USGS
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Great Lakes Science Center

Center Review Book

February, 2004

GLSC Center Review Book
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Introduction

GLSC Strategic Review and Administrative Review Agenda

* Sessions open to all Center staff

Monday, February 23, 2004 (at the GLSC)

	9:00-2:00	Regional review of Center science management files
	1:00-1:30	Administrative Panel meet with Center Director
	1:30-2:00	Administrative Panel meet with Center Director and Administrative Staff
	2:00-5:00	Administrative review (Administrative Panel)
	2:00-3:00	Management Panel in-briefing (David Bornholdt)
	3:00-5:00	Facility tour (Management Panel, Administrative Panel)
	5:00-6:00	Additional discussions as needed

Tuesday, February 24, 2004 (Administrative at GLSC, all other activities at Crowne Plaza)

	8:00-5:00	Administrative review (Administrative Panel)
	8:00-9:00	Management Panel members' non-review work time
*	9:00-9:30	Introductions (David Bornholdt, Leon Carl)
*	9:30-11:30	Overview & Perspectives, Eastern Region Office Regional Perspective (Suzette Kimball, Bonnie McGregor) National Perspective (Susan Haseltine) Question and answer period
*	11:30-1:00	Lunch
*	1:00-1:30	Center Vision (Leon Carl)
*	1:30-2:00	Center Management (Geraldine Cooksey)
*	2:00-2:30	Facilities and Safety (Charles Wootke, Carol Edsall)
*	2:30-3:00	Research Vessels (Joseph Walters)
	3:00-6:00	Management Panel Discussions (closed; Review Team)
*	6:00-7:30	Social (posters, cash bar; ALL INVITED)

Wednesday, February 25, 2004 (Administrative at GLSC, all other activities at Crowne Plaza)

	8:00-9:00	Management Panel members' non-review work time
	8:00-5:00	Administrative review (Administrative Panel)
*	9:00-9:30	Biological Informatics (Scott Nelson)

*9:30-10:00 Contaminant Biology (James Hickey)

*10:00-10:30 Break

*10:30-11:00 Terrestrial, Freshwater and Marine Ecosystems (Douglas Wilcox)

*11:00-11:30 Fisheries: Aquatic And Endangered Resources (James Johnson)

*11:30-12:00 Invasive Species (S. Jerrine Nichols)

* 12:00-1:00 Lunch

* 1:00-2:00 Status & Trends: Deep Water Science Program (Jacqueline Savino)

* 2:00-2:30 GLSC Field Stations: Problems, Prospects, and Potential (Richard Whitman, Jason Stockwell)

2:30-3:00 One-On-One discussions

3:00-6:00 Management Panel discussions (closed; Review Team)

Thursday, February 26, 2004 (Administrative at GLSC, all other activities at Crowne Plaza)

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8:00-5:00 Administrative review (Administrative Panel)

* 9:00- 9:30 Sea Lamprey Control
Hammond Bay Biological Station (Roger Bergstedt)

* 9:30-10:00 Communicating Our Science (Thomas Todd)
Internal, External

*10:00-10:30 Break

*10:30-11:30 New Directions/Partnerships

* 11:30-1:00 Lunch

* 1:00-2:00 One-On-Ones

2:00-3:30 Management Panel discussions (closed), closeout preparation

3:30-6:00 Staff closeout preparation

Friday, February 27, 2004 (Administrative at GLSC, all other activities at Crowne Plaza)

7:00-8:00 Breakfast close-out (Leon Carl, Suzette Kimball, David Bornholdt)

8:00-9:00 Management Panel members non-review work time

9:00-10:00 Close-out for Center Directorate (David Bornholdt, Suzette Kimball, Leon Carl)

*10:00-12:00 Center close-out, questions and answers (Management panel, all staff)

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Center Overview

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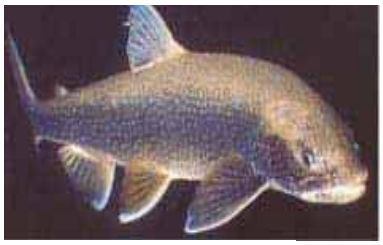
Great Lakes Science Center Overview

Mission

The **Great Lakes Science Center (GLSC)** meets the Nation's need for scientific information for restoring, enhancing, managing, and protecting the living resources and their habitats in the Great Lakes. Since 1927 the Center's research has provided critical information for the sound management of Great Lakes fish populations and other important natural resources (e.g. coastal wetlands and aquatic biota) in the basin.

GLSC staff have a wealth of expertise in fish stock assessment and community dynamics, aquatic habitat and food web interactions, nearshore and coastal wetlands ecology, terrestrial ecology, and exotic species.



A lake trout, a valuable Great Lakes sport, commercial and tribal fish.

The USGS, as the science arm of the Department of Interior, is federally mandated to conduct fishery research on the Great Lakes. The GLSC operates five large research vessels, one on each lake. The vessels are equipped for fish population assessment studies, as well as for limnological and habitat sampling.

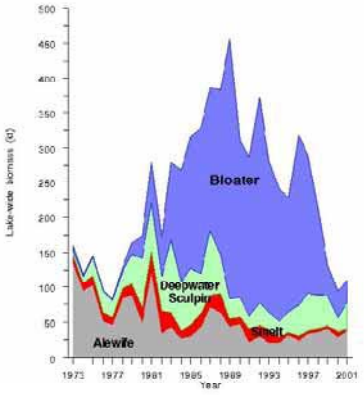
Scientific Capabilities

The GLSC uses an interdisciplinary approach, teams, and collaboration to provide the information needed to solve the complex biological issues (e.g., exotic species impacts) and natural resource management problems (e.g., fisheries allocations) facing the Great Lakes. Working in partnership with resource management agencies, GLSC provides unbiased scientific information on Great Lakes biological and habitat resources, and determines the effectiveness of resource management and ecological restoration efforts. All eight Great Lakes states, tribal fishery management authorities, Canadian federal and provincial authorities and U.S. federal partners are the Center's main cooperators.

The Center operates research vessels for fisheries and habitat research. (R/V Kiyi)

Long-term Fishery Research

The GLSC is federally mandated to conduct long-term studies on the fisheries resources of the Great Lakes. The Center has a long history of partnerships and interactions with state, tribal, and U.S and Canadian federal agencies. Each year the GLSC performs annual fish stock assessments to provide these agencies with the information they require to manage the fisheries.



Resource managers use information on prey fish abundance to establish fishing quotas and stocking levels of game fish.

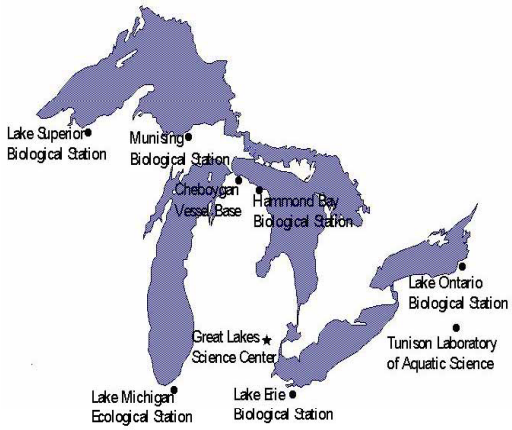
Other GLSC priorities include:

- Prey fish assessments for managing trout, salmon, and whitefish fisheries.
- Population dynamics and habitat ecology of native fishes with emphasis on lake trout restoration.
- Ecological effects of exotic species (zebra mussels, ruffe, gobies and sea lamprey).
- Predictive modeling to assist managers in their development of harvest quotas, stocking decisions, and the protection of sustainable fisheries.
- Chemical stressor interferences to trophic transfer processes in food and energy webs.
- Contaminant trends in lake trout and walleye and their major prey.
- Global climate change and effects of water level fluctuations on aquatic organisms and their habitats.

Field Locations

The Center is located on the North Campus of the University of Michigan where two-thirds of its 100 staff members are located. Eight field stations are located throughout the Great Lakes basin. Extensive laboratories are located at the Center and its field stations. Two field stations, located at Munising, MI and Porter, IN focus on coastal issues of concern to the National Park Service.

Lake Superior Biological Station, Ashland, WI
The home of the R/V Kiyi, the Center's newest and largest research vessel, this station focuses its research on the biology, population dynamics, stock delineation, and yield prediction of Lake Superior fishes with emphasis on lake trout, lake herring, and other forage fishes, as well as on the ecological effects of the invading ruffe on native species and ecosystems.



Lake Erie Biological Station, Sandusky, OH
Research focuses on changes in the population dynamics of walleye, yellow perch, lake trout and other key predator and forage species. The R/V Musky II operates from this station, with coordinated annual surveys conducted in the western and central basins.

Lake Ontario Biological Station, Oswego, NY
Primary research at this station involves assessing prey fishes to determine Lake Ontario's capacity to support stocked trout and salmon and evaluate restoration of naturally reproducing lake trout. Lake research is based off of the R/V Kaho, which is closely coordinated with jurisdictional and academic partners.

Cheboygan Vessel Base, Cheboygan, MI
The Cheboygan Vessel Base provides primary research vessel capability aboard the R/V Grayling across Lake Huron. The R/V Siscowet is temporarily servicing Lake Michigan from Cheboygan and will be replaced by the R/V Sturgeon when renovations are complete. A primary research activity is assessing the forage base for salmonids and other fishes of economic importance.

Tunison Laboratory of Aquatic Science, Cortland, NY
The Tunison Laboratory conducts research to foster sound management and stewardship of aquatic ecosystems and assist in restoring depleted species, such as the Atlantic salmon, in the watersheds of Lake Ontario and the St. Lawrence River.

Hammond Bay Biological Station, Millersburg, MI
Research at the Hammond Bay Biological Station focuses on development of alternative methods of controlling sea lamprey populations, refinement of existing methods, and on the effects of sea lampreys on Great Lakes fishes. The station participates in a formal research partnership with the Great Lakes Fishery Commission and Michigan State University.

Lake Michigan Ecological Station, Porter, IN
Scientists at this station focus on issues relevant to public lands, trust species, and shared natural resources. Research is often a joint venture with other agencies such as the National Park Service, U.S. EPA, regional universities, and state agencies. Research includes long-term studies on population trends and changes within aquatic and terrestrial biological communities, analysis of the effectiveness of prescribed burns to maintain oak/savanna habitat, effects of contaminants on plants and animals, and studies on endangered and invasive species.

Munising Biological Station, Munising, MI
This station focuses on studies of disturbance regimes of Great Lakes coastal vegetation with an emphasis on exotic species, fire ecology in boreal forests and sand dune dynamics.


Crew at work on the R/V Kiyi

Great Lakes Science Center History

History

The Great Lakes Science Center (GLSC) traces its beginnings to 1871 when Congress, by joint resolution, established the United States Fish Commission and charged it with responsibility for investigations and inquiries concerning studies on the biological and physical problems of food fishes along the coasts and in the lakes of the United States. In addition, it was charged with conducting studies on fishing methods, compilation of fish catch and trade statistics, as well as the introduction and propagation of "useful food-fishes" throughout the nation.

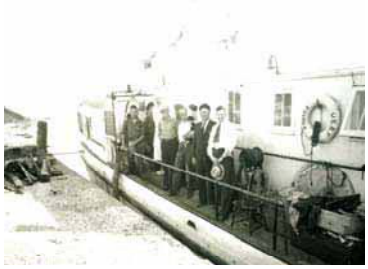
Initial investigations in the Great Lakes began in 1871 in Lake Michigan - the Lake with the longest shoreline within the United States and the largest number of

In 1932, a scientist weighs and measures chubs and lake trout. GLSC scientists do similar work today.

fisheries. The Fish Commission sponsored numerous independent studies in the Great Lakes throughout the late 19th and early 20th Century. These studies included fish stock assessments, basic biology, fish feeding, limnology, general ecology, and fish propagation. By Act of February 14th 1903, the U.S. Fish Commission and the Office of the Commissioner of Fish and Fisheries was placed in the newly created Department of Commerce and Labor and renamed the U.S. Bureau of Fisheries. In 1913, the Department of Labor was separated from the Department of Commerce that retained the U.S. Bureau of Fisheries. Beginning in 1917, the Bureau of Fisheries funded a continuous series of studies. Walter Koelz compiled commercial fishery statistics and ultimately published a milestone monograph on whitefishes of the Great Lakes. His assistant, John Van Oosten, conducted pioneering work on the age and growth of key Great Lakes species.

In 1927, the U.S Fish Commission established the Great Lakes Fishery Investigations as the program for Great Lakes fishery research that now resides at the GLSC, with John Van Oosten as its Director (numerous mentions in reports of the Bureau of Fisheries, 1927-1939). This program was started as a consequence of the furor generated by the collapse of the cisco fishery in Lake Erie in 1925. In 1939, the Department of Commerce's U.S. Bureau of Fisheries was transferred to the Department of Interior along with the Department of Agriculture's Bureau of Biological Survey to form the Fish and Wildlife Service within the Department of Interior (DOI).

By 1955, sea lamprey work at the Great Lakes laboratory was conducted under the authority of the Great Lakes Fishery Convention of 1954 in collaboration with



The crew and staff of the Fulmar, the Center's first research vessel, in 1932. Dr. John Van Oosten is at the far right.

the Great Lakes Fishery Commission. The Fish and Wildlife Act of 1956 created the U.S. Fish and Wildlife Service (USFWS) in DOI as well as its two bureaus, the Bureau of Commercial Fisheries and the Bureau of Sport Fisheries and Wildlife. The Act declares a National Fishery Policy that recognizes the Nation's fish, shellfish, and wildlife as a valuable renewable natural resource. The fishery investigations in the Great Lakes were transferred to the Bureau of Commercial Fisheries, and, in 1959, were renamed the Great Lakes Biological Laboratory.

An Executive Order by President Richard M. Nixon in 1970 transferred some of the fisheries activities of the Bureau of Commercial Fisheries to the newly established National Oceanographic

and Atmospheric Administration (NOAA) in the Department of Commerce. Most specifically, all freshwater fishery functions and research, especially those relating to the Great Lakes, remained with the Department of Interior and were re-

The Center operates research vessels for fisheries and habitat research. (R/V *Grayling)*

named the Great Lakes Fishery Laboratory. In 1970, the Great Lakes Fishery Laboratory conducted research across all the Great Lakes in the areas of: fish stock assessment; fish population dynamics; zooplankton and phytoplankton distribution and abundance; physical limnology; benthic invertebrate distribution and abundance; food webs and fish feeding ecology; nutrient dynamics and bioenergetics; invasive species; habitat degradation and ecology; contaminants; fish tagging; fish physiology; and biometrics.

The Great Lakes Fishery Laboratory continued its mandate for biological research under the Bureau of Sport Fisheries and Wildlife until 1974 when the Bureau was wrapped into the general structure of the USFWS. The Laboratory renamed the National Fisheries Research Center – Great Lakes in 1987. During the 1980s the Center added wetlands work to its research areas.

The biological research functions of the Department of Interior were reorganized by Secretarial Order in September 1993 under the newly created National Biological Survey (NBS, renamed the National Biological Service in 1995). The biological research functions of the USFWS and the National Park Service (NPS) in the Great Lakes were consolidated under the management of the National Fisheries Research Center - Great Lakes that was renamed the Great Lakes Science Center in 1994. The addition of biologists from NPS expanded GLSC's research capabilities into terrestrial and wetland ecosystems and augmented the previous programs that had existed at the Center.

A protected embayment wetland

A House-Senate Conference Committee directed the merger of NBS into the U.S. Geological Survey in their Report of Sept. 21, 1995 to be effective in fiscal year 1996. The former NBS became the Biological Resources Division (BRD, later Discipline) of USGS. Reorganizations within USGS gave the GLSC a field station at Cortland, New York (Tunison Laboratory of Aquatic Science), as well as the loss of one of the former NPS field stations at International Falls, Minnesota.

The diverse biological work of the GLSC continues under a number of pertinent authorities. Congress has authorized several additional appropriations to the GLSC's base budget in the last few fiscal years to allow it to carry out its biological mandates. These appropriations clearly demonstrate the relevance of fisheries research at the federal level and provide for the continuance of the Great Lakes fisheries research program in DOI/USGS/BRD.

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Great Lakes Science Center Historical Time Line

1871 – U.S. Fish Commission formed – Spencer Baird, first Commissioner of Fish and Fisheries

1872 – U.S. Fish Commission initiates propagation work with Great Lakes whitefish.

