comparable, complementary data from throughout the Basin would also facilitate larger scale, comprehensive management and protection of fisheries resources in the Great Lakes.

All five groups agreed that unified data standards and storage structures are needed to enhance data transfer among Great Lakes agencies, academicians, tribal governments, conservationists, and other relevant interests. Possible software to manage these data include Oracle and Environmental Research Systems Institute's (ESRI) GIS software products, providing relational database structure and spatially explicit formats, respectively. All five groups also agreed that central management (e.g., by the Great Lakes Commission) of these data using a web-based metadata clearinghouse that directs potential users to data sources would be the most appropriate and effective means for making data available within a broad community of experts. This data sharing structure would help to avoid several impediments to data sharing identified by several workgroups, including data security, protection of publication rights, and potential misuse of data. Other issues that have already arisen in other efforts to share data widely across the web, such as firewalls and other technical issues related to serving over the web, would also be avoided. By providing information about data sources to potential users, the users can contact data originators directly, allowing the data originators to decide whether it is appropriate to supply the data to requestors on a case by case basis. All five workgroups also identified significant issues that remain to be resolved for establishing and maintaining this metadata clearinghouse, including the necessary costs, resources, and personnel involved, as well as an appropriate schedule for updating the information provided by the metadata clearinghouse.

Three workgroups also discussed sampling methods and protocols, although the only common theme of these discussions related to the need for developing standards. An important component of standards development is the coordination of timing and equipment to be used by Great Lakes fisheries workers to collect fisheries habitat data that are comparable and consistent among multiple surveys and research efforts. Several questions were also posed in these discussions that expressed a need for developing strategies to guide the development of nearshore habitat protocols. Specifically, the questions to be addressed by protocols (e.g., what is the distribution of nearshore habitats within the context of the Great Lakes Basin, etc.) and the scale at which such assessment protocols should be used need to be defined. Defining these questions and identifying goals related to nearshore fisheries habitat management, assessment, protection, and restoration up front are key components for success in developing appropriate, widely usable assessment protocols and survey methodologies.

Developing and refining methods for measuring habitats using remote sensing techniques and on-site visits were additional needs expressed by workgroups. This includes the potential use of new and existing technologies developed for other fields, such as light detection and ranging technology (LIDAR), and innovative uses for other existing data sources, such as historical rates of development and shoreline change provided by tax and equalization maps. There is also great need for developing and refining remote sensing techniques to evaluate biological communities in Great Lakes nearshore areas (e.g., LandSAT imagery and side scan SONAR).

Facilitated Discussion IV Results - Funding and Partnership Needs

Many participants had to leave the workshop before the final discussion; thus, the final discussion was conducted as a single, larger group comprised of the remaining workshop participants. Participants identified several research priorities that reflect some of the most pressing nearshore fisheries habitat issues that need to be explored in the near future. These priorities fell into four focal areas, including ecological research, habitat classification and mapping, strategic planning, and outreach. No one focus emerged as a particularly critical priority; therefore, all four priorities are considered to be of equal importance for funding in the near future.

Explicit fish uses of nearshore habitats and associated fisheries production are largely unknown, especially with respect to individual fish species. The emphasis for ecological research should therefore be placed on more explicitly defining linkages between Great Lakes fish communities and the set of abiotic and biotic conditions provided by nearshore habitats. This includes the identification of critical and essential features of habitats that influence fisheries production and whether nearshore habitats of the Great Lakes are limiting with respect to fisheries production. Enhanced understanding of the importance of Great Lakes nearshore habitat for fisheries production would help to identify the most crucial elements to be targeted in assessment, management, protection, and restoration efforts. It is especially important to identify existing critical habitat features for protection before they are lost given that it is much easier to protect existing resources than it is to restore degraded habitats.

Very little is known about the variety, distribution, spatial extent, and condition of nearshore habitats existing in the Great Lakes. Therefore, habitat classification, inventory, delineation, and mapping are also critical priorities for Great Lakes nearshore fisheries habitat research funding. Identifying the suite of nearshore habitats that exists is particularly important given the continued rapid rate of habitat loss. There is a very pressing need to catalogue what habitats exist, where these habitats occur, and how these habitats are distributed within the context of the Great Lakes. Within specific habitat types, identifying examples of persisting high quality habitat can provide protection targets, which is particularly crucial given that protecting existing high quality habitat now will be much easier than having to restore that habitat after it has been degraded. This includes developing innovative approaches for determining historical conditions, rates of change, current distributions, and status of nearshore habitats.

A third area that the workgroup emphasized as a research priority for funding was strategic planning and identification of habitat-related goals. Ideally, this would include the research community, agency personnel, fisheries resource user groups, and policy makers so that comprehensive strategies and goals can be developed by all parties directly involved in management, regulation, and legislation affecting Great Lakes fisheries. This may be the most pressing need related to fisheries habitat management, protection, and restoration in the Great Lakes given that it would help to unite fisheries interests while at the same time developing unified, directed goals for management that can help to more effectively direct research, management, regulatory, and policy foci and activities.

The last priority area for research funding relates to outreach, marketing, and restoration. Effective transfer of scientific knowledge to the public in layperson's terms to increase awareness of the cumulative effects of shoreline development and management on fisheries resources is an essential element for protecting nearshore fisheries habitats. Without facilitating this increased understanding on the part of the public, residential, commercial, and legislative demands on shorelines will continue unabated, continuing perhaps one of the greatest threats to sustainable Great Lakes fisheries. A component of this approach is marketing to translate the benefits of protection and restoration into financial gain, including economic incentives and cost savings to be realized from protection, restoration, and "softer" approaches to engineering that reflect more environmentally compatible practices in the development of coastal areas. Finally, small restoration targets and pilot projects need to be identified to demonstrate success in the public eye without a large investment of resources on the front end. Once measures of success are developed and benefits are realized, larger scale efforts can then be developed and implemented.

Workshop Participants

Jim Atkinson
Department of Fisheries and Oceans
501 Towerhill Road, Peterborough, ON K9H 7S3 Canada
Voice: 705-750-4053 E-mail: atkinsonj@dfo-mpo.gc.ca

Pete Badra
Michigan Natural Features Inventory
Michigan State University Extension
Stevens T. Mason Building, PO Box 30444
Lansing, MI 48909-7944
Voice: 517-241-4179 E-mail: badrap@michigan.gov

Sharon Baker
MI Department of Environmental Quality, Water Division
Constitution Hall, 2nd Floor South Tower,Lansing, MI 48913
Voice: 517-335-3310 E-mail: bakersl@michigan.gov

Joel Brammeier
Lake Michigan Federation
220 S. State Street, Suite 1900, Chicago, IL 60604
Voice: 312-939-0838 E-mail: jbrammeier@lakemichigan.org

Mark Breederland
Michigan Sea Grant
200 Grand River Suite 102, Port Huron, MI 48060
Voice: 810-989-6323 E-mail: breederm@msue.msu.edu

Stephanie Carman
Michigan Natural Features Inventory
Michigan State University Extension
Stevens T. Mason Building, PO Box 30444
Lansing, MI 48909-7944
Voice:517-241-4178 E-mail: carmans@michigan.gov

Randy Claramunt
Michigan Department of Natural Resources
Charlevoix Fisheries Research Station
96 Grant Street, Charlevoix, MI 49720
Voice: 231-547-2914 E-mail: claramur@michigan.gov

Mark Coscarelli
Great Lakes Fishery Trust
600 West St. Joseph, Suite 10, Lansing, MI 48933-2265
Voice: 517-484-4954 E-mail: mcoscarelli@pscinc.com

Sara Creque
Illinois Natural History Survey
Lake Michigan Biological Station
400 17th Street, Zion, IL 60099
Voice: 847-872-8677 E-mail: screque@staff.uiuc.edu

John Dettmers
Illinois Natural History Survey
Lake Michigan Biological Station
400 17th Street, Zion, IL 60099
Voice: 847-872-8677 E-mail: dettmers@inhs.uiuc.edu

Jonathan Fuller
Ohio Department of Natural Resources
Lake Erie Geology Group
1634 Sycamore Line, Sandusky, OH 44870-4132
Voice: 419-626-4296 E-mail:karen.harold@dnr.state.oh.us

John Gannon
International Joint Commission
Great Lakes Regional Office
100 Ouellette Ave,Windsor, ON N9A 6T3 Canada
Voice: 519-257-6711 E-mail: gannonj@windsor.ijc.org

Bruce Gerke
Ohio Department of Natural Resources
Lake Erie Geology Group
1634 Sycamore Line, Sandusky, OH 44870-4132 USA
Voice: 419-626-4296 E-mail: karen.harold@dnr.state.oh.us

Dave Gesl
U.S. Army Corps of Engineers, Plan Formulation Branch
Detroit District, P.O. Box 1027, Detroit, MI 48231
Voice:313-226-7495 E-mail:david.w.gesl@lre02.usace.army.mil

Reuben Goforth
Michigan Natural Features Inventory
Michigan State University Extension
Stevens T. Mason Building, P.O. Box 30444
Lansing, MI 48909-7944
Voice: 517-335-4581 E-mail: goforthr@michigan.gov

Wayne Groesbeck
Michigan Anglers Association
1308 Calvin Avenue, Muskegon, MI 49442-4111
Voice: 231-777-1555 E-mail: wgroes1308@aol.com

Robert Haas
Michigan Department of Natural Resources
Mount Clemens Fisheries Research Station
33135 S. River Rd., Mt. Clemens, MI 48045
Voice: 586-465-4771 E-mail: haasrc@michigan.gov

Thomas Hamilton
White River Watershed
2785 Weesies Road, Montague, MI 49437
Voice: 231-894-4301 E-mail: hamiltonreef@chartermi.com

Sharon Hanshue
MI Department of Natural Resources, Fisheries Division
Mason Building, P.O. Box 30446, Lansing, MI 48909
Voice: 517-335-4058 E-mail: hanshus1@michigan.gov

Stephen Hensler
University of Michigan, School of Nat. Res. & Environment
430 East University Drive, Ann Arbor, MI 48109
Voice: 734-763-5467 E-mail: shensler@umich.edu

Workshop Participants

David Jude
University of Michigan
School of Natural Resources and Environment
430 East University Drive, Ann Arbor, MI 48109
Voice: 734-763-3183 E-mail: djude@umich.edu

John Koches
Grand Valley State Univeristy
Annis Water Resources Institute
740 West Shoreline Drive, Muskegon, MI 49441
Voice: 616-331-3749

Kurt Kowalski
USGS Great Lakes Science Center
1451 Green Road, Ann Arbor, MI 48105-2807
Voice: 734-214-9308 E-mail: kurt_kowalski@usgs.gov

Arunas Liskauskas
Ontario Ministry of Natural Resources
Upper Great Lakes Management Unit
1450 7th Ave. East, Owen Sound, ON N4K 2Z1 Canada
Voice: 519-271-5927 E-mail:arunas.liskauskas@mnr.gov.on.ca

Scudder Mackey
Great Lakes Protection Fund
1560 Sherman Ave., Suite 880, Evanston, Illinois 60201
Voice: 847-425-8151 E-mail: sdmackey@glpf.org

Mark MacKay
Lake Huron GIS Project
8717 North Roscommon Road, Roscommon, MI 48653
Voice: 989-275-5151 E-mail: mackaym@michigan.gov

Paul Marangelo
The Nature Conservancy, Michigan Field Office
101 East Grand River Avenue, Lansing, MI 48906
Voice: 517-316-2270 E-mail: pmarangelo@tnc.org

Emily Marshall
University of Michigan, School of Natural Resources
Institute for Fisheries Research
1109 North University, Ann Arbor, MI 48109
Voice: 734-663-3554 x103 E-mail: marshale@michigan.gov

Archie Martell
Little River Band of Ottawa Indians
375 River Street, Manistee, MI 49660
Voice: 231-723-1594 E-mail: amartell@lrboi.com

Robert McLaughlin
University of Guelph, Zoology Department
Guelph, ON N1G 2W1 Canada
Voice: 519-824-4120x53620 E-mail: rlmclaug@uoguelph.ca

Sandra Morrison
U.S. Gecological Survey, Great Lakes Science Center
1451 Green Road, Ann Arbor, MI 48105-2807
Voice: 734-214-9393 E-mail: smorrison@usgs.gov

Paul Nichol
ECOSYSTEMS
Environmental and Information Management Services
14 Fair Avenue, Lindsay, ON K9V 3P1 Canada
Voice: 705-324-6883 E-mail: nichol@ecosystems.on.ca

Gale Nobes
Muskegon River Watershed Assembly
2011 Miner, Muskegon, MI 49441
Voice: 231-755-4895 E-mail: troutmn@verizon.net

Karen Rodriguez
U.S. Environmental Protection Agency
Great Lakes National Program Office
77 West Jackson, G-17J, Chicago, IL 60604
Voice: 312-353-2690 E-mail: rodriguez.karen@epa.gov

Edward Roseman
P.O. Box 195, Niantic, CT 06357
Voice: 860-447-1791 x4533
E-mail: edward_f_roseman@dom.com

Alan Rowlinson
Fisheries & Oceans Canada
1219 Queen St. East, Sault Ste Marie, ON P6A 2E5 Canada
Voice: 705-941-2010 E-mail: rowlinsona@dfo-mpo.gc.ca

Rich Rudolph
Fisheries and Oceans Canada
1500 Paris Street, Unit 1, Sudbury, ON P3E 3B8 Canada
Voice: 705-522-5907 E-mail: rudolphr@dfo-mpo.gc.ca

Carl Ruetz
Annis Water Resources Institute
Grand Valley State University
740 West Shoreline Drive, Muskegon, MI 49441
Voice: 616-331-3946 E-mail: ruetzc@gvsu.edu

Jacqueline Savino
U.S. Geological Suvey, Great Lakes Science Center
1451 Green Road, Ann Arbor, MI 48105-2807
Voice: 734-214-7258 E-mail: jacqueline_savino@usgs.gov