1880 – 1895 U.S. Fish Commission opens whitefish hatcheries in Alpena, MI, Duluth, MN, Put-in-Bay, OH, Cape St. Vincent, NY, Detroit and Sault Ste. Marie, MI.

1901 – U.S. Fish Commission research vessel *Shearwater* on the Great Lakes.

1903 – U.S. Fish Commission merged into the new Department of Commerce and Labor and renamed the U.S. Bureau of Fisheries.

1920 – Walter Koelz hired by U.S. Bureau of Fisheries to compile information on Great Lakes fisheries. Housed in Museum of Zoology, the University of Michigan.

1921 – John Van Oosten hired as assistant to Walter Koelz

1925 – John Van Oosten takes charge of fisheries investigations for the U.S. Bureau of Fisheries when Walter Koelz leaves on an Arctic expedition.

1927 – 1. U.S. Bureau of Fisheries officially forms a research team under the direction of John Van Oosten, Great Lakes Fishery Investigations, in response to the collapse of the lake herring fishery in Lake Erie.
2. Walter Koelz completes his monograph, "Coregonid Fishes of the Great Lakes" published in 1929.

1928 – 1. Research vessel *Shearwater* sent to eastern Lake Erie by U.S. Bureau of Fisheries.
2. Institute for Fisheries Research founded at the University of Michigan with Walter Koelz as its first Ichthyologist – a state funded agency.

1930 – Research vessel *Fulmar* acquired for fishery and limnology studies on Lake Michigan.

1940 – Bureau of Fisheries and Bureau of Biological Survey are merged by Presidential Plan to form the U.S. Fish and Wildlife Service.

1950 – 1. James W. Moffett becomes Chief of Great Lakes Fishery Investigations.
2. Sea lamprey control work becomes a major focus.
3. Great Lakes Fishery Investigations moves out of the Museum of Zoology to headquarters on the central campus of the University of Michigan.

1951 – R/V *Cisco* becomes the first federal designed and dedicated for aquatic research on the Great Lakes.

1952 – Establishment of field stations at Hammond Bay, MI, Marquette, MI and Sturgeon Bay, WI for sea lamprey research and control

1956 – 1. Great Lakes Fishery Commission created and housed with Great Lakes Fishery Investigations. Norm Baldwin is first Secretary of the Great Lakes Fishery Commission.
2. Fish and Wildlife Act creates the Bureau of Commercial Fisheries and the Bureau of Sport Fisheries and Wildlife in the U.S. Fish and Wildlife Service. Great Lakes Fishery Investigations are assigned to the Bureau of Commercial Fisheries.

1957 – Establishment of field stations for aquatic research at Sandusky, OH with research vessel (R/V) *Musky* and Ashland, WI with R/V *Siscowet*.

1959 – Great Lakes Fishery Investigations changes its name to Great Lakes Biological Laboratory.

1961 – R/V *Kaho* constructed for aquatic research on the Great Lakes. Vessel base established at Saugatuck, MI for the R/Vs *Cisco* and *Kaho.*

1965 – Great Lakes Biological Laboratory moves to a new, modern facility on Green Road on the northern periphery of the University of Michigan campus.

1967 – George Harry becomes Director of the Great Lakes Biological Laboratory.

1970 – Howard Tait becomes Director of the renamed Great Lakes Fishery Laboratory

1975 – Joseph Kutkuhn becomes Director of the Great Lakes Fishery Laboratory.

1977 – R/V *Grayling* constructed is constructed for aquatic research on the Great Lakes and is stationed at a new vessel base in Cheboygan, MI.

1978 – Establishment of a field station at Oswego, NY with research vessel R/V *Kaho*.

1982 – Bernhard Griswold Becomes Director of the Great Lakes Fishery Laboratory.

1984 – John Stanley becomes Director of the Great Lakes Fishery Laboratory.

1986 – Great Lakes Fishery Laboratory is renamed the National Fisheries Center-Great Lakes.

1987 – National Fisheries Center-Great Lakes is renamed National Fisheries Research Center-Great Lakes.

1993 – Biological research positions and science centers in the Department of Interior are transferred to the National Biological Survey, a new Department of Interior agency.

1994 – National Fisheries Research Center-Great Lakes is renamed Great Lakes Science Center.

1995 – National Biological Survey is renamed National Biological Service.

1996 – 1. Gregory Smith becomes Director of the Great Lakes Science Center.
2. National Biological Service is merged into U.S. Geological Survey as the Biological Research Division.

1997 – Tunison Laboratory of Aquatic Science joins the Great Lakes Science Center. The Lab was founded in 1930 by an Act of Congress.

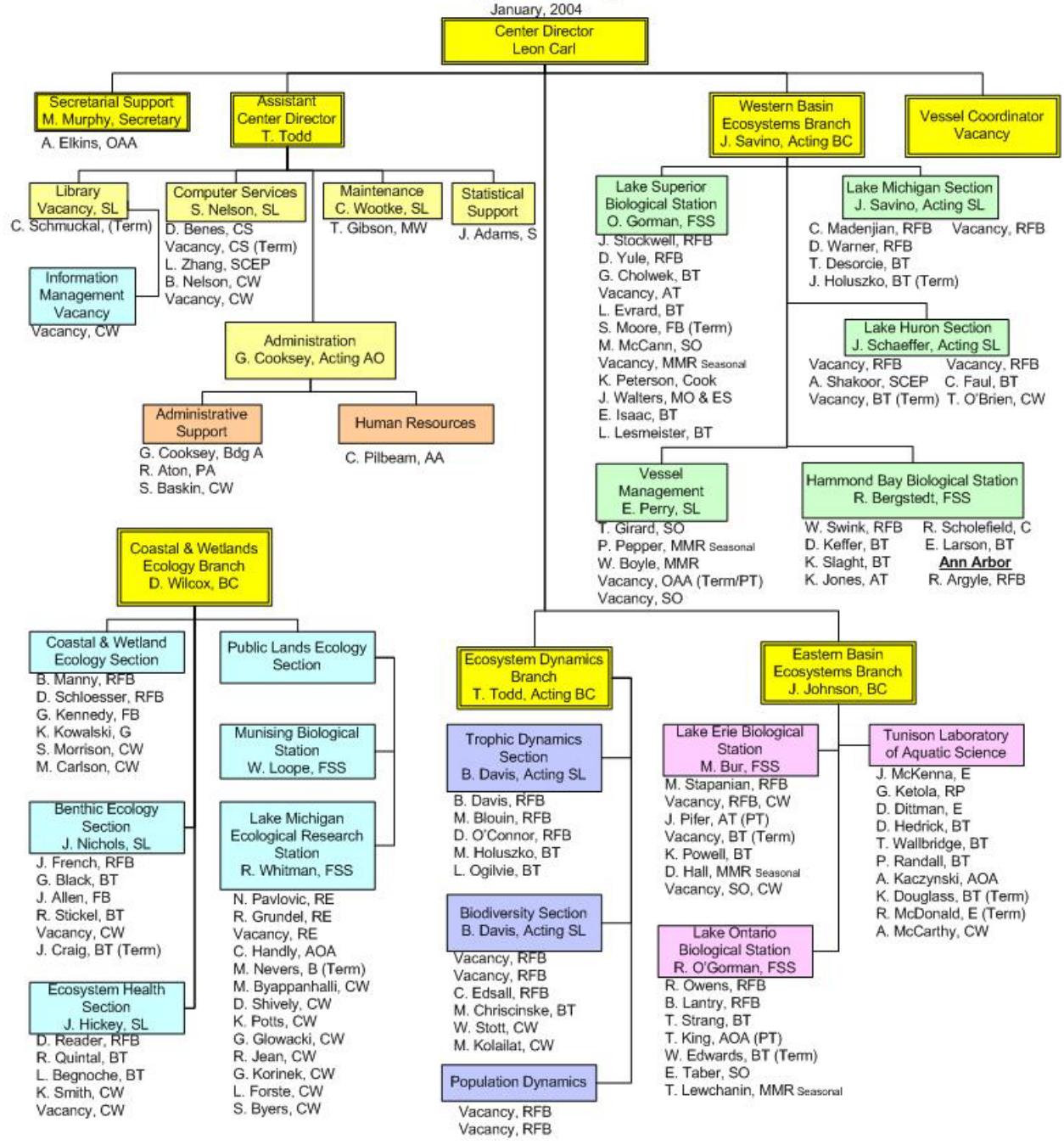
1998 – Nancy Milton becomes Director of the Great Lakes Science Center.

2002 – 1. R/V Kiyi is built for Lake Superior and is docked in Ashland, WI.
2. Overhaul of the R/V Sturgeon, scheduled for 2004 completion.

2003 – Leon Carl becomes Director of the Great Lakes Science Center

Great Lakes Science Center
Staffing Plan Update

January, 2004



Key

AA - Administrative Assistant	C - Chemist	FSS - Field Station Supervisor	OAA - Office Automation Assist.	S - Statistician
AOA - Administrative Operations Assist.	CC - Communication Coordinator	G - Geographer	PA - Purchasing Agent	SCEP - Stud. Career Empl. Prog.
AO - Administrative Officer	CS - Computer Specialist	L - Laborer	PST - Physical Science Tech.	SEA - Seasonal Employee
B - Biologist	CW - Contract Worker	LT - Library Technician	PT - Part Time	SL - Section Leader
BC - Branch Chief	E - Ecologist	MMR - Marine Machinery Repairer	RE - Research Ecologist	SO - Ship Operator
Bdg A - Budget Analyst	ES - Equipment Specialist	MO - Marine Ops	RP - Research Physiologist	
BT - Biological Technician	FB - Fishery Biologist	MW - Maintenance Worker	RFB - Research Fishery Biologist	

Authorities of the Biological Resources Discipline, U.S. Geological Survey

Fish and Wildlife Coordination Act of 1934 (16 U.S.C. 661 et seq.) authorizes the Secretary to prepare plans to protect wildlife resources, to conduct surveys on public lands, and to accept funds or lands for related purposes; authorizes the investigation and reporting of proposed Federal actions that affect the development, protection, rearing, and stocking of all species of wildlife and their habitat in controlling losses, minimizing damages, and providing recommendations to minimize impacts on fish and wildlife resources.

Fish and Wildlife Act of 1956 (16 U.S.C. 742(a)-742d, 742e-742j-2) authorizes the Secretary to conduct investigations, prepare and disseminate information, and make periodic reports to the public regarding the availability and abundance and the biological requirements of fish and wildlife resources; provides a comprehensive national fish and wildlife policy and authorizes the Secretary of the Interior to take steps required for the development, management, advancement, conservation, and protection of fisheries and wildlife resources through research, acquisition of refuge lands, development of existing facilities, and other means.

Migratory Bird Treaty Act of 1918, as amended (16 U.S.C. 703-711) implements four international treaties that individually affect migratory birds common to the United States, Canada, Mexico, Japan, and the former Soviet Union. This Act establishes Federal responsibility for protection and management of migratory and nongame birds, including the establishment of season length based on scientific information relative to zones of temperature, distribution, abundance, breeding habits and times and lines of migratory flight of migratory birds. It also establishes the Secretary of the Interior's responsibility for bag limits, and other hunting regulations, and issuance of permits to band, possess or otherwise make use of migratory birds.

Migratory Bird Conservation Act title of the Act of May 26, 1900, (16 U.S.C. 715) establishes the Migratory Bird Conservation Commission; authorizes the Secretary of the Interior to conduct investigations and publish documents related to North American birds.

Cooperative Research and Training Units (16 U.S.C. 753a, (as amended)) authorizes the Secretary of the Interior to enter into cooperative agreements with colleges and universities, State fish and game agencies, and nonprofit organizations for the purpose of developing adequate, coordinated, cooperative research and training programs for fish and wildlife resources.

Federal Land Policy and Management Act of 1976 (FLPMA), (43 U.S.C. 1701 et seq., Sections 113 and 307(a)) authorizes the Secretary of the Interior to conduct investigations, studies, and experiments involving the management, protection, development, acquisition, and conveying of public lands; and to prepare and maintain inventories of all public land resources.

U.S. Geological Survey Organic Act of March 3, 1879, as amended (43 U.S.C. 31 et seq.) authorizes the Secretary of the Interior to publish geological and economic maps which illustrate the resources and classifications of the lands and to publish reports upon general and economic geology and paleontology.

Endangered Species Act of 1973, as amended (16 U.S.C. 1531-1543) provides for the conservation of threatened and endangered species of fish, wildlife, and plants; and authorizes establishment of cooperative agreements and grants-in-aid to States that establish and maintain active and adequate programs for endangered and threatened wildlife and plants.

Marine Mammal Protection Act of 1972, as amended (16 U.S.C. 1361-1362, 1372-1384, 1401-1407) establishes a responsibility to conserve marine mammals with management authority vested in the Department of the Interior for the sea otter, walrus, polar bear, dugong, and manatee.

Great Lakes Fishery Act of 1956 (16 U.S.C. 931-939) implements the Convention on Great Lakes Fisheries between the United States and Canada; authorizes construction, operation, and maintenance of sea lamprey control works; and established the Great Lakes Fisheries Commission.

Fish-Rice Rotation Farming Program Act of 1958 (16 U.S.C. 778-778d) authorizes the Secretary of the Interior to establish experimental stations for research and experimentation to determine species of fish most suitable for culture on a commercial basis in shallow reservoirs and flooded rice lands and to develop methods for the control of parasites and diseases. Authorizes the acquisition of lands and construction of facilities, cooperation with States and others, and dissemination of research results.

National Aquaculture Act of 1980 (16 U.S.C. 2801-2810) directs the Secretary of the Interior to participate in the development of a National Aquaculture Development Plan and authorizes research, development, and other activities to encourage the development of aquaculture in the United States.

Federal Environmental Pesticide Control Act of 1972 amending the 1947 Federal Insecticide, Fungicide, and Rodenticide Control Act (7 U.S.C. 136 et seq.) establishes a program for controlling the sale and distribution of "economic poisons;" requires registration of pesticides to avoid unreasonable adverse affects to humans or the environment.

Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990, (16 U.S.C. 4701) establishes a Federal program to prevent introduction of and to control the spread of introduced aquatic nuisance species and the brown tree snake.

National Park Service Organic Act, as amended and supplemented (16 U.S.C. 1-4, 17j-2, 18f, 431-433, 461-467) authorizes the Secretary of the Interior to investigate, study, and continually monitor the welfare of areas whose resources exhibit qualities of national significance and which may have potential for inclusion in the National Park System. In addition, the Secretary is directed to submit a "National Park System Plan," which constitutes a professional guide for the identification of natural themes of the United States and is revised annually.

Clean Air Act Amendments of 1977, as amended (42 U.S.C. 7418; 42 U.S.C. 7470, et seq.) requires Federal facilities to comply with air quality standards to the same extent as nongovernmental entities; and establishes requirements to prevent significant deterioration of air quality and in particular, to preserve air quality in national parks, national wilderness areas, national monuments, and national seashores.

Water Resources Development Act of 1990 (33 U.S.C. 2201 et seq.) authorizes a program for planning, construction, and evaluation of measures for fish and wildlife habitat rehabilitation and enhancement; cooperative effort and mutual assistance for use, protection, growth, and development of the Upper Mississippi River system; implementation of a long-term resource monitoring program; and implementation of a computerized inventory and analysis system.

Oil Pollution Act of 1990 (33 U.S.C. 2701 et seq.) provides enhanced capabilities for oil spill response and natural resource damage assessment. Includes the identification of ecologically sensitive areas and the preparation of scientific monitoring and evaluation plans. Research is to be directed and coordinated by the National Wetlands Research Center.

Coastal Barrier Resources Act of 1982 (16 U.S.C. 3501) designates various underdeveloped coastal barrier islands, depicted by specific maps for inclusion in the Coastal Barrier Resources System.

Outdoor Recreation Programs Act (16 U.S.C. 460-1(f)) authorizes the Secretary of the Interior to sponsor, engage in, and assist in research relating to outdoor recreation, directly or by contract or cooperative agreements, and make payments for such purposes; undertake studies and assemble information concerning outdoor recreation; and cooperate with educational institutions and others in order to assist in establishing education programs and activities to encourage public use and benefits from outdoor recreation.