Karie Slavik
University of Michigan Biological Station
501 East University Avenue, Ann Arbor, MI 48109-1090
Voice: 734-763-4462 E-mail: slavik@umich.edu

Nichol Stout
Grand Valley State University
Annis Water Resources Institute
740 West Shoreline Drive, Muskegon, MI 49441
Voice: 616-331-3092 E-mail: stoutn@gvsu.edu

Workshop Participants

Mike Thomas
Michigan Department of Natural Resources
Mount Clemens Fisheries Research Station
33135 South River Road, Mt. Clemens, MI 48045
Voice: 586-465-4771 E-mail: thomasmv@michigan.gov

Thomas Todd
U.S. Geological Survey, Great Lakes Science Center
1451 Green Road, Ann Arbor, MI 48105
Voice: 734-214-7227 E-mail: thomas_todd@usgs.gov

Jeff Tyson
Ohio Department of Natural Resources
305 East Shoreline Drive, Sandusky, OH 44870
Voice: 419-625-8062 E-mail: jeff.tyson@dnr.state.oh.us

Sarah U'Ren
The Watershed Center Grand Traverse Bay
232 East Front Street, Traverse City, MI 49684
Voice: 231-935-1514 E-mail: suren@gtbay.org

Don Uzarski
Grand Valley State University,
Annis Water Resources Institute
740 West Shoreline Dr., Muskegon, MI 49441
Voice: 616-331-3989 E-mail: uzarskid@gvsu.edu

Kevin Walters
Great Lakes Commission
2805 South Industrial Highway, Suite 100
Ann Arbor, MI 48104-6791
Voice: 734-971-9135 E-mail: kwalters@glc.org

Neville Ward
Department of Fisheries & Oceans
100 Main Street, Suite 425
Thunder Bay, ON P7B 6R9 Canada
Voice: 807-346-8251 E-mail: wardN@dfo-mpo.gc.ca

Paul Webb
University of Michigan Biological Station
School of Natural Resources and the Environment
501 East Univeristy Ave., Ann Arbor, MI 48109-1090
Voice: 734-647-1952 E-mail: pwebb@umich.edu

Asa Wright
4301 Arbor Drive, Okemos, MI 48864 USA
Phone: 517-349-5955 E-mail: atfish@aol.com

Nearshore Fisheries Habitat Bibliography

Anonymous. 1993. Michigan fish stocking record: a list of fish stocked by county, watersite, species, age, mark and operation. Michigan Department of Natural Resources, Fisheries Division, Lansing, MI.

Baird, W.F. and Associates. 1996. Approach to the physical assessment of developments affecting fish habitat in the Great Lakes nearshore regions. Canadian Manuscript Report of Fisheries and Aquatic Sciences 2352. 101pp.

Benson, B.J. and J.J. Magnuson. 1992. Spatial heterogeneity of littoral fish assemblages in lakes: relation to species diversity and habitat structure. Canadian Journal of Fisheries and Aquatic Science 49:1493-1500.

Berst, A.H. and G.R. Spangler. 1973. Lake Huron: the ecology of the fish community and man's effect on it. Great Lakes Fishery Commission, Technical Report No. 21, Ann Arbor, MI.

Blaber, S.J.M. and T.G. Blaber. 1980. Factors affecting the distribution of juvenile estuarine and inshore fish. Journal of Fish Biology 17:143-162.

Bowlby, J.N. and D. Green. 1987. Efficiency of aquatic habitat inventory surveys in the assessment of fish species present. Ontario Ministry of Natural Resources, Ontario Fisheries Acidification Report Serial No. 87-08, Toronto, Ontario.

Bray, K. 1996. Habitat models as tools for evaluating historic change in the St. Mary's River. Canadian Journal of Fisheries and Aquatic Science 53(Suppl.1):88-98.

Brazner, J.C. 1997. Regional, habitat and human development influences on coastal wetland and beach fish assemblages in Green Bay, Lake Michigan. Journal of Great Lakes Research 23:36-51.

Brazner, J.C. 1994. Patterns in fish assemblages from coastal wetland and other littoral habitats in Green Bay, Lake Michigan. Ph.D. dissertation, University of Wisconsin, Madison, WI.

Brazner, J.C., D.K. Tanner and J.A. Morrice. 2001. Fish-mediated nutrient energy exchange between a Lake Superior coastal wetland and its adjacent bay. Journal of Great Lakes Research 27:98-111.

Brazner, J.C. and E.W. Beals. 1997. Patterns in fish assemblages from coastal wetland and beach habitats in Green Bay, Lake Michigan: a multivariate analysis of abiotic and biotic forcing factors. Canadian Journal of Fisheries and Aquatic Sciences 54:1743-1759.

Brazner, J.C. and J.J. Magnuson. 1994. Patterns of fish species richness and abundance in coastal marshes and other nearshore habitats in Green Bay, Lake Michigan. Verhandlungen Internationle Vereinigung fur Theoretische und Angewandte Limnologie 25:2098-2104.

Brown, R. W., M. P. Ebener, T. J. Sledge and W. W. Taylor. 1995. Forage fish assemblage structure in the littoral and nearshore areas of St. Martins Bay, Lake Huron. Pages 207-222, In: The Lake Huron Ecosystem: Ecology, Fisheries and Management.

Busch, W.D.N. and S.J. Lary. 1996. Assessment of habitat impairments impacting the aquatic resources of Lake Ontario. Canadian Journal of Fisheries and Aquatic Sciences 53(Suppl.1):113-120.

Busiahn, T. R. 1994. A review of land use effects on the nearshore fish community of Lake Superior. Conference on ecosystem management strategies for the Lake Superior Region, May 17-18, Duluth, Minnesota.

Cardinale, B.J., V.J. Brady and T.M. Burton. 1998. Changes in the abundance and diversity of coastal wetland fauna from the open water/macrophyte edge towards shore. Wetlands Ecology and Management 6:59-68.

Casselman, J.M. and C.A. Lewis. 1996. Habitat requirements for northern pike, *Esox lucius*. Canadian journal of Fisheries and Aquatic Science 53(Suppl.1): 161-174.

Chick, J.H. and C.C. McIvor. 1994. Patterns in the abundance and composition of fishes among beds of different macrophytes - viewing a littoral-zone as a landscape. Canadian Journal of Fisheries and Aquatic Sciences 51:2873-2882.

Christie, W.J. 1973. A review if the changes in the fish species composition of Lake Ontario. Great Lakes Fishery Commission Technical Report No. 23, Ann Arbor, MI.

Christie, W.J., C.I. Goddard, S.J. Nepszy, J.J. Collins and W. MacCallum. 1987. Problems associated with fisheries assessment methods in the Great Lakes. Canadian Journal of Fisheries and Aquatic Sciences 44:431-438.

Nearshore Fisheries Habitat Bibliography

Christie, W.J., J.J. Collins, G.W. Eck, C.I. Goddard, J.M. Hoenig, M. Holey, L.D. Jacobson, W. Maccallum, S.J. Nepszy, R. Ogorman and J. Selgeby. 1987. Meeting future information needs for Great Lakes fisheries management. Canadian Journal of Fisheries and Aquatic Sciences 44:439-447.