Outer Continental Shelf (OCS) Lands Act (43 U.S.C. 1331) authorizes the Secretary to prescribe rules and regulations to provide for the prevention of waste and conservation of the natural resources of the OCS; to conduct geological and geophysical explorations of the OCS; and to study any region in any gas and oil lease sale to obtain information necessary for assessment and management of environmental impacts on human, marine, and coastal areas which may be affected by oil and gas development on such areas.

Draft Strategic Science Plan
Great Lakes Science Center

Mission

Advancing scientific knowledge and providing scientific information for restoring, enhancing, managing, and protecting the living resources and their habitats in the Great Lakes basin ecosystem.

Background

The Great Lakes Science Center (GLSC) is a biological research center of the U.S. Geological Survey (USGS). The GLSC works directly with management agencies and key stakeholders to provide the critical biological and ecological information needed to protect biological resources in the Great Lakes region. The GLSC responds to research and information needs of the two sovereign nations, eight states, the Province of Ontario, and Native American tribes that are found within the Great Lakes basin. The Center's research spans a range of topics including fish populations and communities, aquatic habitats, nearshore and coastal communities, terrestrial ecology and the biological processes that occur in the complex Great Lakes ecosystem. The GLSC's long-term data sets are a powerful tool for studying Great Lakes processes on broad spatial and temporal scales. The Center's science plan focuses on developing a forward-looking approach in main themes such as: the development of effective monitoring programs and indicators of ecosystem change in both offshore and coastal ecosystems; theme areas of critical need such as the role of thiamine deficiency in aquatic ecosystems; initiatives to improve biological resources within the Huron-Erie Corridor; and emerging issues such as aquatic and terrestrial invasive species.

The GLSC traces its origins to 1871 when Congress, by joint resolution, established the United States Fish Commission and charged it with responsibility for investigations and inquiries concerning the supply of food fishes of the coasts and lakes of the United States and the determination of protective, prohibitory, or precautionary measures to be adopted. Initial investigations began in 1871 in Lake Michigan, and the U.S. Fish and Wildlife Service and its two Bureaus, the Bureau of Commercial Fisheries and the Bureau of Sport Fisheries and Wildlife evolved from these early investigations. The current GLSC was established in 1927 as the Great Lakes Biological Laboratory, with John Van Oosten as its Director. This program was started as a consequence of the furor generated by the collapse of the cisco fishery in Lake Erie in 1925. The Great Lakes Science Center has resided in the Department of Interior since 1939, but has changed bureaus and undergone several name changes over the last half century.

The headquarters of the GLSC is located on the North Campus of the University of Michigan in Ann Arbor. The GLSC has about 40 researchers and 60 support staff. About half of the Center's staff are located in Ann Arbor and half are located at the Center's field stations. Strategic placement of the Center's field operations facilitates research conducted over this large geographic area. The Center has four field stations, one vessel base, and three field station/vessel base combinations dispersed throughout the Great Lakes Basin. Research support for ongoing projects is provided through the headquarters location.

Unique among USGS centers is the fleet of large vessels that the GLSC maintains and employs. These vessels, which range in length from 45 to 107 feet, are well-equipped for population assessment and limnological studies in the Great Lakes. Equipment on these vessels includes wet laboratories, trawls, gillnets, larval fish tow nets, equipment for limnological and contaminant sampling, hydroacoustical fish-detection systems, and Loran C/GPS navigation computer systems for the precise location of sampling stations. The Center has side-scan sonar and a remotely operated vehicle.

A major strength of the GLSC are the long-term databases, especially of forage fish in each of the Great Lakes, accumulated by Center researchers during 50 years of surveys. These continue to be an important source of information on the dramatic changes that have occurred and continue to occur in the Great Lakes ecosystem. Database management is also growing in content, capability, and accessibility to provide managers with reliable and unbiased information necessary for making management decisions in the region. Many of our research studies build on these databases, complementing assessments of the resource in a community and ecosystem context. Synthesis activities using interdisciplinary approaches or creating predictive models are now essential for moving the field

forward and anticipating needs of Great Lakes managers. GLSC researchers are continually increasing collaborative efforts with university and agency personnel to achieve these syntheses.

Core Capabilities

Science

Fish Population Research

The GLSC has a long history of significant contributions to the understanding of aquatic resources in the Great Lakes, through partnerships and interactions with state, tribal, and U.S. and Canadian federal agencies. The main focus of the Center's fish population research is on the long-term dynamics of native and non-native aquatic species and the sustainability of Great Lakes fisheries. Fish community structure has changed substantially in the Great Lakes since the Center was established. Species extinctions and establishment of invasive and non-native species including sea lamprey, alewife, rainbow smelt, ruffe, gobies have occurred in each lake. Because of changes in fish community structure over the last few decades, Center scientists study whether fish communities based on non-native species (such as alewife and rainbow smelt) are capable of sustaining both angling and commercial fisheries for top predators in all five Great Lakes. Even if these fisheries are sustainable, it is necessary to understand how food chains supported by non-native species compare to that of fisheries that are supported by native prey species such as the several species of deepwater ciscoes that once existed in most of the Great Lakes. Research is also undertaken to identify the factors impeding progress towards restoration of native species, including studies on fish behavior, habitat, recruitment, survival, and population genetics. The Center is recognized for its work on issues affecting the entire aquatic ecosystem in the Great Lakes basin including lake trout restoration, sea lamprey control, and annual fish stock assessments that provide timely information directly to our state and tribal partners who are responsible for managing the fisheries. In addition, the unique communities and local disturbances (i.e., habitat alterations) associated with each lake provide opportunities to study ecological processes in a comparative manner. Data sets describing the abundance of both predator and prey fish species in each lake encompass several decades and are among the most highly valued data sources in the Basin for understanding the long-term dynamics of the fish community in relation to biotic and abiotic influences, and for modeling Great Lakes ecosystem dynamics.

Fish community dynamics investigations are aided by the ability to perform genetic analyses to identify population substructure and patterns of gene flow. Both protein electrophoretic and DNA recombinant technology are used at the Center to investigate spatial and temporal genetic relationships within and among Great Lakes fish populations. Center scientists are also using genetics to survey endangered fish species and to provide historical population genetic information about extinct fish populations and species. Center scientists are currently focusing on the use of non-lethal tissue extraction techniques for these analyses.

Health of Aquatic Biota

The Center has had a long and distinguished history of conducting physiological, toxicological, and analytical chemistry studies to determine the effects of environmental contaminants on aquatic biota. In addition to contaminants, it is currently recognized that exotic species, physical habitat changes, and other biogeochemical factors influence the health of aquatic biota in the Great Lakes. Scientists have also been conducting biological monitoring of lake trout egg hatchability for several years by collecting wild eggs and monitoring their health as they develop and hatch. Center researchers are concurrently exploring and refining likely methodologies for quick and accurate estimation of chemical environmental behavior, hazard, and fate based on the chemical's structure. An evolving database of compounds, their measured properties, and theoretical parameters is the basis for predictive software. Application of risk assessment to evaluate progress toward setting and meeting target conditions of contaminant decline and improvement in species diversity, habitat, and food provides managers with a scientific basis for making decisions concerning the health and sustainability of fish populations.

Trophic Interactions

Trophic level studies in the Great Lakes encompass a wide variety of organisms from invertebrates to fish and birds. Field studies of Great Lakes organisms often lead to laboratory studies designed to provide information under controlled conditions. For example, feeding preferences of predators and competition within a trophic level can be

determined by combinations of field and laboratory studies. Specialized tanks and video monitoring equipment are used to examine competitive interactions of native and exotic fish species. Center scientists are experienced in rearing, holding, and experimenting with coldwater exotic and native species. The Center maintains facilities to quarantine exotic species such as the Eurasian ruffe, which can then be used to study competition with desirable endemic species such as yellow perch.

The Center maintains equipment for collecting and identifying most of the invertebrates and fish found in the Great Lakes. Diet studies conducted at the GLSC aid in determining preferences of predators and competition within a trophic level for different assemblages of fish. A variety of technical capabilities including GIS, acoustics, and side-scan sonar allow researchers to study the interplay of fish diet and habitat and provide a link between fish population dynamics and trophic studies.

Research to determine the ecological role of native species within and between different trophic levels in the Great Lakes help determine which species are vulnerable to replacement or depletion. Researchers evaluate natural and human-induced factors including climate, land-use patterns, management practices, habitat, contaminants, and invasive species that can cause changes in the abundance of Great Lakes species. In conjunction with these studies, measures of biodiversity applicable to Great Lakes assemblages are being developed to identify specific locations and species that should be prioritized for protection. Biodiversity studies also contribute to development of rehabilitation strategies for species and their habitats. The structure and dynamics of fish assemblages can be used to infer the status of aquatic ecosystem health. Several useful measures of ecosystem health based on structure (richness, diversity, non-native species) and productivity have been identified. Measures of community stability need to be identified to further assist in understanding persistence of aquatic assemblages. Some management actions affect the diversity and sustainability of aquatic species; models relying on predator-prey dynamics to demonstrate these effects can be used to evaluate alternative management strategies in the Great Lakes basin.

Exotic and Invasive Species

To date, over 140 exotic aquatic species have been documented in the Great Lakes. In addition, Center scientists working at Indiana Dunes National Lakeshore have identified over 325 non-native species in a flora of 1460 species. Establishment of exotic species has had substantial effects in open lakes (e.g., alewife and rainbow smelt), wetlands, (e.g., reed canary grass and purple loosestrife), terrestrial systems (e.g., garlic mustard and Asiatic bush honeysuckle), and nearshore waters (e.g., zebra mussels and ruffe). Research to identify impacts of invasive species in systems of the Great Lakes basin provides opportunities to study the links between species diversity and aquatic ecosystem stability. The introduction and colonization of invasive species may affect genetic diversity (through genetic bottlenecks or hybridization) of native species, which in turn may play a role in maintaining the overall health and persistence of native populations. Understanding habitat requirements and adaptive ecology of invaders may also shed light on the types of organisms most likely to invade and colonize particular systems. Knowledge about potential invasive species may help in the control and prevention of these species and increase our management capability of habitats. A combination of field, laboratory and modeling studies are conducted to provide information pertinent to prevention, containment, and control of exotic species. Some research efforts have been dedicated to determining the ecology, distribution, life history, and reproductive behavior of exotic species.

Perhaps the best known example of the Center's work on exotic species has been its longterm work on the sea lamprey. Research at the Hammond Bay Biological Station focuses on the effects of sea lampreys on Great Lakes fishes. Specific areas of research include alternate control techniques, application of lampricides, life history studies, population assessment, and interactions between fish and sea lampreys. Research activities on sea lamprey biology and impacts are supported through the Great Lakes Fishery Commission.

Terrestrial Ecology

The Indiana Dunes, where Henry Cowles of the University of Chicago formulated his theory of ecological succession in the 1890's, is often recognized as the birthplace of the modern science of ecology. Today Center scientists, some working at the very site of Cowles pioneering investigations, continue along his line of inquiry with examinations of how anthropogenic and non-anthropogenic disturbances affect native terrestrial ecosystems. Investigations by Center staff are informed by the great changes in the context of native ecosystems that have occurred since Cowles' time. Linkages among changing lake levels, climate, and terrestrial vegetation communities

are investigated. Patterns of exotic plant invasion into the Great Lake's national parks, and how these invasions displace native communities, are documented. The effects of loss of historic disturbance patterns, such as changes in fire regimes, are examined.

The species-rich savanna and prairie habitats that once dominated the western reaches of the Great Lakes region have faired especially poorly over the past 150 years. Restoration of even remnant areas is important if this native habitat is to remain on the landscape. Center scientists are actively involved in studies to improve the restoration toolkit by examining how fire frequency and timing affect animal and plant populations, by studying how the heterogeneous light environments of savannas influence abundance of plants and animals, and by development of models to assist managers in setting restoration goals.

Coastal Ecosystem Studies

Embayments, wetlands, river mouths, beaches, moraines, and coastal dunes are found along 7,500 km of shoreline of the Great Lakes and inland aquatic habitats managed by the U.S. Fish and Wildlife Service and National Park Service. There are 1,150 km of connecting channels in the lakes proper (the St. Marys, St. Clair, Detroit, Niagara and St. Lawrence rivers), and over 1,300 distinct coastal wetlands (total area of 1,200 km^2) along the shores of the Great Lakes and connecting channels in the United States. Because of the desirability of coastal habitats for residential, industrial, and recreational uses, these areas have been highly susceptible to human-induced perturbations, such as habitat modification, contamination, and water-level regulation. Field and laboratory research is conducted to determine the effectiveness of restoration programs in altered habitats (e.g., diked and dredged), identify rare species (e.g., ciscoes and native clams), investigate the causes of frequent beach closures due to bacterial contamination that plague beaches throughout the region (and, indeed, throughout the country), determine environmental factors that correlate with survival of species (e.g., contaminants and climate change) and develop means of enhancing and protectiing habitats for rare species (e.g., Karner blue butterfly). One goal is to understand how perturbations, such as shoreline development, vessel traffic, or changes in rates of sand deposition, affect nearshore habitats with a goal of developing restoration techniques to remediate these impairments. Center scientists also work to better document linkages, such as nutrient exchange, between nearshore habitats and lakes.

Facilities and Science Support

The Great Lakes Science Center headquarters is located on the North Campus of the University of Michigan in Ann Arbor where one half of its 100 staff members are located. In addition, the Center has four biological stations, one vessel base, and three vessel base-biological station combinations dispersed throughout the Great Lakes basin. Strategic placement of the Science Center's field operations facilitates research conducted over this large geographic area. Biological stations are located at: Munising, Michigan (Munising Biological Station); Millersburg, Michigan (Hammond Bay Biological Station); Porter, Indiana (Lake Michigan Ecological Research Station); and Cortland, New York (Tunison Laboratory of Aquatic Science). A mid-basin vessel base is located at Cheboygan, Michigan. Combined biological stations and vessel bases are located at: Ashland, Wisconsin (Lake Superior Biological Station); Sandusky, Ohio (Lake Erie Biological Station); and Oswego, New York (Lake Ontario Biological Station).

Large Lake Sampling Capabilities

The Center operates five large research vessels in the Great Lakes: the R/V *Kiyi* (stationed at the Lake Superior Biological Station), the R/Vs *Siscowet*, *Sturgeon* (expected in operation in 2004 to replace the *Siscowet*), and *Grayling* (stationed at the Cheboygan Vessel Base), the R/V *Musky* II (stationed at the Lake Erie Biological Station), and the R/V *Kaho* (stationed at the Lake Ontario Biological Station). The vessels, which range in length from 45 to 107 feet, are equipped with wet laboratories, trawls, gillnets, larval fish tow nets, equipment for limnological and contaminant sampling, acoustic fish-detection systems, and computers. All vessels also have state-of-the-art navigation systems for the precise location of sampling stations. The Center is the only organization in the United States and Canada that has a research vessel on each of the Great Lakes. This makes the Center unique in its ability to conduct comparative offshore field studies on fish population dynamics and related limnological and habitat research topics.

The R/V *Kiyi* (built in 1999; 107 ft. long) is dedicated primarily to research on Lake Superior. The R/V *Grayling* (1977; 75 ft.) is dedicated to research on lakes Huron, Michigan, and Superior as is the R/V *Siscowet* (1946; 57 ft.)

and the R/V *Sturgeon* (1975; 107 ft.). As the Center's largest vessels, the R/Vs *Grayling*, *Sturgeon*, and *Kiyi* are the most versatile and are equipped to conduct a wide range of limnological, habitat, and fisheries studies including specialized equipment for conducting acoustic fish sampling. The R/V *Musky* II (1960; 45 ft. long) is the smallest vessel in the Great Lakes fleet and conducts research on Lake Erie. It is used for fisheries, limnological, and habitat research studies. The R/V Kaho (1961: 65ft.) is the primary research vessel on Lake Ontario that conducts fish, limnological, and habitat studies. The recent addition of the R/V *Stickleback* (2002; 40 ft.) to the fleet at Ashland, Wisconsin allows for more nearshore work on Lake Superior than does the larger, deeper-draft R/V *Kiyi*.