Christie, W.J., M. Becker, J.W. Cowden and J.R. Vallentyne. 1986. Managing the Great Lakes as a home. Journal of Great Lakes Research 12:2-17.

Christie, W.J. 1973. A review of the changes in the fish species composition of Lake Ontario. Great Lakes Fishery Commission Technical Report No. 23, Ann Arbor, MI.

Chubb, S and C. R. Liston. 1985. Relationships of water level fluctuations and fish. Pages 121-140, In: Coastal Wetlands, Prince and D'Itri (eds.), Lewis Publishers, Inc., Chelsea, MI.

Chubb, S.L. and C.R. Liston. 1986. Density and distribution of larval fishes in Pentwater Marsh, a coastal wetland on Lake Michigan. Journal of Great Lakes Research 12:332-343.

Coberly, C.E. and R.M. Horrall. 1980. Fish spawning grounds in Wisconsin waters of the Great Lakes. Marine Studies Center and Sea Grant Institute, University of Wisconsin, Madison, WI.

Cole, R.A. and J.R. Macmillan. 1984. Sampling larval fish in the littoral-zone of western Lake Erie. Journal of Great Lakes 10:15-27.

Cooper, C.L., J.J. Mizera and C.E. Herdendorf. 1984. Distribution, abundance, and entrainment of larval fishes in the western and central basins of Lake Erie. United States Environmental Protection Agency Project Summary EPA-600/S3-84-017.

Comer, P. J., D. A. Albert, L. J. Scrimger, T. Leibfreid, D. Schuen and H. Jones. 1993a. Historical wetlands of Saginaw Bay watershed. Michigan Natural Features Inventory Report to the Michigan Department of Natural Resources, Land and Water Management Division, Lansing, MI. 105pp.

Comer, P. J., D. A. Albert, L. J. Scrimger, T. Leibfreid, D. Schuen and H. Jones. 1993b. Historical wetlands of Saginaw Bay watershed. Michigan Natural Features Inventory Report to the Saginaw Bay Watershed Initiative, Michigan Department of Natural Resources, Office of Policy and Program Development, Lansing, MI. 68pp.

Cosentino, P. M. 1983. Fish community structure and the utilization of Harsens Island marsh-bay complex, Lake St. Claire. Michigan Department of Natural Resources, Fisheries Research Report 1913, Ann Arbor, MI.

Dalziel, R.I.R. 1988. Survey of critical fish habitat within IJC-designated AOC's June-October, 1987. Unpublished report to Ontario Ministry of Natural Resources, Toronto, Ontario.

Diana, J. S. and R. Salz. 1990. Energy storage, growth and maturation of yellow perch from different locations in Saginaw Bay, Michigan. Transactions of the American Fisheries Society 119: 976-984.

Dorr, J.A., D.V. O'Connor and D.J. Jude. 1981. Substrate conditions and abundance of lake trout eggs in a traditional spawning area in southeastern Lake Michigan. North American Journal of Fisheries Management 1:165-172.

Edsall, T.A. 1999. Indicators of Great Lakes ecosystem health. IAGLR '99. International Association for Great Lakes Research: Great Lakes, Great Science, Great Cities. Program and Abstracts.

Edsall, T.A. 1999. The growth-temperature relation of juvenile lake whitefish. Transactions of the American Fisheries Society 128:962-964.

Edsall, J.H., M.E. Holey, M.E. Manny and G.W. Kennedy. 1995. An evaluation of lake trout reproductive habitat on Clay Banks Reef, northwestern Lake Michigan. Journal of Great Lakes Research 21(Suppl.1):418-432.

Edsall, T.A., C.L. Brown, G.W. Kennedy and J.R.P. French. 1992. Surficial substrates and bathymetry of five historical lake trout spawning reefs in nearshore waters of the Great Lakes. Great Lakes Fishery Commission Technical Report 58, Ann Arbor, MI.

Edsall, T.A., P.P. Poe, R.T. Nester and C.L. Brown. 1989. Side-scan sonar mapping of lake trout spawning habitat in northern Lake Michigan. North American Journal of Fisheries Management 9:269-270.

Egerton, F.N. 1985. Overfishing or pollution? Case history of a controversy on the Great Lakes. Great Lakes Fishery Commission Technical Report No. 41, Ann Arbor, MI.

Environment Canada and U.S. Environmental Protection Agency (EPA). 1995. State of the Great Lakes –

1995. Governments of the United States of America and Canada. Environment Canada, Burlington, Ontario and U.S. Environmental Protection Agency, Chicago, IL.

Evans, D.O., G.J. Warren, and V.W. Cairns. 1990. Assessment and management of fish community health in the Great Lakes: synthesis and recommendations. Journal of Great Lakes Research 6:639-669.

Evans, D.O., B.A. Henderson, N.J. Bax, T.R. Marshall, R.T. Oglesby and W.J. Christie. 1987. Concepts and methods of community ecology applied to freshwater fisheries management. Canadian Journal of Fisheries and Aquatic Science. 44(Suppl.2):448-470.

Fitzsimons, J.D., J. Jonas, R. Claramunt and J.E. Marsden. 2001. An evaluation of spawning activity by lake trout in northeastern Lake Michigan. Page 41, In: Abstracts from the 44th conference on Great Lakes Research, Great Lakes Science: Making it Relevant. June 10-14, 2001.

Fitzsimons, J.D. 1996. The significance of man-made structures for lake trout spawning in the Great Lakes: are they a viable alternative to natural reefs? Canadian Journal of Fisheries and Aquatic Sciences 53(Suppl.1):142-151.

Goodyear, D.D., T.A. Edsall, D.M. Dempsey, G.D. Moss and P.E. Polinski. 1982. Atlas of the spawning and nursery areas of the Great Lakes fishes. Vol. IV: Lake Ontario. U.S. Fish and Wildlife Service Technical Report FWS/OBS-82/52, Washington, DC.

Grapentine, L.C. 2001. Enhanced identification of biological impairment by use of habitat - benthic community models in assessments of disturbed sites. Page 41, In: Abstracts from the 44th conference on Great Lakes Research, Great Lakes Science: Making it Relevant. June 10-14, 2001.

Harris, H.J., V.A. Harris, H.A. Reiger and Rapport, D.J. 1988. Importance of the nearshore area for sustainable redevelopment in the Great Lakes with observations on the Baltic Sea. Ambio 17:112-120.

Hartman, W. 1973. Effects of exploitation, environmental changes and new species on the fish habitats and resources of Lake Erie. Great Lakes Fishery Commission Technical Report No. 22, Ann Arbor, MI.

Hayes, D.B. 1996. Linking fish habitat to their population dynamics. Canadian Journal of Fisheries and Aquatic Science 53(Suppl.1):383-390.

Herdendorf, C.E. 1987. The ecology of the coastal marshes of Lake Erie: a community profile. National Wetlands Research Center, Fish and Wildlife Research Center, U. S. Department of Interior, Biological report 85(7.9).

Herdendorf, C.E. 1990. Great Lakes estuaries. Estuaries 13:493-503.

Herdendorf, C.E., S.M. Hartley and M.D. Barnes (eds.). 1981a. Fish and wildlife resources of the Great Lakes coastal wetlands with in the United States. Vol. 1: Overview. United States Fish and Wildlife Service, Office of Biological Services Technical Report FWS/OBS-81/02-v1, Washington, D.C.

Herdendorf, C.E., S.M. Hartley and M.D. Barnes (eds.). 1981b. Fish and wildlife resources of the Great Lakes coastal wetlands with in the United States. Vol. 2: Lake Ontario. United States Fish and Wildlife Service, Office of Biological Services Technical Report FWS/OBS-81/02-v2, Washington, D.C.

Herdendorf, C.E., S.M. Hartley and M.D. Barnes (eds.). 1981c. Fish and wildlife resources of the Great Lakes coastal wetlands with in the United States. Vol. 3: Lake Erie. United States Fish and Wildlife Service, Office of Biological Services Technical Report FWS/OBS-81/02-v3, Washington, D.C.

Herdendorf, C.E., S.M. Hartley and M.D. Barnes (eds.). 1981d. Fish and wildlife resources of the Great Lakes coastal wetlands with in the United States. Vol. 4: Lake Huron. United States Fish and Wildlife Service, Office of Biological Services Technical Report FWS/OBS-81/02-v4, Washington, D.C.

Herdendorf, C.E., S.M. Hartley and M.D. Barnes (eds.). 1981e. Fish and wildlife resources of the Great Lakes coastal wetlands with in the United States. Vol. 5: Lake Michigan. United States Fish and Wildlife Service, Office of Biological Services Technical Report FWS/OBS-81/02-v5, Washington, D.C.

Herdendorf, C.E., S.M. Hartley and M.D. Barnes (eds.). 1981f. Fish and wildlife resources of the Great Lakes coastal wetlands with in the United States. Vol. 6: Lake Superior. United States Fish and Wildlife Service, Office of Biological Services Technical Report FWS/OBS-81/02-v6, Washington, D.C.

Nearshore Fisheries Habitat Bibliography

Hintz, A. 1994. Observations of the nearshore fish community in the U.S. waters of northern Lake Huron, 1993. U.S. Fish and Wildlife Service Technical Report. 12pp.

Holmes, J.A. and T.W. Whillans. 1984. Historical fisheries of Hamilton Harbor. Canadian Technical Report of Fisheries and Aquatic Science 1257.

Hook, T.O., N.M. Eagan and P.W. Webb. 2001. Habitat and human influences on larval fish assemblages in northern Lake Huron coastal marsh bays. Wetlands 21:281-291.

Horns, W.H. 1991. Site-specific substrate mapping of Julian's reef. Illinois Natural History Survey Aquatic Ecology Technical Report 91/7, Springfield, IL.

Johnson, D.L., W.E. Lynch and T.W. Morrison. 1997. Fish communities in a diked Lake Erie wetland and an adjacent undiked area. Wetlands 17:43-54.

Johnson, D.L. 1989. Lake Erie wetlands: fisheries considerations. Pages 257-274, In: Lake Erie and its estuarine systems, K.A. Krieger (ed.). Estuary-of-the-Month Seminar. U.S. Department of Commerce, Washington, D.C.

Jude, D. J. and F. J. Tesar. 1985. Recent changes in the inshore forage fish of Lake Michigan. Canadian Journal of Fisheries and Aquatic Sciences 42: 1154-1157.

Jude, D.J. and J. Papas. 1992. Fish utilization of Great Lakes coastal wetlands. Journal of Great Lakes Research 18:651-672.

Jude, D.J., C.P. Madenjian, P.J. Schneeberger, H.T. Tin, P.J. Mansfield, T.L. Rutecki, G.E. Noguchi and G.R. Heufelder. 1982. Adult, juvenile, larval fish populations in the vicinity of the J.H. Campbell power plant, 1981, with special reference to the effectiveness of wedge-wire intake screens in reducing entrainment impingement of fish. Great Lakes Resource Division Special Report 96, University of Michigan, Ann Arbor, MI.

Jude, D.J., H.T. Tin, G.R. Heufelder, P.J. Schneeberger, C.P. Madenjian, T.L. Rutecki, P.J. Mansfield, N.A. Auer and G.E. Noguchi. 1981. Adult juvenile larval fish populations in the vicinity of the J.H. Campbell power plant, eastern Lake Michigan, 1977-1980. Great Lakes Resource Division Special Report 86, University of Michigan, Ann Arbor, MI.

Jude, D.J., Tesar, F.J., Tomlinson, J.C., Miller, T.J., Thurber, N.J., Godun, G.G., J.A. Dorr III. Inshore Lake Michigan fish populations near the D.C. Cook nuclear power plant during preoperational years-1973, 1974. Great Lakes Resource Division Special Report 71, University of Michigan, Ann Arbor, MI.

Kelch, D.O.,F.L. Snyder and J.M. Rutter. 1999. Artificial reefs in Lake Erie: biological impacts of habitat alteration. American Fisheries Society Symposium, 22:335-347.

Kelso, J.R.M. and C.K. Minns. 1996. Is fish species richness at sites in the Canadian Great Lakes the result of local or regional factors? Canadian Journal of Fisheries and Aquatic Sciences 53(Suppl.1):175-193.

Kelso, J.R.M., R.J. Steedman and S. Stoddart. 1996. Historical causes of change in Great Lakes fish stocks and the implications for ecosystem rehabilitation. Canadian Journal of Fisheries and Aquatic Sciences 53(Suppl.1):10-19.

Kitchell, J.F., L.A. Eby, X. He, D.E. Schindler and R.A. Wright. 1994. Predator-prey dynamics in an ecosystem context. Journal of Fish Biology 45(Suppl.A): 209-226.

Klarer, D.M., K.A. Krieger, R.T. Heath and C.E. Herdendorf. 1990. Priorities for Great Lakes coastal wetlands research: recommendations of a planning conference. Pages 301-303, In: Proceedings of an International Symposium: Wetlands of the Great Lakes Protection and Restoration Policies; Status of the Science, J. Kusler and R. Smardon (eds.). Association of State Wetland Managers, Niagara Falls, NY.

Klarer, D.M., K.A. Krieger, R.T. Heath and C.E. Herdendorf. 1992. A call for research on Great Lakes Coastal Wetlands. Journal of Great Lakes Research 18:525-528.

Koonce, J. F., W. D. N. Busch and T. Czapla. 1996. Restoration of Lake Erie: contribution of water quality and natural resource management. Canadian Journal of Fisheries and Aquatic Sciences 53(Suppl.1): 105-112.

Kraft, C. E. and B. L. Johnson. 1992. Fyke-net and gill-net size selectivities for yellow perch in Green Bay, Lake Michigan. North American Journal of Fisheries Management 12: 230-236.

Nearshore Fisheries Habitat Bibliography

Lane, J.A., C.B. Portt and C.K. Minns. 1996. Spawning habitat characteristics of Great Lakes fishes. Canadian Manuscript Report of Fisheries and Aquatic Sciences. 53pp.