Nearshore Sampling Capabilities

The Center operates a fleet of twelve small (18-25 feet) research vessels outfitted with various types of gear such as advanced navigation systems and specialized equipment required for fishery and limnological research in inland, nearshore, and connecting waters of the Great Lakes. These small vessels facilitate a variety of aquatic sampling methods including sampling of fish for predator-prey contaminant studies, capturing of specimens for laboratory studies, sampling of bottom substrate, sampling of plankton, sampling of water quality, ground truthing aerial photographs, telemetry, and diving with SCUBA to support various research activities.

Small vessels are effective because of their size and relatively low operating costs. Small vessels have been modified to serve as electrofishing boats, shallow-water fish trawlers, gill-netters and trap-netters, substrate samplers, plankton and water samplers, and macrophyte samplers. Small vessels may be easily moved from lake to lake as well as from project to project to conduct research of short duration.

The ability to examine the ecological, physical, and spatial characteristics of plant and wildlife habitat (e.g., coastal wetlands, reefs, shoals) is enhanced by technologies that can be used on small vessels including: a Global Positioning Systems (GPS) community base station; GPS receivers; PLGR+96 receivers; and a Geographic Information System (GIS) to locate, manage data, facilitate data analyses, and increase research precision. Scientists also use side-scan sonar and a remotely operated vehicle (ROV) with video to document difficult to observe events, such as trout spawning behavior.

Fish Holding and Rearing Facilities

The Center in Ann Arbor has extensive fish rearing and holding facilities, including 200- and 600-gallon fiberglass tanks, egg incubators, and other tanks for holding fish and conducting behavioral, physiological, and toxicological studies. The facilities are supplied by two 100-gallon-per-minute wells with associated equipment that includes iron filters, deionizers, settling tanks, permanent and portable chillers, and pumps and reservoirs for conditioning water. Fish rearing and holding facilities supplied by a deep water intake from Lake Huron are also available at the Hammond Bay Biological Station (HBBS). The HBBS includes tanks and flow-through "living streams" primarily used for research on the effects of sea lamprey on Great Lakes fishes. The HBBS also has a specialized facility for sterilizing male sea lamprey for a biological control program.

Chemistry and Other Laboratories

The Center in Ann Arbor has several dedicated chemistry laboratories that have primarily conducted contaminant residue analyses. The main instrumentation consists of a mass spectrophotometer and gas chromatographs. Fume hoods, organic chemical storage, and bench space exists in potential support of several research projects.

Other laboratory space in Ann Arbor is dedicated to preparation and identification of samples collected in the field. Separate areas are dedicated to preparation of larger fishes for a variety of studies including such activities as otolith and coded-wire tag removal and tissue preparation for chemical analyses. Some of the laboratories are dedicated to analyses of benthic and planktonic invertebates as well as larval fish and contain a variety of specialized microscopes. An attached greenhouse in Ann Arbor is used to conduct controlled experiments on wetland processes.

Statistical Support Services

Statistical support is an essential feature of the research cycle during study design, data management, and analyses. During the study planning phase, statistical support assists with experimental design, survey sample design, and choice of statistical methods. During the conduct of studies, statistical support assists with data management and analytical questions and with interpretation and presentation of results as necessary. The Center employs a staff statistician to provide support throughout the research cycle.

Library and Information Services

The library, named in honor of Dr. John Van Oosten, the Center's first director, contains technical materials supporting the research activities of the Center. A specialized collection of books, journals, serials, reprints, and several CD-ROM databases are available in the library. In addition, the library subscribes to various on-line services for computerized literature searches and participates in a shared cataloging and interlibrary loan system. The library's Internet home page (**http://www.glsc.usgs.gov/library**) provides further information about the library's activities and services.

Database and Information Management

The GLSC uses current technology for database and information management. The Center employs local area networks (LAN) to connect computers within the Center and within field stations. Databases served from computers at the GLSC headquarters are accessible by researchers at field stations. LAN technology allows access to relational databases on fish population dynamics in the Great Lakes, commercial catch statistics, contaminant analyses for Great Lakes fishes, and the administrative information system. Data entry capabilities on the Center's large vessels and in the laboratories are provided using Oracle technology. Internet connectivity permits Center scientists to browse the World Wide Web and allows our partners and the public to view our home page (**http://www.glsc.usgs.gov**).

GUIDING PRINCIPLES

Strategic Direction

Enhance the Great Lakes Science Center's diverse science programs, capabilities, and talents to strengthen our scientific contribution to the resolution of complex Great Lakes ecosystem issues.

Customer Strategic Goal

Improve service to users of our information, our customers, and broaden our customer base with timely and pertinent scientific information and effective interaction that increases our understanding of customer needs.

Customer Long-term Goals

- **Measurement Framework**
  Understand and anticipate the needs of the Great Lakes Science Center's customer base and periodically evaluate how our science programs relate to these needs.

- **Products and Services**
  Develop new products and services that are responsive to and reflect the needs of both DOI and external customers.

- **Customer Engagement**
  Increase involvement of multiple partners, cooperators, and coalitions in contributing to mutually beneficial science program outcomes and impacts.

Program Strategic Goal

Provide significant scientific insight into the structure, function, and status of the dynamic and changing ecosystems of the Great Lakes region, in response to present and anticipated threats to the integrity of these ecosystems, through focus on management-driven, critical need, and emergent issues.

Program Long-term Goals

- **Great Lakes Environment and Natural Resources**
  Increase usefulness of long-term deep-water monitoring data and aquatic resource information to clients, expand systematic investigations, provide managers with better understanding of trends in habitat degradation and with better tools to mitigate damage and to restore degraded habitats, increase quality and quantity of predictive tools for scenario building and decision-making in Great Lakes natural systems.

- **Mix of Science Activities**
  Balance the mix of long term data collection and monitoring, research and development, and assessments and applications to be responsive and flexible.

People Strategic Goal

Attract and maintain a diversified, quality workforce with the skills that enhance our science programs and serve our customers.

People Long-term Goals

- **Skills**
  Enhance science and technical skills of the Great Lakes Science Center's workforce.

- **Reward Program**
  Reinforce strategic direction through a Center reward system.

- **Flexibility**
  Achieve human resources flexibility to meet changing needs.

- **Leadership**
  Foster visionary leadership and management professionalism.

Operations Strategic Goal

Maintain a level of infrastructure and operational processes and practices to efficiently and effectively support the Center's workforce, science programs, and customers.

Operations Long-term Goals

- **Information Infrastructure**
  Ensure efficient data integration and access to satisfy both the Center's internal and external customers.

- **Operational Process and Practices**
  Improve the efficiency of the Center's administrative and science support and science program activities through streamlining, quality improvements, and cost reductions.

- **Facilities Infrastructure**
  Optimize facilities location, distribution, and use to reduce costs while ensuring science program effectiveness and quality of work environment.

- **Communication**
  Clearly communicate to all audiences consistent message about our strategic direction and science programs.

VISION

To become the keystone biological research institution in the Great Lakes through conducting relevant cutting-edge basin-wide ecosystem research and disseminating critical scientific information that facilitates ecosystem management through interactions with our clients and partners.

PROGRAM GOALS

STATUS AND TRENDS

Current Program

Fish community structure has changed substantially in the Great Lakes since the Center was established. During the late 1960's and 1970's, piscivores were rare due to sea lamprey predation, and the fish community was dominated by two invaders: alewife, and rainbow smelt that had reached nuisance levels of abundance. Fisheries managers alleviated these conditions by controlling sea lampreys, and stocking both Pacific salmonids and native predators such as lake trout and walleyes. This rehabilitated the Great Lakes ecosystem, but created a novel fish community in which stocked predators preyed on non-native prey. By the 1980's predator rehabilitation was so successful that prey shortages occurred. The situation was complicated by recent increase in predator recruitment that exacerbated prey shortages, changes in prey fish dynamics, and system-wide changes in food webs that resulted from new invasives such as zebra mussels that were introduced via ship ballast water. Many of these changes were documented through GLSC annual bottom trawl surveys that occur in all five Great Lakes.

Currently, the program works closely with the resource management community to provide scientifically sound approaches to measuring, assessing, and reporting the status and trends of biological resources. GLSC maintains surveys in each lake because each Great Lake has a unique fish community. Trawl surveys assess health of both predator and prey species, although much of our work is focused on preyfish communities. The GLSC has also conducted long-term gillnet assessment of native lake trout in Lake Superior and of hatchery-reared lake trout in all of the Great Lakes to evaluate the status of lake trout rehabilitation. Because lake trout are a long-lived fish, effectiveness of management efforts are only determined through a long-term surveillance. We provide critical information and methods to support fisheries management agencies and their stakeholders. GLSC has the USGS lead for a long-term program of research for assessing status and trends of Great Lakes fish populations and management of associated databases. GLSC biologists conduct original research on systematics and biodiversity of vertebrates. GLSC also develops methods to assess the status and trends for other taxa of interest to DOI.

Future Direction

The Center's Status and Trends Program is responsive to the goals of the DOI and USGS. Strong partnerships with the states, provinces, federal, and universities will be maintained. As opportunities permit, new tasks will be initiated to meet the increasingly complex needs of both the biological and governmental arms of the aquatic conservation community.

Our annual bottom trawl estimates are an important long-term data set that have documented wide fluctuation in the Great Lakes prey fish communities and can be used for a variety of long term ecological studies. Future research efforts will be directed at understanding the mechanisms underlying these changes to better address the managers' information needs. Immediate priorities will be to maintain existing expertise in open water fish community

assessment, including marrying historical trawling techniques with new ones, as well as improving gill net and acoustic surveys. New technology for real-time, on-line interaction with population databases will be developed and adapted for use by USGS partners. To better understand the factors influencing the prey fish community, we will incorporate value-added sampling of lower trophic levels to the overall survey design. Center researchers are still investigating the important factors affecting the status of lake trout, a keystone species, in the Great Lakes. Surveys of lake trout will continue to aid in development of management plans and will evaluate the effects and consequences of new management strategies.

The goals of future collaborations will be to explore ways of (1) identifying and minimizing biases that may exist in survey design, (2)) modifying survey techniques to allow the estimation of detection probability with the subsequent integration of detection probability into population estimates, and (3) improving the value of monitoring programs through collection of ancillary data on potentially significant environmental attributes. Finally, GLSC will assure that the technology infrastructure is sufficient to provide state-of-the-art database management, storage, and retrieval to meet the increasing demands for information by the conservation and scientific communities.

Goals and 5-Year Objectives

Goal 1. To assess, project, and report the status and trends of the Great Lake's biological resources to facilitate research, enable resource management and stewardship, and promote public understanding and appreciation of our living resources.

- Objective 1: Develop and evaluate inventory and monitoring methods, protocols, experimental designs, analytic tools, models, and technologies to measure biological status and trends.
- Objective 2: Provide a framework that facilitates the integration of information from a variety of sources at multiple spatial and temporal scales to describe and track the abundance, distribution, productivity, and health of Great Lakes plants, animals, and ecosystems.
- Objective 3: Collaborate with partners to identify opportunities for tailoring long-term status and trends assessment programs to meet specific management and conservation needs as they arise, without compromising the ability to draw basin wide inferences.
- Objective 4: Explore developing technologies for their ability to improve the processing and management of population databases.
- Objective 5: Incorporate directly measured and remotely-sensed data on potential environmental correlates of population change into status and trends surveys.
- Objective 6: Collect, archive, and share selected, critical, high-quality monitoring data in cooperation with our partners to enable a determination of the status and trends of biological resources.
- Objective 7: Produce and provide analyses and reports that synthesize information on the status and trends of Great Lakes' ecosystems and are responsive to the needs of the scientific community, fish and resource managers, policy makers, and the public.

FISHERIES: AQUATIC AND ENDANGERED RESOURCES (FAER)

Current Program

Research is focused on the study of fishes, fisheries, aquatic invertebrates, and their aquatic or water-dependent habitats. Species in decline and those that are threatened by extinction are of special research interest as is study of factors that affect population growth and recruitment to key aquatic habitats. Investigations determine the physiological, behavioral, and genetic responses of fish populations to environmental change. Novel methods for restoration and management involving culture techniques, artificial propagation, habitat enhancement, and the diagnosis and control of disease are developed and tested. Systematic research evaluates species relationships using classical morphological and modern molecular genetic techniques. Microbiological studies of fish pathogens lead to important advances in disease control. Predictive models of population and community interactions help forecast species abundance and elucidate predator-prey and habitat relationships. The objectives of the program are to conduct field and laboratory investigations on the biology of fish and invertebrates in the Great Lakes watershed to better delineate environmental tolerances and constraints of these taxa; to conduct field and laboratory investigations on the ecology of fish and invertebrates in the Great Lakes watershed to better understand niche requirements and interactions with other species in their biotic communities; and to provide information on the biology and ecology of

fish and invertebrates to assist resource managers with decisions to restore, enhance, maintain, and protect the freshwater biological resources and their supporting ecosystems in the Great Lakes watershed.

The GLSC, in dialogue with DOI and other resource managers, determines those species and habitats of highest priority for investigation. GLSC researchers, in collaboration with agency and academic partners, focus their efforts on species and habitats of greatest concern for protection and restoration. Investigations in the laboratory emphasize taxonomy, physiology, and behavior while field investigations focus on biodiversity and life histories, seasonal and spatial distribution patterns, ecological interrelationships and habitat requirements.

Future Program

Research carried out under the FAER program in the GLSC will continue to emphasize restoration ecology, effects of habitat loss and alteration, trophic relationships, genetics, physiological and behavioral ecology, and the effects of environmental change on native aquatic species. Anthropogenic impacts including invasive species, habitat loss and alteration and global climate change, decreased lake productivity, and increased water clarity greatly affect native biota in the basin and demand increased scientific attention by GLSC scientists within the FAER program. Because of these ecosystem-level changes, new approaches, development of new technologies and increased predictive capability will be integral to the GLSC's FAER program.

Due to the complexity and scale of the Great Lakes landscape the GLSC will strive to integrate the scientific expertise and expand upon existing linkages and networks with resource managers and collaborators that will be required to carry out scientifically sound and meaningful research in the basin. There interactions will help GLSC scientists identify and prioritize the future research direction of the Center under the FAER program. The GLSC will encourage the use and development of new and innovative approaches and technologies in the research carried out by Center scientists.

Goals and Five-Year Objectives

Goal 1: To understand functional relationships among aquatic species and their habitats.
- Objective 1: Study factors that affect population fitness and recruitment to key aquatic habitats.
- Objective 2: Provide integration of scientific investigations across disciplines and emphasize landscape scale studies.
- Objective 3: Provide better predictive capability.
- Objective 4: Develop and explore new technologies, perspectives, approaches, and partnerships.
- Objective 5: Share data, information, and knowledge with managers.

Goal 2: Provide scientific leadership in understanding factors affecting the health of aquatic organisms in support of their conservation and recovery.
- Objective 1: Determine the physiological, behavioral, and genetic responses of fishery populations to environmental change.
- Objective 2: Develop and explore new technologies, perspectives, approaches, and partnerships.
- Objective 3: Share data, information, and knowledge with managers.

Goal 3: Improve understanding and provide information on the dynamics of life history and species interactions that affect aquatic communities.
- Objective 1: Evaluate species relationships using classical morphological and modern molecular genetic techniques.
- Objective 2: Develop new or alternative approaches for fisheries management.
- Objective 3: Develop population viability analyses, limiting factor determination, and modeling for population and community resilience and recovery.
- Objective 4: Evaluate food webs in aquatic systems.
- Objective 5: Evaluate effects of life history variation on aquatic communities

INVASIVE SPECIES

Current Program

The Great Lakes Science Center (GSLC) conducts a combination of field, laboratory, and modeling studies to provide information pertinent to impact, prevention, containment, and control of invasive species. The Great Lakes ecosystem has been threatened by the continuing invasion of exotic species for over 100 years. Since the 1800's, over 136 exotic algae, fish, invertebrates, and various plants have become established in the Great Lakes. Surveys by GLSC scientists have documented more than 300 non-native plant species at a single terrestrial study site and found that, even in protected areas, non-native species often comprise more than 20% of total plant richness. Particularly with the opening of the St. Lawrence Seaway, the rate of successful introduction of exotic species into the Great Lakes has surged. More than one-third of these invasive organisms were introduced since the 1960s and many now dominate the aquatic community in both numbers and biomass. The most problematic aquatic invasive species include the common carp, Eurasian ruffe, Eurasian water milfoil, purple loosestrife, quagga mussel, round goby, rusty crayfish, sea lamprey, spiny waterflea, and the zebra mussel. These ten invasive species alone have contributed to massive extinctions of native fauna, severe alterations in local food webs supporting the entire Great Lakes ecosystem, and, in cases such as the zebra mussel, have resulted in millions of dollars of damage to local water users such as power plants.

Exotic species in the Great Lakes rarely remain a regional issue due to the interconnectivity of watersheds through canals, commercial and private boat traffic, and recreational practices. A prime case of rapid expansion from a regional to a national issue can be seen with the invasion of the zebra mussel. Zebra mussels were first introduced into the Great Lakes around 1986. In less than ten years, these mussels spread throughout the Great Lakes, into many small inland lakes and river in most of the states bordering the Great Lakes, and moved down into the Mississippi River, where they now occur all the way down to New Orleans. A second exotic species, the round goby, is poised to repeat this invasion pattern and a third, the silver carp, is poised to move from the river up into the Great Lakes.

Our current program focuses on many aspects of the invasive species issue that vary by species and distributional pattern. Distribution and density of specific invasives are tracked in certain areas, including studies on ruffe population dynamics in Lake Superior, round goby in upper Lake Michigan, and zebra mussels in upper Lake Huron. Other studies focus on ecosystem impact, such as in Lake Ontario, where zebra and quagga mussels have altered ecosystem function to such an extent that key native species, such as *Mysis* shrimp, are in decline. Other studies focus on control issues, such as reducing lamprey populations through the use of pheromones, or preventing the spread of round gobies into the Mississippi River by using electric barriers.

Future Directions

We must improve our ability to forecast invasions of exotic species and to prevent exotic species from becoming established in the Great Lakes watershed. Management efforts to limit the expansion of exotic species once they become established are generally costly and rarely successful. Our ability to prevent future successful invasions will depend on improvement in key areas, specifically: in our ability to predict which species are most likely to be the next successful invader; on our ability to predict ecological and economic impact before widespread colonization of an invasive species occurs; on our ability to develop new tools for control or elimination of exotic species; and, on improving collaboration between the Great Lakes community and other watersheds to increase available expertise while moving toward a broader strategy on prevention and control of shared species.

Goals and 5-Year Objectives

Goal 1. Tracking the changing population structure of biota in the Great Lakes basin.

- Objective 1. Monitor the population dynamics of exotic species.
- Objective 2. Determine the impact each exotic species has on native fauna.
- Objective 3. Determine the role of each exotic species on ecosystem energy, nutrient, and contaminant pathways.

Goal 2. Development of predictive models to provide an early warning on new invaders and on potential ecosystem impact.

Objective 1. Which is the next most likely invader; what are the pathways for likely invasion, and how can invasion be stopped?
Objective 2. What impact will the new invader have on ecosystem function, native biota, and surrounding communities?

Goal 3. Development of tools to prevent, minimize impact, and eradicate invasive species.
Objective 1. Develop alternatives to chemical treatments such as pheromone attractants to disrupt exotic species reproduction.
Objective 2. Improve efficacy of physical barrier technology to prevent physical movement of the exotic species into and across the region.

Goal 4. Collaborate with Center biologists and outside state, federal, agencies to provide necessary information in an accurate and timely manner on the movement of the exotic species across the region and its impact on native biota.
Objective 1. Enhance existing early warning systems so that relevant individuals and organizations in the region are quickly notified when a new invasive is identified or poised to enter the Great Lakes.
Objective 2. Improve the timeliness of distribution of GLSC research findings through development of topic-targeted web pages.

CONTAMINANTS

Current Program

Chemical stressors of many classes impact on fisheries in the Great Lakes to different degrees and on many levels, and are a priority with the U. S. Fish and Wildlife Service, the U. S. Environmental Protection Agency, and Great Lakes basin states, Canadian provinces, and their municipalities. The combination of the large surface area and volume; heavy concentration of agriculture, industry and municipal development; and the long hydraulic retention time of the Great Lakes make fisheries particularly susceptible to these stressors. This program, dating from the 1960s and 1970s, has had a long history of providing good science and needed information to the Great Lakes basin community by way of residue monitoring, property estimation, and software development for contaminant behavior, fate, and transport studies, as well as hazard assessment.

Future Directions

A major emphasis of this program has shifted very recently from residue monitoring to food and energy web considerations, specifically the elucidation of chemical stressor trophic transfer patterns, bioaccumulation, and like problems important to the Center mission. These stressors include both traditional and emerging issue contaminants as well as dietary components. There is need to elucidate the identity and trophic transfer pathways of many of these chemical stressors. Once identified, the hazard these stressors present to Great Lakes biota are assessed and communicated.

The long-term goal of our program is to provide the capability for hazard and impact assessment of thousands of observed and potential chemical stressors found in fish, sediment, and water on trophic transfer processes of the Great Lakes food and energy webs.

To meet this goal, we utilize the ecosystem approach to stressors that involves a) identifying natural processes and functions for ecosystems and b) subsequent study of the nature and effects of perturbations to allow us to predict consequences. Within this context, in order to achieve the long-term goal, we 1) make analytical measurements of chemical stressors for identification and quantitation (where necessary), and elucidate stressor impacts on trophic transfer through food and energy webs, 2) either use existing or develop new (where needed) mathematical models and chemical property databases to help compile necessary physicochemiical information to describe chemical stressor environmental behavior including toxicity, persistence and bioaccumulation potential, 3) develop a hazard ranking using additional literature data on toxicities, bioaccumulation, biodegradation, and sources, 4) assess risk of site-specific contamination to biota, and when possible 5) suggest remediation strategies.

Goals and 5-Year Objectives

Goal 1. Elucidate trophic transfer interferences and pathways of chemical stressors such as traditional and emerging contaminants, pharmaceuticals and personal care products (PPCPs), endocrine disruptors, and dietary components, in Great Lakes food webs.

Objective 1. Develop laboratory assay capability for use in early mortality syndrome investigations in Great Lakes basin. Collaborate research efforts with known Centers and researchers, and create viable database for all data.

Objective 2. Develop proficiency in both theory and application of stable isotope analysis to ecological problems such as trophic transfer pathway elucidation and stressor interference. Develop in-house capability, if possible, for stable isotope work or else establish collaborations allowing for stable isotope measurements.

Objective 3. Develop collaborations with both Center PI biologists and outside research groups for the investigation of trophic transfer interferences from identified chemical stressors such as traditional and emerging contaminants including pharmaceuticals, personal care products , endocrine disruptors, and nutrients in Great Lakes biota.

Goal 2. Develop property-predictive QSARs where necessary for general field use with observed chemical stressors from Goal 1, Objective 3 to fill in critical data gaps, especially for inorganic and heavy metal species. .

Objective 1. Assimilation of existing QSAR methodology and databases for use as a generic "toolbox" to assist ecosystem health investigations including environmental fate and risk and hazard assessment.

Objective 2. Continue development, refinement, and distribution of QSAR-based risk and hazard assessment tools, including metal property-prediction parameters such as databases and software for field use. Create CDs and complete the CRADA process for external application of finished product(s).

Goal 3. Determine likely sources, exposure routes, speciation, bioavailability, and ultimate environmental fate(s) for critical chemical compounds identified in Goal 1, Objective 3.

Objective 1. Understand derivation of and improve existing quality criteria by incorporating chemical stressor speciation and bioavailability factors for more accurate risk and hazard assessment.

Objective 2. Develop subsequent quality criteria database(s) reflecting these modifications.

Goal 4. Apply data, data estimation methods, and tools derived from the relevant Objectives in Goals 1 - 3 to current and future risk and hazard assessment issues for more accurate and useable assessments.

Objective 1. Compile "toolbox" of software and databases to facilitate risk and hazard assessments at affected sites and/or with national databases.

Objective 2. Work with BEST and NAWQA as part of their National Synthesis Teams, assisting with the analyses of their numerous databases. Work with other research consortia such as LEEI to lend a more accurate risk and hazard assessment.

Goal 5. Apply crucial assessments in Goal 4, Objective 1, to development of restoration and adaptive management frameworks for impaired ecosystems. These assessments will improve the scientific basis for rehabilitation and restoration of ecosystems such as wetlands, fish spawning grounds, etc. They will also assist in the development of strategies to designate and characterize Index Sites representative of the nation's ecosystems.

Objective 1. Compile and understand needs of Great Lakes basin LaMPs and RAPs with the aim of fine-tuning research goals to answering the needs of the basin community.

Objective 2. Develop collaborations with appropriate committees and such to relay needed data as developed.

TERRESTRIAL, FRESHWATER, AND MARINE ECOSYSTEMS: PUBLIC LANDS AND AQUATIC ECOLOGY PROGRAMS

Current Program

Within the Great Lakes Science Center, interdisciplinary research on coastal ecosystems of the Great Lakes is carried out by the Coastal and Wetland Ecology Branch. Current wetland research efforts focus on quantifying the relations between Great Lakes water levels and wetlands directed toward developing and testing environmentally

sensitive regulation plans for Lake Ontario, determining the role of ground water in wetland response to climate change and refining proxies for climate change over the past 4700 years in chronosequences of beach ridges and intervening swales, and developing and evaluating restoration and alternative management strategies for wetlands on USFWS refuge lands. Public lands and aquatic ecology programs currently emphasize research on priority topics in support of public lands management, especially management of Great Lakes' national parks and wildlife refuges in the coastal zone. Studies areas include determining the developmental history of dune ecosystems to further conservation and restoration efforts, investigating the relations between fire regimes and maintenance of savanna habitats and the plant and animal communities they support, evaluating potential methods for controlling invasive plant species and assessing the importance of factors that might increase susceptibility to invasion, and developing and evaluating new monitoring technologies and sampling procedures for bacterial contamination in support of management of swimming beaches. Studies within the corridor extending from southern Lake Huron through the St. Clair River, Lake St. Clair, the Detroit River, and into western Lake Erie currently focus on assessing fish and wildlife resources and their habitats. Initiatives include creation and evaluation of spawning habitat for lake sturgeon in the Detroit River and use of aquatic remote sensing technologies to evaluate the extent and quality of essential habitats within the corridor, as well as evaluating the natural restoration of burrowing mayfly populations in the corridor.

Future Directions

The Great Lakes Science Center will engage in interdisciplinary research to address high priority management issues in coastal ecosystems of the Great Lakes, with continued emphasis on Department of the Interior and other public lands. Coastal ecosystems function at multiple spatial and temporal scales and cannot be divorced from their surrounding watersheds, landscapes, and developmental histories. Understanding of natural functions in coastal ecosystems is necessary to provide support for knowledgeable management decisions; an understanding of the landscape settings and developmental processes that dictate the manner in which those ecosystems operate today is required. Despite its importance, limited information of this type is currently available. Filling that gap in knowledge is the foundation of GLSC future research on coastal ecosystems. Upon that foundation, the interactions between physical and biological processes will be assessed and the effects of natural stressors of coastal ecosystems will be studied. With appropriate background information, the role of human stressors and disturbances can then be evaluated and quantified, including the influence of the increasingly urban matrix in which natural areas are embedded. Efforts will be made to improve the usefulness of research results through communications with natural resource managers, who may then make informed decisions on actions to halt unnatural disturbances and to initiate mitigation or restoration programs. The GLSC will provide scientific guidance to support those management actions, including evaluation of the potential for success, development of methods that are compatible with the natural functions and processes of the ecosystems, evaluation of success in on-land applications, and follow-up studies to support adaptive management such that successful results can be retained. Looking further into the future, the GLSC will evaluate probable long-term evolution of the Great Lakes shoreline, coastal processes, and coastal ecosystems to develop trajectories and models for predicting how the altered coastal zone will behave in the future.

Goals and Five-Year Objectives

Goal 1. Increase scientific understanding of the development, structure, dynamics, and functions of Great Lakes coastal ecosystems (e.g., wetlands, shallow waters, beaches, dunes, oak savannas) in relation to surrounding landscapes.

- Objective 1. Develop an understanding of landscape setting, underlying geology, resultant hydrology, ensuing biological development, time scale of development, and interactions in Great Lakes coastal ecosystems.
- Objective 2. Apply knowledge of development of coastal ecosystems to understanding of naturally sustainable functions.
- Objective 3. Develop reference sites and long-term datasets that can be used to document the structure, dynamics, and natural functions of coastal ecosystems across spatial and temporal scales.
- Objective 4. Develop models of coastal ecosystems that demonstrate natural processes and functions and provide managers with knowledge of the resources they manage.

Goal 2. Increase scientific understanding of how interactions between physical and biological processes affect coastal ecosystems.

- Objective 1. Improve characterization of the chemical and physical properties of coastal ecosystems across the

continuum from upland to aquatic environments.

Objective 2. Improve understanding of how landscape setting, geology, and hydrology affect distribution of biological components of Great Lakes coastal ecosystems.

Objective 3. Identify natural stressors to coastal ecosystems, including stressor feedbacks among biological, chemical, and physical properties.

Objective 4. Develop spatial models of coastal ecosystems that incorporate landscape heterogeneity, fragmentation, connectivity, and barriers to biological movement between, within, and among components.

Goal 3. Increase scientific understanding of effects of anthropogenic disturbance on coastal ecosystems.

Objective 1. Develop an understanding of the effects of human stressors, such as climate change, disruption of upland-to-aquatic linkages, shoreline modification, altered sediment supply and transport, altered hydrology, land-use change, development on uplands, chemical and microbiological alterations, invasive species and introduction of non-native organisms, and disruption of fire regime on habitats in the coastal zone.

Objective 2. Evaluate the temporal implications of disturbance regimes, including length of disturbance events, frequency of recurrence, severity, and long-term effects.

Objective 3. Develop methods to quantify the effects of disturbance, including interaction of multiple threats, and develop predictive tools and indicators for evaluating disturbance effects.

Objective 4. Develop mechanistic models for coastal processes and disturbance effects that enable managers to understand the implications of disturbance regimes to habitats, biota, public health, and critical processes that extend beyond the coastal zone.

Goal 4. Increase scientific understanding of restoration, mitigation, and management methodologies for conservation of coastal ecosystems.

Objective 1. Determine the realistic possibilities for reversing physical and biological changes or restoring degraded ecosystems, thus allowing sound goals for restoration to be set.

Objective 2. Develop new and improved methods for restoring, rehabilitating, managing, protecting, and creating coastal ecosystems and their component flora and fauna that incorporate an ecosystem approach and establish or retain connectivity across the landscape.

Objective 3. Develop models for predicting success of projects, including indicators and performance criteria that quantify ecological responses and risk-assessment models, especially in the field of public health.

Objective 4. Work in partnership with managers to evaluate the success of on-land applications of management practices, including development of monitoring programs tailored to allow adaptive management that retains successes achieved.

Goal 5. Increase scientific understanding of the potential future of coastal ecosystems.

Objective 1. Evaluate the probable long-term evolution of the shoreline, coastal processes, and coastal ecosystems in the absence of human disturbance to understand how the natural system might have behaved if not disturbed.

Objective 2. Develop landscape and successional trajectories and models that predict and project how the altered coastal zone will behave in the future.

Facilities and Safety

Facilities

The Great Lakes Science Center headquarters is located on the North Campus of the University of Michigan in Ann Arbor where most of its 107 staff members are located. In addition, the Center has four field stations, one vessel base, and three vessel base-field station combinations dispersed throughout the Great Lakes Basin.

Strategic placement of the Science Center's field operations facilitates research conducted over this large geographic area. **Field stations** are located at Munising, Michigan; Millersburg, Michigan (Hammond Bay Biological Station); Porter, Indiana (Lake Michigan Ecological Station), and Cortland, New York (Tunison Laboratory of Aquatic Science. A mid-basin **vessel base** is located at Cheboygan, Michigan. **Combined field stations and vessel bases** are located at Ashland, Wisconsin (Lake Superior Biological Station); Sandusky, Ohio (Lake Erie Biological Station); and Oswego, New York (Lake Ontario Biological Station).

Overview for USGS Great Lakes Science Center and Field Stations

The USGS Great Lakes Science Center is located on the eastern edge of the North Campus of the University of Michigan within the city limits of Ann Arbor, Michigan. The building is a two-story brick structure that is 44,000 square feet in size, and was built in 1964. The building has 45 scientific and administrative offices, 12 biological laboratories, and one 5,000 square foot wet-laboratory. There is an additional one-story brick structure next to the Center that is used for vehicle and building maintenance and repair. The main building's offices and laboratories are temperature and humidity controlled. There are two water wells on the 3.86 acre parcel of land. The Center uses city-supplied water, electricity, and gas. The buildings and the land are owned and maintained by the U.S. Geological Survey. The Center has eight remotely located Field Stations spread among the five Great Lakes, none of which have more than ten full-time permanent employees.