Langlois, T.M. 1941. Two processes operating for the reduction in abundance or elimination of fish species from certain types of water areas. Transactions of the North American Wildlife Conference 6:189-201.

Lawrie, A.H. and J. F. Rahrer. 1973. Lake Superior: a case history of the lake and its fisheries. Great Lakes Fishery Commission Technical report No. 19, Ann Arbor, MI.

Leslie, J.K. and C.A. Timmins. 1994. Ecology of young-of-the-year fishes in Severn Sound, Lake Huron. Canadian Journal of Zoology-Revue Canadienne De Zoologie 72:1887-1897.

Leslie, J.K. and C.A.Timmins. 1993. Distribution, density, and growth of young-of-the-year fishes in Mitchell Bay, Lake St Clair. Canadian Journal of Zoology-Revue Canadienne De Zoologie 71:1153-1160.

Lester, N.P., W.J. Dunlop and C.C. Wilcox. 1996. Detecting changes in the nearshore fish community. Canadian Journal of Fisheries and Aquatic Science 53(Suppl.1):391-402.

Lewis, C.A., N.P. Lester, A.D. Bradshaw. J.E. Fitzgibbon, K. Fuller, L. Hakanson and C. Richards. 1996. Considerations of scale in habitat conservation and restoration. Canadian Journal of Fisheries and Aquatic Sciences 53(Suppl.1):440-445

Liston, C.R. and S. Chubb. 1985. Relationships of water level fluctuations and fish. Pages 123-140, In: Coastal Wetlands, H.H. Prince and F.M. D'Itri (eds.). Lewis Publishers, Chelsea, Michigan, USA.

Lucchesi, D. O. 1988. A biological analysis of the yellow perch population in the Les Cheneaux Islands, Lake Huron. Michigan Department of Natural Resources Fisheries Research Report 1958, Fisheries Research Institute, Ann Arbor, MI.

Lyon, J.G., and R.D. Drobney. 1984. Lake level effects as measured from aerial photos. J. Surv. Eng. 110:103-111.

MacCallum, M.E. 1989. The Nipigon River: a retrospective summary of information about the fish community. Technical Report No.6, North Shore of Lake Superior Remedial Action Plan, Thunder Bay, Ontario.

MacLeod, W.D., C.K. Minns, A. Mathers and S. Mee. 1995. An evaluation of biotic indices and habitat suitability scores for classifying littoral habitats. Canadian Manuscript Report of Fisheries and Aquatic Sciences 2334. 31 pp.

Manny, B. A., D. J. Jude and R. L. Eshenroder. 1989. Field test of a bioassay procedure for assessing habitat quality on fish spawning grounds. Transactions of the American Fisheries Society 118: 175-182.

Maynard, L. and D.Wilcox. 1996. Coastal wetlands of the Great Lakes: State of the Lakes Ecosystem Conference working Paper. Environment Canada and the United States Environmental Protection Agency Technical Report EPA 905-D-96-001c.

Minns, C.K. 1990. Effect of habitat features on fish production in littoral areas of the Bay of Quinte. Pages 103-112, In: Bay of Quinte Remedial Action Plan 1990 Project, Quinte Annual Report, Monitoring Report No. 2.

Minns, C.K. and J.R.M. Kelso. 2000. No! It is time for a Great Lakes ecosystem management agreement that subsumes the Great Lakes water quality agreement. Journal of Great Lakes Research 26:1-2.

Minns, C.K., R.G. Randall, J.E. Moore and V.W. Cairns. 1996. A model simulating the impact of habitat supply limits on northern pike, *Esox Lucius*, in Hamilton Harbour, Lake Ontario. Canadian Journal of Fisheries and Aquatic Sciences 53(Suppl.1):20-34.

Minns, C.K., J.R.M. Kelso and R.G. Randall. 1996. Detecting the response of fish to habitat alterations in freshwater ecosystems. Canadian Journal of Fisheries and Aquatic Sciences 53(Suppl.1):403-414.

Minns, C.K., V.W. Cairns, R.G. Randall and J.E. Moore. 1994. An index of biotic integrity (IBI) for fish assemblages in the littoral-zone of Great Lakes Areas of Concern. Canadian Journal of Fisheries and Aquatic Sciences 51:1804-1822.

Minns, C.K., V.W. Cairns, R.G. Randall, A. Crowder and A. McLaughlin. 1993. Macrophyte surveys of littoral fish habitat in Great Lakes Areas of Concern: Bay of Quinte, Hamilton Harbour, and Severn Sound-1988 to 1992. Canadian Technical Report of Fisheries and Aquatic Science 1936.

Nearshore Fisheries Habitat Bibliography

Minns, C.K., J.R.M. Kelso and W. Hyatt. 1978. Spatial distribution of nearshore fish in the vicinity of two thermal generating stations, Naticoke and Douglas Point, on the Great Lakes. Journal of the Fisheries Research Board of Canada. 35:885-892

Minns, C. K and D. A. Hurley. 1988. Effects of net length and set time of fish catches in gill nets. North American Journal of Fisheries Management 8: 216-223.

Moore, J.E., C.K. Minns, B. Valere and R.G. Randall. 1998. Productive capacity of Great Lakes nearshore fish habitats: Design and implementation of an electrofishing survey database. Canadian Manuscript Report of Fisheries and Aquatic Science 2441. 38 pp.

Navarro, J. E. and D. L. Johnson. 1992. Ecology of stocked northern pike in two Lake Erie controlled wetlands. Wetlands 12: 171-177.

Nelson, D.D. and R.A. Cole. 1975. The distribution abundance of larval fishes along the western shore of Lake Erie at Monroe, Michigan. Institute of Water Resources Technical Report 32.4, Michigan State University, East Lansing, MI.

Nester, R.T. and T. P. Poe. 1982. Effects of beach nourishment on the nearshore environment in Lake Huron at Lexington Harbor. Miscellaneous Report, U.S. Army Coastal Engineering Research Center. 59pp.

O'Gorman, R. 1983. Distribution and abundance of larval fish in the nearshore waters of western Lake Huron. Journal of Great Lakes Research 9:14-22.

Organ, W.L., G.L. Towns, M.O. Walter, R.B. Pelletier and D.A. Riege. 1978. Past and presently known spawning grounds of fishes in the Michigan coastal waters of the Great Lakes. Michigan Department of Natural Resources, Fisheries Technical Report No. 78-7, Lansing, MI.

Paneck, F.M. 1979. Cumulative effects of small modifications to habitat. Fisheries 4:54-57.

Peck, J.W. 1979. Utilization of traditional spawning reefs by hatchery lake trout in the upper Great Lakes. Michigan Department of Natural Resources, Fisheries Report No. 1871, Lansing, MI.

Perrone Jr. M., P.J. Schneeberger and D.J. Jude. 1983. Distribution of larval yellow perch (*Perca Flavescens*) in nearshore waters of southeastern Lake Michigan. Journal of Great Lakes Research 9:517-522.

Poe, T.P., C.O. Hatcher, C.L. Brown and D.W. Schloesser. 1986. Comparison of species composition and richness of fish assemblages in altered and unaltered littoral habitats. Journal of Freshwater Ecology 3:525-536.

Randall, R.G. and C.K. Minns. 2002. Comparison of a habitat productivity index (HPI) and an index of biotic integrity (IBI) for measuring the productive capacity of fish habitat in nearshore areas of the Great Lakes. Journal of Great Lakes Research 28:240-255.

Randall, R.G., C.K. Minns, V.W. Cairns and J.E. Moore. 1996. The relationship between an index of fish production and submerged macrophytes and other habitat features at three littoral areas in the Great Lakes. Canadian Journal of Fisheries and Aquatic Sciences 53(Suppl.1):35-44.

Randall, R.G., C.K. Minns, V.W. Cairns and J.E. Moore. 1993. Effect of habitat degradation on the species composition and biomass of fish in Great Lakes Areas of Concern. Canadian Technical Report of Fisheries and Aquatic Science 1941.

Regier, H.A., V.C. Applegate and R.A. Ryder. 1969. The ecology and management of the walleye in western Lake Erie. Great Lakes Fishery Commission Technical Report No. 15, Ann Arbor, MI.

Robillard, S.R. and J.E. Marsden. 2001. Spawning substrate preferences of yellow perch along a sand-cobble shoreline in southwestern Lake Michigan. North American Journal of Fisheries Management 21:208-215.

Ryder, R.A. and S.R. Kerr. 1989. Environmental priorities: placing habitat in hierarchic perspective. Canada Special Publication Fisheries and Aquatic Science 65.

Savino, J.F., M.T. Bur, M.A. Blouin, B.M. Davis, M.C. Fabrizio, G.W. Kennedy, J.E. McKenna and T.N. Todd. 2001. Critical habitats for young fishes in coastal areas of west-central Lake Erie. Abstracts from the 44th Conference on Great Lakes Research, June10-14, 2001. Great Lakes Science: making it relevant, p. 118.

Savino, J. F., M. A. Blouin, B. M. Davis, P. L. Hudson, T. N. Todd and G. W. Fleischer. 1994. Effects of pulsed turbidity and vessel traffic on lake herring eggs

and larvae. Journal of Great Lakes Research 22: 436-443.

Schierow, L.J. and G. Chesters. 1988. Evaluation of the Great-Lakes nearshore index. Water Research 22:269-277.

Sierszen, M. E., J. R. Keough and C. A. Hagley. 1996. Trophic analysis of ruffe (*Gymnocephalus cernuus*) and white perch (*Morone Americana*) in a Lake Superior coastal food web using stable isotope techniques. Journal of Great Lakes Research 22: 436-443.

Sly, P.G. 1984. Habitat (Great Lakes, N.A.). Pages 33-39, In: Strategies for rehabilitation of lake trout in the Great Lakes, Proceedings of a conference on lake trout research, August 1983. Great Lakes Fishery Commission Technical Report No. 40.

Sly, P.G. and W.D. Busch (eds.). 1992. Introduction to the process, procedure, and concepts used in the development of an aquatic habitat classification system. CRC Press, Inc., Boca Raton, FL.

Smith, P.G. 1986. Toward the protection of Great Lakes natural heritage. IAGLR-86 Program. International Association for Great Lakes Research, 29th conference, May 26-29, 1986. 49pp.

Spangler, G. R. and J. J. Collins. 1992. Lake Huron fish community structure based on gill net catches corrected for selectivity and encounter probability. North American Journal of Fisheries Management 12: 585-597.

Steedman, R.J., T.H. Whillans, A.P. Behm, K.E. Bray, K.I. Cullis, M.M. Holland, S.J. Stoddart and R.J. White. 1996. Use of historical information for conservation and restoration of Great Lakes aquatic habitat. Canadian Journal of Fisheries and Aquatic Sciences 53 (Suppl.1):415-423.

Steedman, R.J., T.H. Whillans, A.P. Behm, K.E. Bray, K.I. Cullis, M.M. Holland, S.J. Stoddart and R.J. White. 1996. Use of retrospective information for aquatic habitat. Canadian Journal of Fisheries and Aquatic Science 53 (Suppl.1).

Steedman, R.J. and H.A. Regier 1990. Ecological bases for an understanding of ecosystem integrity in the Great Lakes basin. In: An ecosystem approach to the integrity of the Great Lakes in turbulent times, C.J. Edwards and H.A. Regier (eds.). Great Lakes Fishery Commission Special Publication No. 90-4, Ann Arbor, MI.

Stephenson, T.D. 1990. Fish reproductive utilization of coastal marshes of Lake-Ontario near Toronto. Journal of Great Lakes Research 16:71-81.

Swanson, B.L. 1982. Artificial turf as a substrate for incubating lake trout eggs on reefs in Lake Superior. Progressive Fish Culture 44:109-111.

Taylor, W.W., Smale, and M.H. Freeberg. 1987. Biotic and abiotic determinants of lake whitefish (*Coregonus clupea formis*) recruitment in northeastern Lake Michigan. Canadian Journal of Fisheries and Aquatic Sciences 44 (Suppl.2):313-323.

Trautman, M.B. 1981. The fishes of Ohio. Ohio State University, Ohio Sea Grant Program and Center for Lake Erie Area Research, Columbus, OH.

Tufescu, M.V.A. and T.V. Tufescu. 1996. Ratios of expected values (REX), a method for impact evaluation of thermal discharges on the fish community in the Pickering littoral waters of Lake Ontario. Hydrobiologia 328:9.

U.S. Fish and Wildlife Service. 1995. Great Lakes fishery restoration study. U.S. Fish and Wildlife Service Technical Report, Department of the Interior, Washington, D.C.

Weaver, M.J., J.J. Magnuson and M.K. Clayton. 1997. Distribution of littoral fishes in structurally complex macrophytes. Canadian Journal of Fisheries and Aquatic Sciences 54:2277-2289.

Wells, L. 1973. Distribution of fish fry in nearshore waters of southeastern and east-central Lake Michigan, May-August 1972. Administrative Report, Great Lakes Fisheries Laboratory, Ann Arbor, MI.

Wells, L. and A. McLain. 1973. Lake Michigan: man's effects on native fish stock and other biota. Great Lakes Fishery Commission Technical Report No. 20, Ann Arbor, MI.

Werner, E.E., D.J. Hall. D.R. Laughlin, D.J. Wagner, L.A. Wilsmann and F.C. Funk. 1977. Habitat partitioning in a freshwater fish community. Journal of Fisheries Research Board of Canada 34:360-370.

Wilcox, D. A., J. E. Meeker, P. L. Hudson, B. J. Armitage, M. G. Black and D. G. Uzarski. (In Review). Development of evaluation criteria to assess and protect the biological integrity of Great Lakes wetlands.

Whillans, T.H. 1996. Historic and comparative perspectives on rehabilitation of marshes as habitat for fish in

the lower Great Lakes Basin. Canadian Journal of Fisheries and Aquatic Sciences 53(Suppl.1):58-66.