USGS Great Lakes Science Center
1451 Green Road
Ann Arbor, MI 48105

The following Field Stations are part of the USGS Great Lakes Science Center:

Building Address and Description: Lake Superior Biological Station
2800 Lake Shore Drive East
Ashland, WI 54806-2427

The Lake Superior Biological Station is located within the city limits of Ashland, Wisconsin. The USGS staff consists of four scientists, two technicians, and three boat crew. The building is a one-story structure that is 9,067 usable square feet in size, and was built in 1988. The building has scientific and administrative office spaces, two biological laboratories, and one wet laboratory. There is an additional structure next to the station that is used for a gas shed. The main building's offices and laboratories are temperature and humidity controlled. The station uses city supplied water, electricity, and gas. The building and land are owned and maintained by the owner, Ron Nye. It is shared by USGS, U.S. Fish and Wildlife Service, and National Park Service. The dock for R/V Kiyi is located on a pier several miles from the building.

Building Address and Description: Cheboygan Vessel Base
606 Water Street
Cheboygan, MI 49721

The Cheboygan Vessel Base is located in northern lower Michigan near the south shore of Lake Huron in Cheboygan County. The facility is located within the city limits of Cheboygan on the Cheboygan River and is easily accessible from US-23. There is one building and three large vessels on site. The building is a 2,850 square foot storage and work building that was constructed by the Center. This building is used as a workshop for repairing mechanical and fishing gear, office space for the vessel crews and as a storage facility for equipment and fishing gear that is used by the Center's Lake Michigan and Lake Huron sections. The docking facility consists of a 110 foot cement-capped dock with steel sheet pilings. In addition to the two USGS vessels (R/V Grayling and R/V Siscowet), a U.S. Fish and Wildlife Service 85 foot vessel (R/V Togue) used for fish stocking is located adjacent to the property. There are three full time and one seasonal employees at Cheboygan. Office and shop space is provided for one permanent and one seasonal U.S. Fish and Wildlife Service employee.

Building Address and Description: Hammond Bay Biological Station
11188 Ray Road
Millersburg, MI 49759

The Hammond Bay Biological Station is located 13 miles northwest of Rogers City, Michigan on the shoreline of Lake Huron. The buildings and laboratories are easily accessible from US-23. The Station is a two-story building built in 1879 by the U.S. Lifesaving Service and later occupied by the U.S. Coast Guard. The building was acquired in 1952 and has been used for sea lamprey research since then. Additions to the building were constructed at various times from the 1920s through 1980s. The main laboratory has four offices, a library, a meeting room, three

raceways, a chemistry lab, a room to house pollution abatement equipment, and wet lab space (approximately 7,650 square feet). In addition, there are seven outbuildings used for shop and storage areas (approximately 2,600 square feet). A second laboratory, constructed in 1990, is used seasonally by the U.S. Fish and Wildlife Service for the sterilization of sea lampreys used in a sterile male release program. The sterilization facility has one office, a mechanical/storage room, and wet lab space (approximately 2,510 square feet). The main laboratory and sterilization facility are monitored and alarmed for power outages, temperature, water level, fire, and burglary. There are two water wells and two water intake pipelines (one shallow and one deep) that supply Lake Huron water for sea lamprey research. Presque Isle Electric supplies electric service and the facility uses LP gas for heat. The buildings and the land (54 acres) are owned and maintained by the USGS. There are seven full time staff, and, during spring and summer months, the total number of people can reach up to 25, including USGS temporary staff and visiting researchers. The entire property is surrounded by a chain link fence with a remotely controlled sliding gate for access.

Building Address and Description: Lake Ontario Biological Station
17 Lake Street
Oswego, NY 13126

The U.S. Geological Survey's Lake Ontario Biological Station is located on the harbor in Oswego, New York on the southeastern shore of Lake Ontario. The 4,875 square foot building is a single story wood frame structure, built in 1979 and renovated and enlarged in 2001-2002. The building has five offices, a small laboratory, a conference room and two large bays with vehicle access and storage space. Currently, there are five full-time permanent employees, one permanent part-time employee, one term technician, and one seasonal marine machinery repairer at the station. The building is owned and maintained for U.S. Geological Survey by the Port of Oswego Authority. The R/V Kaho is docked behind the building in a secure boat basin maintained and controlled by the U.S. Coast Guard.

Building Address and Description: Tunison Laboratory of Aquatic Science
3075 Gracie Road
Cortland, NY 13045

The Tunison Laboratory of Aquatic Science is located in Cortland County, New York on approximately 100 acres off Gracie Road, north of NY Route 13. The buildings were constructed in the 1960s and contain about 16,500 square feet of laboratory and office space. The Laboratory building consists of offices for eight permanent staff and laboratory rooms designed and equipped for research use. Fish holding and experimental rearing facilities consist of: 24 outside raceways, six concrete holding tanks, a wet laboratory, and a metabolism room. The Hatchery building consists of offices, a classroom, a diet room, and holding tanks. There is a separate garage/shop with four bays for vehicles. There is also a small chemical shed and a storage shed on Laboratory grounds. There are five propane tanks on the grounds for heat and humidity control and four wells supplying water. The buildings and land are owned and maintained by the U.S. Geological Survey. There are three houses used as residences on this property. One is occupied by a USGS employee and the other two are leased to Lime Hollow Nature Center.

Building Address and Description: Lake Erie Biological Station
NASA/Plum Brook Station
6100 Columbus Avenue
Sandusky, OH 44870

The Lake Erie Biological Station is located on Plum Brook Station (PBS), a satellite operation of NASA's Glenn Research Center and is located near Sandusky, Ohio. All operations are located at two sites, Engineering Building and D-Site. Currently there are two scientists, one seasonal marine machinery repairer, one part time administrative technician, and one biological technician at the station. The entire NASA facility is surrounded by a chain link fence and access is through a gate with a guard station. The R/ V Musky II is docked at a marina in Sandusky.

Building Address and Description: Lake Michigan Ecological Station
Indiana Dunes National Lakeshore
1100 North Mineral Springs Road
Porter, IN 46304

Research focus is on the development of management strategies for restoration of damaged or degraded habitat and threats to biodiversity and on the characterization of aquatic habitats and development of mitigation strategies for improvement of aquatic ecosystems. The building is owned and maintained by the National Park Service. USGS staff occupies a building on the grounds of the Indiana Dunes National Lakeshore. Staff includes three scientists, an administrative technician, and several biological technicians; the staff increases considerably with visiting researchers and student assistants during the summer months.

Building Address and Description: Munising Biological Station
Pictured Rocks National Lakeshore
8391 Sand Point Road
Munising, MI 49862

The Station is focusing on studies of disturbance regimes of Great Lakes coastal vegetation with an emphasis on fire and dune dynamics. USGS has one permanent scientist located at this station who occupies one office that is owned and maintained by the National Park Service on the grounds of the Pictured Rocks National Lakeshore.

Field Stations

Lake Ontario Biological Station

The USGS Great Lakes Science Center is dedicated to providing scientific information for restoring, enhancing, managing, and protecting living resources and their habitats in the Great Lakes basin.
The Center is headquartered in Ann Arbor, Michigan, and has biological stations and research vessels located throughout the Great Lakes Basin.

Background

The Lake Ontario Biological Station (LOBS) at 17 Lake Street in Oswego, New York, is a field station of the U.S. Geological Survey's Great Lakes Science Center in Ann Arbor, Michigan. The Center is headquarters for a broad and complex program of research on fish and other living resources of the Great Lakes region. The mission of the LOBS is to determine the changing population dynamics and status of Lake Ontario fish stocks induced by natural processes, management actions, and recently established exotic species. For LOBS scientists to accomplish their mission, the GLSC maintains the 65-foot research vessel *Kaho* in Oswego, NY.

Sorting a trawl on the deck of the R/V*Kaho*

Staff

Personnel currently assigned to the LOBS include three fishery research biologists, two biological technicians, one administrative technician, one research vessel captain, and one marine machinery repairer.

Partners

The LOBS has strong ties to the research community of central New York. Since 1978, most long-term research and monitoring activities, such as assessing important fish stocks, have been conducted annually in partnership with the New York Department of Environmental Conservation. Short-term research on emerging issues is accomplished either in-house, in cooperation with USGS scientists at the Tunison Laboratory of Aquatic Sciences (Cortland, NY), or in partnership with local universities (Cornell University and State University College of Environmental Science and Forestry). Other cooperators include the Great Lakes Fishery Commission, U.S. Fish and Wildlife Service, Ontario Ministry of Natural Resources, and Department of Fisheries and Oceans Canada

Recent Accomplishments

Scientists at the Lake Ontario Biological Station documented that lake trout stocked in Lake Ontario as part of a bi-national effort to reestablish a self-sustaining population successfully reproduced in U.S. waters during 1993-99. Widespread reproduction by hatchery lake trout is not evident in any of the other Great Lakes except Lake Superior.
They also demonstrated that reproductive success of alewives is strongly influenced by water temperatures, thus providing fishery managers a means of anticipating the future direction of the population. Alewives are the primary food of salmon and trout in Lake Ontario. Consequently, the decline of alewife recruitment prompted management agencies to reduce stocking in 1992. Research at the station documented that survival of hatchery-reared lake

Sampling zooplankton on the R/V Kaho.

trout stocked from shore plummeted in the mid 1990s, presumably because of predation in nearshore waters. To increase survival of stocked trout and salmon, the New York Department of Environmental Conservation began stocking fish offshore in deep water in 1998.

Contact:

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Tunison Laboratory of Aquatic Science

The USGS Great Lakes Science Center is dedicated to providing scientific information for restoring, enhancing managing and protecting living resources and their habitats in the Great Lakes region.
The Center is headquartered in Ann Arbor, Michigan, and has biological stations and research vessels located throughout the Great Lakes Basin.

Background
The Tunison Laboratory of Aquatic Science in Cortland, New York, was authorized by an act of Congress in 1930 and was initially called the Cortland Experiment Station. Early work at the station centered around research in nutrition and husbandry of trout. Consequently the station had a series of minor name changes associated with its mission including "Trout Nutrition Laboratory" (1940's), "Eastern Fish Nutrition Laboratory" (1950's), and "Tunison Laboratory of Fish Nutrition" (1970's). In the early 1990's because of a shift in research emphasis the station was re-named the Tunison Laboratory of Aquatic Science. The mission of the Laboratory is to provide resource managers the scientific information needed to preserve, protect, and restore biological resources throughout the Great Lakes basin.

Facilities
The Laboratory is located on 100 acres of land and consists of three buildings for offices, laboratories and storage. The main building consists of three offices, three laboratories, one classroom and five indoor raceways. The laboratory building consists of seven offices, eight laboratories, an isolation facility, conference room and a library room. The storage building houses up to four vehicles and the backup generator, and has a shop and tool room. The laboratory also has 24 outdoor concrete raceways and three residences, two of which are used by the Lime Hollow Nature Center which is co-located on Tunison's 100 acres. Tunison's acreage contains nature trails and stream, pond, and wetland habitats.


The Tunison Laboratory

Partners
The Tunison Laboratory of Aquatic Science cooperates with a wide variety of both research and management partners. These include the New York State Department of Environmental Conservation, U.S. Fish and Wildlife Service, Bureau of Indian Affairs, St. Regis Mohawk Tribe, New York Sea Grant, U.S. Environmental Protection Agency, Ontario Ministry of Natural Resources, Water Resources Division (USGS), State University of New York College of Environmental Science and Forestry, Cornell University, and Hobart and William Smith Colleges.

Research Capabilites
Research carried out at Tunison focuses on a wide array of issues that are important to state, federal, tribal and Canadian natural resource managers throughout the Great Lakes. Specific research topics currently being investigated by Tunison scientists include (1) examining the feasibility of restoring Atlantic salmon, American eel, and lake sturgeon in Lake Ontario and the St. Lawrence River, (2) determining the effects of double-crested cormorant predation on fish populations in Lake Ontario and the St. Lawrence River, (3) determining the effect of cormorant control measures (egg oiling) on reducing impacts on fish populations, (4) examining the cause, effect and possible remediation of thiamine deficiency that causes high fry mortality in salmonids, (5) determining the ecological health of Great Lakes tributaries, near shore areas, and embayments as it relates to native species restoration and exotic species expansion, (6) determining the effects of dressenid mussel proliferation on Lake Ontario food-webs and associated

declines of native amphipods, (7) development of low phosphorus fish feeds to reduce phosphorus levels in hatchery effluent, and (8) assessing the biodiversity and health of wetland habitats within the Montezuma National Wildlife Refuge and along the St. Lawrence River.

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Lake Erie Biological Station

The USGS Great Lakes Science Center is dedicated to providing scientific information for restoring, enhancing, managing, and protecting living resources and their habitats in the Great Lakes Region.
The Center is headquartered in Ann Arbor, Michigan, and has biological stations and research vessels located throughout the Great Lakes Basin.

Background
The Lake Erie Biological Station (LEBS) is a field station of the U.S. Geological Survey's Great Lakes Science Center in Ann Arbor, Michigan. The Center is headquarters for a broad and complex program of research on fish and other living resources of the Great Lakes region. The research of the LEBS focuses on changes in the populations and food web dynamics of important Lake Erie fish, including exotic species, using the R/V Musky II for offshore waters and the R/V Pike for nearshore work.

The R/V Musky II.

Staff
Personnel currently assigned to the LEBS include one fishery research biologist, one research ecologist, two biological technicians and one administrative assistant.

Partners
The Station currently conducts fish stock assessment cruises to the west-central basin in cooperation with the Ohio Division of Wildlife. LEBS has cooperated in lake trout monitoring with New York Department of Environmental Conservation, Pennsylvania Fish & Boat Commission, and Ontario Ministry of Natural Resources since the early 1990s. The station has assisted the U.S. EPA in conducting long term environmental surveys in the central basin since the late 1980s, and also cooperates with the U.S. Fish and Wildlife Service, universities, and international Lake Erie task groups under the auspices of the Great Lakes Fishery Commission.

Recent Accomplishments
Current research includes long-term diet and population studies of nearshore and offshore fish communities; influence of habitat structure as refuges for small fish; factors influencing bird species diversity in wetlands and offshore habitats; influence of exotic species on food web dynamics; and effects of exotic mussels on the nutrient turnover rate in Lake Erie.
LEBS has also helped document the reduced survival of hatchery-reared lake trout and the recruitment decline of adult white bass in Lake Erie.
With the rapid population increase of double-crested cormorants, the station has completed several studies to determine their diet and foraging behavior. Young gizzard shad, emerald shiners, and freshwater drum were identified as the principal prey fish in their diets. Cormorants prefer to forage in shallow waters and near islands or reefs.

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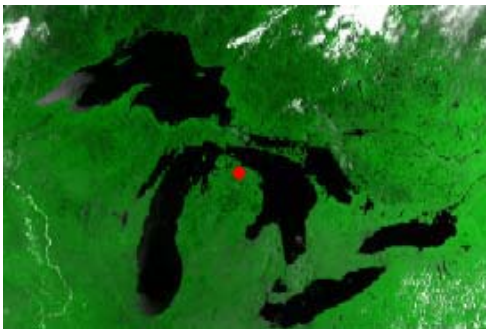
Hammond Bay Biological Station

The USGS Great Lakes Science Center is dedicated to providing scientific information for restoring, enhancing managing and protecting living resources and their habitats in the Great Lakes region.
The Center is headquartered in Ann Arbor, Michigan, and has biological stations and research vessels located throughout the Great Lakes Basin.



The Station

The Hammond Bay Biological Station (HBBS) is a field station of the USGS Great Lakes Science Center. Located at 11188 Ray Road near Millersburg, Michigan, it was a former U.S. Life Saving Service and U.S. Coast Guard Station, and was built in 1879. It became a biological research station in 1950 and has since made important contributions in sea lamprey research and control in the Great Lakes. Scientists here were responsible for many major developments, including design of effective barriers, discovery of the selective lampricide (TFM) used in stream treatments, discovery of a second lampricide (Bayluscide), and development of the sterile-male-release technique for sea lamprey control.

Primary Research Capabilities

Work at the HBBS centers almost exclusively on the study and control of the parasitic sea lamprey that invaded

the Great Lakes and devastated many native fish species. Scientists at the station study all three stages of the sea lamprey life cycle: the larval phase that burrows into stream bottoms, the parasitic phase that feeds on host fishes, and the spawning phase that migrates upstream in spring to spawn. Research on sea lampreys and their hosts is conducted both within the laboratory and in the field.

Facilities

The station is able to pump Lake Huron water from two depths at over one million gallons per day. Larval sea lampreys can be held and fed for extended periods. Water temperatures can be controlled to allow studies of both warm and cold-water fishes or to study the effects of parasitic feeding by sea lampreys. Artificial spawning channels allow study of sea lamprey spawning behavior. Analytical capabilities include spectrophotometry, high performance liquid chromatography, and spectrofluorometry. The station is equipped to conduct static and flow-trough toxicity tests used to examine the effects of various factors on lampricide toxicity in the laboratory and the field. A nearby stream with a combined low-head and electrical barrier allows study of migratory behavior in sea lampreys. A launch ramp provides access to Lake Huron.

Cooperating Agencies

Funded by the Great Lakes Fishery Commission (GLFC), the station conducts research and provides technical support for the GLFC and its control agents--the U. S. Fish and Wildlife Service and the Department of Fisheries and Oceans Canada. Cooperative studies are conducted with GLFC-funded researchers from universities in the U.S and Canada, and with fishery biologists from state, provincial, and tribal agencies throughout the Great Lakes Basin. Through an agreement with the GLFC,

A lake trout attacked by sea lampreys

the station is formally partnered with Michigan State University and the University of Guelph. When possible, station facilities are provided to other university researchers worldwide who are engaged in research on lampreys.

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Cheboygan Vessel Base

The USGS Great Lakes Science Center is dedicated to providing scientific information for restoring, enhancing managing and protecting living resources and their habitats in the Great Lakes region.
The Center is headquartered in Ann Arbor, Michigan, and has biological stations and research vessels located throughout the Great Lakes Basin.

Background

The base is located on the West side of the river below the US-23 bridge. The office is in a single story, vinyl sided, 2,850 square foot stick building. This building serves as an office for the vessel crews, and as a maintenance and storage facility. The base employs 5 to 7 people who are charged with maintaining the three large vessels, facility, grounds and government vehicles. We are equipped to do most above water repairs, and store and maintain, trawls, nets and other scientific gear.

We have 132 ft of dockage on the Cheboygan river with 12 feet of water at dock side (we are hoping to annex the 66 feet of city dock adjoining our property). The facility is shared with the Fish and Wildlife Service who moor the fish stocking vessel (Togue) here.

History

1987 Took over the property from the United States Coast Guard.
1989 Rebuilt the dock.
1995 Constructed the maintenance, storage and now office building.
1998 Upgraded the vessel shore power systems.
2000 Upgraded the vessel shore power systems again to handle 440 volts 3 phase service.

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Munising Biological Station

The USGS Great Lakes Science Center is dedicated to providing scientific information for restoring, enhancing managing and protecting living resources and their habitats in the Great Lakes region. The Center is headquartered in Ann Arbor, Michigan, and has biological stations and research vessels located throughout the Great Lakes Basin.

Background

The Munising Biological Station (MBS) is co-located with Pictured Rocks National Lakeshore in Munising, Michigan along the southeastern shore of Lake Superior. The station conducts ecosystem and community level studies of vegetation, soils and landforms on USDI and other public lands in northern

Michigan and Wisconsin. These studies, focused on coastal terrestrial environments, attempt to connect physical landscape histories with changes in plant communities and individual species populations over various time frames. Studies address broad successional trajectories of vegetation, trends in the fates of rare plant habitats and populations, rates of invasion by alien plant species and other landscape change. The critical and current need for interdisciplinary study of change in coastal ecosystems stems from (and is facilitated by) recent accomplishments in elucidation of lake level histories derived from studies of beach ridge sequences.

MBS has used newly-available lake level histories to temporally frame natural habitat dynamism within Great Lakes coastal dunes. Lake-level-driven changes in coastal dunes have been shown to influence coastal streams, lakes and wetlands as well as dune habitats themselves. Since the biological ramifications of these changes are poorly known, MBS works to place present processes in paleoecological perspective and to demonstrate ecosystem change brought on by stochastic environmental events not directly observed by Europeans, but clearly prominent in the earth system's record. Studies of coastal landscape change serve USDI and other mangers of coastal public lands by documenting patterns of past change so that managers can place management issues (e.g. facility placement and maintenance, monitoring and management of rare species) in proper context.

Projects

Active projects at MBS include: 1. "Holocene history of Great Lakes coastal dunes": This study plan explores the history of broad scale change in soils and dune morphology in response to

lake level change through stratigraphic studies of buried soils that crop out within coastal dune fields. Sites include Pictured Rocks and Sleeping Bear Dunes National Lakeshores, the Hiawatha and Huron-Manistee National Forests, and Tahquamenon Falls and Ludington State Parks; 2. "Response of coastal vegetation to lake level change along the upper Great Lakes". This study investigates change in plant community structure and composition through a time series reading of permanent transects established along the Great Lake coasts; 3) "Imprints of land use history on wetland pine islands and northern hardwood/hemlock/white pine forests". This project employs land use history and resultant impacts to stratify establishment of permanent forest plots in old and second growth pine and hardwood/hemlock forests of Pictured Rocks and Apostle Islands National Lakeshores and the Seney National Wildlife Refuge.

Partners

Primary partners include public land managers in northern Michigan (NPS, USFS, USFWS, MDNR), soil scientists with USDA-NRCS in Marquette, Michigan and collaborators at regional universities (University of Wisconsin-Eau Claire, University of Nebraska, Michigan State University, University of Toledo, Michigan Technological University and Northern Michigan University). Collaboration has brought many tools to investigations of MBS, including ground penetrating radar, wetland and lakebed vibracoring, and optically stimulated luminescence (OSL) dating of sand deposits.

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Lake Superior Biological Station

The USGS Great Lakes Science Center is dedicated to providing scientific information for restoring, enhancing managing and protecting living resources and their habitats in the Great Lakes region.
The Center is headquartered in Ann Arbor, Michigan, and has biological stations and research vessels located throughout the Great Lakes Basin.

Background
The Lake Superior Biological Station (LSBS) is a field station of the USGS Great Lakes Science Center. The U.S. Department of the Interior established LSBS in 1957 to provide information on the status of lake trout populations in Lake Superior. Monitoring of fishery stocks by LSBS was part of a concerted effort by the United States and Canada as coordinated by the Great Lakes Fishery Commission (GLFC) to recover and manage fishes of common concern throughout the Great Lakes following their collapse from overharvest, sea lamprey predation, and habitat degradation.

Facilities
Offices, laboratories, shop, and storage facilities are housed at 2800 Lake Shore Drive East in Ashland, WI. LSBS is co-located with the U.S. Fish and Wildlife Service-Ashland Fishery Resources Office, National Park Service, and Indian Public Health Service.

Vessels
In 2000 a new ship, the R/V *Kiyi*, was delivered to serve as principal research vessel and to replace the former flagship R/V *Siscowet*. The R/V *Kiyi* is much larger (107', 300 tons) than the R/V *Siscowet* (57', 50 tons) that it replaced. The roomy *Kiyi* can comfortably accommodate up to ten crewmembers for long cruises and has large modern wet and dry laboratories. Besides the *Kiyi*, the LSBS has a number of smaller vessels that are used for specialized research missions in near shore waters.

The R/V *Kiyi*, based at LSBS

Partners
LSBS has established research and monitoring relationships with local, state, national and international resource agencies, as well as state and national parks, tribal interests and universities. The station's principal partner is the Great Lakes Fishery Commission and its Lake Superior Technical Committee that includes representatives from Ontario, Michigan, Minnesota, Wisconsin and the Native American nations that border the lake. The committee works cooperatively to manage Lake Superior fish stocks and their environments and identifies information needs and research priorities.

Research Capabilities
The Lake Superior Biological Station is part of a basin-wide program of annual fish stock assessment conducted by the USGS Great Lakes Science Center. This fish stock assessment program provides data to tribal and state agencies managing the fisheries. This assessment program was instrumental in providing the information necessary for management agencies attempting to rehabilitate lake trout populations, which had been severely depleted in Lake Superior. In 1995, through a combination of sea lamprey abatement, stocking, and harvest control, the lake trout was naturally reproducing and declared fully restored and consequently no longer requiring annual stocking from fish hatcheries.

Lake trout

It is a success story of native fish restoration in the Great Lakes. LSBS also monitors the status and trends of the Eurasian ruffe, an invasive fish that made its way into Duluth Harbor in the 1980's.

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Lake Michigan Ecological Research Station

The USGS Great Lakes Science Center is dedicated to providing scientific information for restoring, enhancing managing and protecting living resources and their habitats in the Great Lakes region. The Center is headquartered in Ann Arbor, Michigan, and has biological stations and research vessels located throughout the Great Lakes Basin.

Background

The Lake Michigan Ecological Research Station is a field station of the USGS Great Lakes Science Center. Scientists at LMERS focus on issues relevant to public lands, trust species and shared natural resources. Research is often a joint venture with other agencies such as National Park Service, U.S. Environmental Protection Agency, regional universities, and state agencies. The science is represented in program areas including:

Status & Trends

Long-term studies are conducted describing changes in biological communities and population trends of plants and animals, especially in the Lake Michigan region.

Aquatic Resources

Studies provide critical information needed to determine the possibility of restoring Long Lake at Indiana

Dunes. LMERS is studying the ecology of lakes throughout the National Parks in the Great Lakes Region. Studies in *E. coli* are occurring at Indiana Dunes beaches, City of Chicago beaches, and Dunes Creek. Further testing with rapid response equipment could possibly pinpoint sources.

Wildlife

Investigations are conducted on amphibians, reptiles, birds and butterflies. These programs complement and support the efforts of National Park Service projects and state projects.

Endangered & At Risk Species

Endangered species, such as the Karner blue butterfly, and threatened species are studied to determine factors contributing to their decline. Methods and options for restoring populations and species are developed.

Invasive (non-native) Species

Factors influencing invasions of habitats by non-native species and their effects on the survival of native plants are studied. A joint study is being conducted with Indiana Dunes and Sleeping Bear Dunes National Lakeshores.

Habitats

An extensive study of the effects of experimental burns on oak savanna habitats is being conducted in Miller Woods. This research will analyze the effectiveness of prescribed burns on maintaining this unique habitat.

Contaminants

Studies are conducted to detect contaminant exposure and its effects on plants and animals. The impacts of contaminants are investigated to provide decision makers with

options for mitigation or prevention. Research is being conducted on the Grand Calumet Lagoons and Little Calumet River to ascertain concentrations of contaminants in contaminants in aquatic species. Midwest northern streams are studied to determine baseline environmental status of those areas.

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Research Vessels

The R/V Kaho – Lake Ontario

The USGS Great Lakes Science Center is dedicated to providing scientific information for restoring, enhancing managing and protecting living resources and their habitats in the Great Lakes region.
The Center is headquartered in Ann Arbor, Michigan, and has biological stations and research vessels located throughout the Great Lakes Basin.

Background

The 65 foot long R/V *Kaho* has been the workhorse of the fisheries research fleet in Lake Ontario for more than two decades. The vessel was built in 1961 by Hansen Welding Company in Toledo, Ohio, and since it was assigned to the Lake Ontario Biological Station in 1977, the *Kaho* has participated in long-term population studies of important prey fishes and in long-term studies aimed at evaluating the performance of stocked lake trout used in the bi-national restoration program. Current information on prey fish populations is used by resource managers to adjust stocking schedules, and population models built from the long-term data are used to anticipate future changes in the prey fish community.
In addition to lake trout restoration research, the *Kaho* has participated in tightly focused short-term studies designed to determine the effect of invasive species on the Lake Ontario ecosystem. Such studies included documenting changes in the food web and in fish distribution associated with establishment of invasive species. Studies conducted aboard the *Kaho* documented the spread of zebra and quagga mussels across the lake bottom and the concurrent decline of the burrowing amphipod, *Diporeia*, an important food for many fishes. The *Kaho* is also used to collect fish and environmental samples for a wide spectrum of studies, including the Great Lakes Fish Contaminants Monitoring Program in cooperation with U.S Environmental Protection Agency.

Specifications

The R/V *Kaho* has two crew members, and has sleeping accommodations for four scientific personnel. There are two washrooms, one with a shower, and a full galley including an electric range, microwave, refrigerator and eating area. The *Kaho* has the ability to be at sea for 17 days.

Sampling zooplankton on the R/V Kaho

Length: 65 ft.
Beam: 17.8 ft
Draft: 9 ft.
Displacement: 83 tons
Propulsion: Twin diesel engines (Cummins N-855 Big Cam, 195 HP each), Twin Disc 2.95:1 marine gear, twin Michigan Wheel 3-blade, 40" x 28½" propellers, 3" shafts.
Cruising Speed: 10.4 knots (12 mph)
Range: 2400 miles
Fuel: 3000 gallons

On-board Equipment

Fully equipped for fisheries research, the *Kaho* has bottom and midwater trawls, gillnets, stainless steel sorting table, trawl winches, a deck crane, gillnet lifters, enclosed balances and a wet laboratory with freezers and refrigerators for processing fish collected.
The *Kaho* also has limnological sampling capabilities with a Seabird SBE 19 Bathythermograph with Licor PAR sensor, ALEC Electronics ABT-1 Direct Reading Bathythermograph, 0.5m plankton nets with flow meters, Niskin bottles, Van Dorn water sampler, 9"x9" Ponar bottom sediment sampler, YSI digital temperature probe, and secchi disks.

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The R/V Musky II – Lake Erie

The USGS Great Lakes Science Center is dedicated to providing scientific information for restoring, enhancing managing and protecting living resources and their habitats in the Great Lakes region.
The Center is headquartered in Ann Arbor, Michigan, and has biological stations and research vessels located throughout the Great Lakes Basin.

The R/V *Musky II*

Based in Sandusky, Ohio, the R/V *Musky II* is used primarily in Lake Erie to assess annual recruitment of major prey and predator fish in western Lake Erie as well as lake trout restoration research in the eastern basin. In addition, the *Musky II* has participated in studies designed to determine the impacts of environment changes and invasive species on the Lake Erie ecosystem. Studies include documenting changes in the food web and fish distribution associated with environmental changes. Investigations conducted aboard the *Musky II* documented the first Great Lakes record of the exotic zooplankter *Bythotrephes longimanus* (spiny water flea), first documentation of round gobies in western Lake Erie, and the invasive spread of zebra and quagga mussels. The *Musky II* is also used to collect fish and environmental samples for a wide spectrum of studies, in cooperation with state, federal and Canadian fishery and environmental agencies, and the Great Lakes Fishery Commission.

Specifications

Built in 1960 at Toledo, Ohio, the *Musky II* can be at sea for seven days while sleeping four: two crewmembers and two scientific personnel. It has a fully equipped galley and one head.
Length: 45 feet
Draft: 5 feet
Displacement: 24 gross tons
Propulsion: Single Diesel engine, 250 H.P.
Cruising Speed: 10 knots
Range: 600 miles

A plankton net tow.

On-board Equipment

The *Musky II* is fully equipped for fish sampling with bottom and mid-water trawls, including a Kem trawl net reel, gillnets, a 20- inch Crossley gillnet lifter and hydroacoustics gear. It is also well equipped for limnological sampling with a Ponar bottom sediment sampler, bathythermograph, plankton nets, dissolved oxygen and pH meters, and secchi disks. The vessel has a wet laboratory with hot and cold running water, limited counter space, electrical outlets, freezer and refrigerator.

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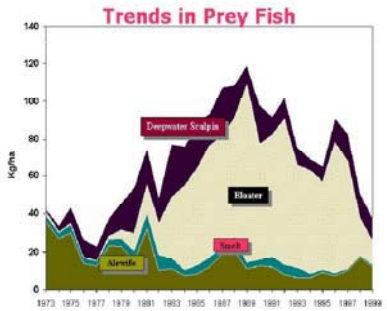
The R/V Grayling - Lake Huron and Lake Michigan

The USGS Great Lakes Science Center is dedicated to providing scientific information for restoring, enhancing managing and protecting living resources and their habitats in the Great Lakes region.
The Center is headquartered in Ann Arbor, Michigan, and has biological stations and research vessels located throughout the Great Lakes Basin.