Whillans, T.H. 1990. Assessing threats to fishery values of Great Lakes wetlands. Pages 156-164, In: Proceedings of the International Wetland Symposium, Wetlands of the Great Lakes: Protection, Restoration, Policies and Status of the Science, J. Kusler and R. Smardon (eds). Association of State Wetland Managers, Inc., Berne, N.Y.

Whillians, T.H. 1987. Wetlands and aquatic resources. Pages 321-356, In: Canadian Aquatic Resources, M.C. Healey and R.R. Wallace (eds.). Canadian Bulletin of Fisheries and Aquatic Sciences 215.

Whillans, T.H. 1985. Related long term trends in fish and vegetation ecology of Long Point Bay and marshes, Lake Erie. Ph.D. thesis. Department of Zoology, University of Toronto, Toronto, Ontario.

Whillans, T.H. 1992. Assessing threats to fishery values of Great Lakes wetlands. Pages 156-165, In: Proceedings of the International Wetland Symposium, Wetlands of the Great Lakes: Protection, Restoration, Policies and Status of the Science, J. Kusler and R. Smardon (eds.). Association of State Wetland Managers, Inc., Berne, N.Y.

Whillans, T.H. 1982. Changes in marsh area along the Canadian shore of Lake Ontario. Journal of Great Lakes Research 8:570-577

Whillans, T.H. 1979. Historic transformations of fish communities in three Great Lakes bays. Journal of Great Lakes Research 5:195-215.

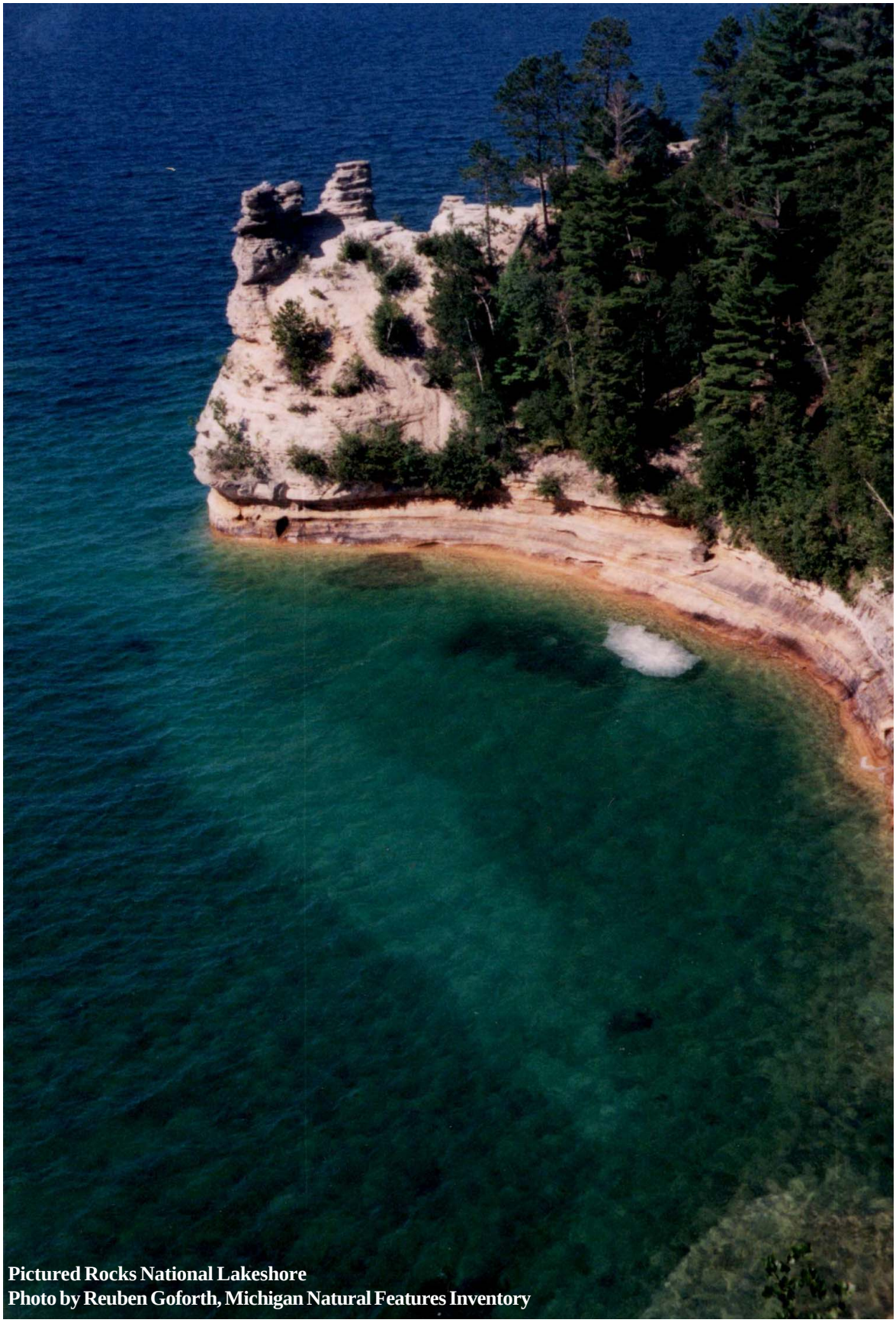
Wilcox, D.A. 1995. The role of wetlands as nearshore habitat in Lake Huron. Pages 223-245, In: The Lake Huron System: Ecology, Fisheries and Management, M.Munawar, T. Edsall and J. Leach (eds.). SPB Academic Publishing, Amsterdam, The Netherlands.

Acknowledgements

We would like to thank Jack Bails and Mark Coscarelli of the Great Lakes Fishery Trust for working with us to develop the idea and framework for this workshop. The Great Lakes Fishery Trust provided the generous financial support that made this workshop possible. We would also like to thank the members of the steering committee, Archie Martell (Little River Band of Ottawa Indians), Sharon Hanshue (Michigan Department of Natural Resources, Fisheries Division), Dr. Tom Coon (Michigan State University), Karen Rodriguez (U.S. Environmental Protection Agency, Great Lakes National Program Office), and Mark Holey (U.S. Fish and Wildlife Service) for their help in further refining the workshop format and other details. Tamara Lipsey (now with the Michigan Department of Environmental Quality) provided extensive organizational support during the early stages of the workshop, including assembling the bibliography, developing a list of potential participants, distributing a preliminary workshop announcement, and producing an advanced draft of the pre-workshop survey. Peter Badra (Michigan Natural Features Inventory) provided critical technical and computer support during the workshop. Finally, we would like to thank all of the survey and workshop participants for their intellectual contributions to the workshop, and we especially thank those participants who contributed oral and poster presentations as part of the workshop.

Lake Superior nearshore area along Pictured Rocks National Lakeshore near Munising, Michigan. Photo by Reuben Goforth.

Lake Superior shoreline near Porcupine Mountains State Wilderness Park, Michigan. Photo by David Stagliano.



Pictured Rocks National Lakeshore
Photo by Reuben Goforth, Michigan Natural Features Inventory

MICHIGAN STATE UNIVERSITY EXTENSION

Great Lakes Fishery Trust

Michigan Natural Features Inventory