Background

The R/V *Grayling* is the Great Lakes Science Center's second largest ship, and is currently operating on both lakes Huron and Michigan. Docked at the Cheboygan Vessel Base in northeast lower Michigan, the *Grayling* is used primarily to carry out annual prey fish assessments. These assessments have occurred annually since the 1970's. They represent an exceptionally long data series that is being used to provide current information on the prey fish base to fisheries managers and to facilitate understanding of long term population trends in the fish community. Data on prey fish populations are especially important in evaluating management strategies such as predator stocking and harvest quotas. Other current research projects aboard the *Grayling* include research into the applications of hydroacoustic technology in fish stock surveys, lake trout restoration, a study of mechanisms regulating diet and growth of lake whitefish in Lake Huron, and documenting the expansion of invasive round gobies in offshore waters and their interactions with native species.



A round goby

Specifications

Built in 1977, the *Grayling* is large enough to comfortably accommodate eight people, including three crew members and five scientific personnel. It has a full galley and two heads with showers, and can be at sea for around 17 days.
Length: 75 feet
Beam: 22 feet
Draft: 9.8 feet
Displacement: 189 metric tons
Cruising Speed: 9.1 knots

On-board equipment

Since the *Grayling* is primarily used for fisheries research, it is equipped with bottom and mid-water trawls, gillnets and gillnet lifter, and hydroacoustics gear. It also has limnological sampling capabilities with a bathythermograph, plankton nets, Ponar bottom sediment sampler, and side-scan sonar.

The Cheboygan Vessel Base

The Cheboygan Vessel Base provides primary research vessel (R/V *Grayling* and *Siscowet*) capability across Lake Huron, eastern Lake Superior, and Lake Michigan, with the vessels operating across four state boundaries, Canadian waters, and treaty waters in lakes Huron and Michigan. The R/V *Grayling* provides the platform for research by investigators in the Lake Huron Project, in hydroacoustics, food web dynamics, and fish community and population dynamics.

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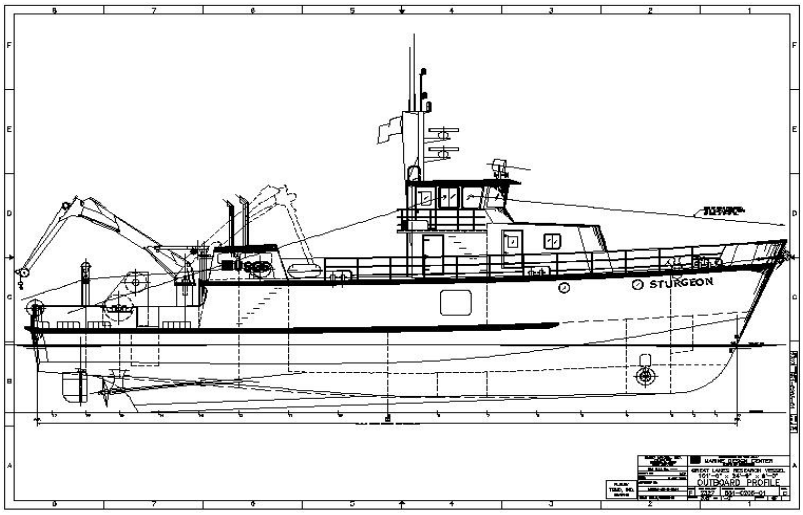
The R/V Sturgeon – Lake Huron and Lake Michigan



Background

The R/V Sturgeon was acquired by the Great Lakes Science Center in July 1993 from the Smithsonian Institution under a property transfer. The vessel formally named the MARSYS RESOLUTE was used by the Institute to support Caribbean studies for over a decade. In early 1994 the vessel was transferred from the Navel Shipyard in Washington DC to the Center's vessel base in Cheboygan, Michigan. For several years Center staff worked on the vessel during the Winter months preparing it for major overhaul. In April 2002 Basic Marine, located in

Escanaba , Michigan was awarded the construction contract and began the complete overhaul of the vessel. The anticipated completion date is May 2004. The primary mission of the STURGEON will be to support fisheries related science in Lake Michigan using state -of -the-art electronic technology and traditional sampling gear like bottom and midwater trawls and gillnets. Its design characteristics include all of the necessary features to support a wide variety of aquatic science projects in the open waters of the Great Lakes.

Specifications:

The STURGEON is designed to operate with a crew of three: a captain, mate and engineer. With berthing for 10 people, the vessel is capable of comfortably supporting a crew of 3 and a scientific staff of 7 for up to a 15 day mission. Accommodations include four 2 person state rooms each with a small sink and vanity, a fully equipped laundry room and a galley and conference center with seating for 10.

Length: 101 feet
Beam: 24.9 feet
Draft 9 feet
Propulsion: Twin Detroit diesels
Cruising speed: 11 knots

On-board equipment:

The STURGEON is designed to function as an offshore work platform during the ice-free season in the Great Lakes. To meet the mission requirements of the USGS and our basin-wide partners the vessel is equipped with sophisticated electronic navigational and scientific gear. Clean electrical power available from two Cummins 99KW generators is capable of meeting all of the electrical demands of hydro-acoustic data acquisition and side scan sonar bottom profiling. Gear deployment can easily be accomplished using paired trawl winches, high capacity deck crane, net reels or the outboard davit. The 50 hp Wesmar dual propeller bow thruster ensures accurate control of the vessel at all times so docking and holding station is done with relative ease. The back deck work area is designed to eliminate obstructions and facilitate sample processing. Interior laboratory space is divided into wet and dry areas. The wet laboratory is equipped with sorting tables, a gill net lifter, computer ports, freezer space and a live well. The dry laboratory is

New deck house.

designed to function as the electronics control room. Here the scientist is able to observe operations on the back deck and monitor all of the electronic gear including pilothouse navigational data.

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The R/V Siscowet – Lake Huron and Lake Michigan

The USGS Great Lakes Science Center is dedicated to providing scientific information for restoring, enhancing managing and protecting living resources and their habitats in the Great Lakes region.
The Center is headquartered in Ann Arbor, Michigan, and has biological stations and research vessels located throughout the Great Lakes Basin.

The R/V *Siscowet*

Based at the Cheybogan Vessel Base in Cheboygan, Michigan, the R/V *Siscowet* is now operating in Lake Huron and Lake Michigan. The *Siscowet* is a temporary replacement for the R/V *Cisco* and will be replaced by the new research vessel the R/V Sturgeon.

The *Siscowet* is currently being used to assist with lake trout studies, and is also participating in a number of preyfish studies on both Lake Michigan and Lake Huron. The sample data provides information on the distribution and abundance of fish species and communities. Studies are also designed to determine the impacts of fishing, habitat alterations, and pollution on fish populations. This information is provided to several state, federal, and Canadian fishery and environmental agencies, and the Great Lakes Fishery Commission.

Specifications

Built in 1946 at Manitowac, Wisconsin, the *Siscowet* sleeps five: two crewmembers and three scientific personnel, and has a fully equipped galley.

Length: 57 feet
Draft: 6 feet
Cruising Speed: 9.6 knots

A plankton net tow.

On-board Equipment

The *Siscowet* is fully equipped for fish sampling with bottom and mid-water trawls,
including gillnets, an instrument winch and a Ponar winch.. It is also well equipped for limnological sampling with a Ponar bottom sediment sampler, bathythermograph, plankton nets, dissolved oxygen and pH meters, and secchi disks. The vessel has a wet laboratory with hot and cold running water, limited counter space, electrical outlets, freezer and refrigerator.

Contact:

Edward Perry
Cheboygan Vessel Base
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Cheboygan, MI 44870
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Email: eperry@usgs.gov

The R/V Kiyi - Lake Superior

The USGS Great Lakes Science Center is dedicated to providing scientific information for restoring, enhancing managing and protecting living resources and their habitats in the Great Lakes region.
The Center is headquartered in Ann Arbor, Michigan, and has biological stations and research vessels located throughout the Great Lakes Basin.

The R/V *Kiyi*

The R/V *Kiyi* is the Great Lakes Science Center's largest research vessel at 107 feet long and it is based on the largest Great Lake, Lake Superior. It is also the Center's newest research vessel, commissioned in April, 2000. It conducts fish stock assessment, fisheries research and habitat monitoring in cooperation with state, federal, tribal and university partners through the Lake Superior Technical Committee of the Great Lakes Fishery Commission. The *Kiyi* uses trawls and gillnets to annually sample preyfish populations and to track progress in the sustainability of the lake trout population. The *Kiyi* is also used to collect fish and environmental samples for a wide spectrum of studies, including the Great Lakes Contaminant Monitoring Program in cooperation with the U.S. Environmental Protection Agency.

Specifications

The *Kiyi* has four crew members: a captain, mate, engineer, and deck chief. In addition to the crew, the *Kiyi* sleeps five scientific personnel and has two heads with showers, a galley, a laundry room, and potable water storage of 2400 gallons. The *Kiyi* can be at sea without replenishment for two weeks.

Length: 107 feet
Beam: 27 feet
Draft: 10 feet
Propulsion: Twin Cummings diesels
Cruising speed: 10 knots

Back deck of the Kiyi

On-board Equipment

The *Kiyi,* which completes many fisheries and limnological cruises per year, is fully equipped for numerous methods of collection. A Kolstrand gillnet lifter, a Stern Oceanographic A frame, trawler net reels, a 9000 pound deck crane, and a davit boom with a Pullmaster bathythermograph winch are on board to facilitate research. A wet lab and freezers allow for on-board processing of samples.
Safety equipment includes a 14 foot inflatable Zodiac boat, 2 ten person life rafts, 15 survival suits, and a fixed CO2 engine room fire suppression system.

Contact:

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Safety Program

Great Lakes Science Center Safety Program

Carol Edsall is the Collateral Duty Safety Officer (CDSO) for the Great Lakes Science Center in Ann Arbor. She is working with the Regional Safety Officer on developing programs and mandatory training for the Center staff. Within 6 months she will receive required training, which includes orientation to the USGS Occupational Safety and Health Program, reviewing basic duties and responsibilities and learning about the available resources and policies from the Regional Safety Manager.

General responsibilities include advising management in developing the occupational safety and health program at the center. The Center's Safety Plan will be reviewed and revised as necessary. Center staff will be informed of safety training requirements and will be advised as to how to best accomplish the training (examples of training are laboratory safety, hazardous communications program, and defensive driving). Safety meetings will be reestablished in order to address employee concerns regarding matters of safety and occupational health.

Dr. James P. Hickey, Research Chemist, is both the Center Chemical Hygiene Officer and the Hazardous Waste Officer. He is responsible for the maintenance of the Chemical Hygiene Plan and enforcement of numerous chemical-related provisions therein. The Chemical Hygiene Plan contains numerous safety-related policies and SOP's, and is required reading for all new employees.

The Great Lakes Science Center underwent an external environmental compliance audit in April, 2002. All open findings from the report issued have been addressed and those findings were entered into the WEBCASS database. The Chemical Hygiene plan has been updated and is available to all employees on the Center's LAN. Training videos for the HAZCOM program have been converted to CD-ROM and will also be available to all staff on the LAN. The most significant accomplishment was the remodeling of the indoor flammable storage area to meet the necessary safety requirements.

Research Themes

USGS Biological Resources Programs
Great Lakes Science Center

Points of Contact:

BIOLOGICAL INFORMATICS

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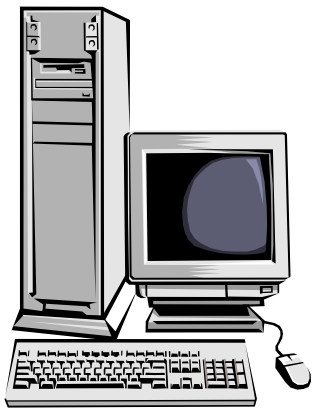
Biological Informatics Program

Introduction

People are the most important part of the Biological Informatics Program of the Great Lakes Science Center. The GLSC currently employs five and one half full time workers and several work-study workers. These workers include a Communications Officer, Statistician, Librarian, Web Designer, Database Developer, Computers Systems Administrator, and the Computer Section Leader. This staff applies innovative technologies and practices to the management of biological data, information, and knowledge, thereby increasing its value to the internal and external customers of the GLSC.

Information Infrastructure - Physical

The physical component of the information infrastructure is first described by its geographical locations. Beside the home office located in Ann Arbor, MI, the GLSC has eight field offices. The Marquette and Munising Michigan field offices have one person each and are collocated with USFWS and NPS respectively. The Cheboygan Vessel Base has a low intensity computing installation. Ashland, WI; Porter, IN; Hammond Bay, MI; Sandusky, OH; Oswego, NY; and Cortland, NY; each have a minimum of five FTEs. These five larger field stations each have a network server as well as PCs and printers.



The GLSC employs the use of PC hardware sufficient to support the deployment of the latest desktop and server operating systems. There are approximately 120 desktop and server PCs throughout the GLSC. The most cost effective approach is attempted in leveraging existing hardware components to make good on previous investments and minimize waste when upgrading systems. Discarded hardware is placed in appropriate reuse/recycling streams. The GLSC participates appropriately in DOI hardware contracts with Dell, IBM and others.

The network infrastructure at all the locations of the GLSC is 100mps Ethernet. Each location is equipped with high-speed Internet connectivity. The Ann Arbor Internet connection is T1 to Reston, VA via MCI-WorldCom. Marquette, Munising, Porter and Sandusky are collocated with USFWS, NPS, NPS, and NASA respectively and utilize the host Internet connection. The other field offices utilize low cost local commercial ISPs: Ashland uses Charter Cable service; Oswego and Cortland use Media One Cable service.

Information Infrastructure – Telecommunications

The GLSC maintains state of the art telecommunications systems at each of its locations. These systems include automated attendant and voice mail for each employee.

Information Infrastructure – Software

The GLSC fully participates with the DOI software contracts for Adobe products, Norton Antivirus, Windows XP, Office XP, Windows 2003 Server, and Oracle 9i. In addition, SAS (Statistical Analysis System) is utilized through a USGS contract.

Information Infrastructure – Security

On December 9, 2003, The House Subcommittee on Technology, Information Policy, Intergovernmental Relations and the Census released its Federal Computer Security Report Card. This release was based on reports required by the Federal Information Security Management Act of 2002. The federal government on the whole received grade D while the Department of Interior received grade F. The Department of Interior as a whole and the USGS in particular is under taking large efforts to improve. The GLSC is working in stride with these efforts. In particular we are keeping all operating systems patched, virus updates applied, firewalls established on all our networks, and our public web server is secured in a demilitarized zone.

This year the USGS is undergoing a Certification and Accreditation process on its IT systems. *Certification* is an evaluation of the security features of an IT system and establishes the extent to it meets documented security requirements. *Accreditation* is the formal declaration by an approving authority that an IT system is compliant with established security requirements. The GLSC is cooperating with this process.

All of the locations of the GLSC maintain offsite backups of all data. The Ann Arbor location maintains this is a bank safety deposit box.

Information Infrastructure – Databases

The GLSC considers its elemental databases to be part of its information infrastructure. Most large datasets are managed using the Oracle relational database management system software. All Oracle databases have been recently converted to the current release of the software: Oracle 9i (except for two lake components of RVCAT). All databases operating under Oracle 9i are intrinsically web enabled. This creates wonderful potential for serving data to the internal and external partners of the GLSC.

RVCAT - The Research Vessel Catch System (RVCAT) contains data going back to 1954. It holds all biological data collected on the large vessels operating in the five Great Lakes and is the life-blood of the deepwater science program. Data on some of the vessels is entered directly into an Oracle database at the point of collection. This data is then imported into the master database within days of cruise completion and ready for analysis.

An RVCAT Integration Committee has been established to oversee the continued development of the system. With representatives from each lake project the committee will undertake the following tasks:

1. Finish implementing the web based approach to RVCAT. Import the two remaining components: Superior and Ontario.

2. Develop Documentation and User manuals for this new Oracle 9i approach: "RVCAT for Dummies".

3. Make deepwater science and summaries available on the web.

4. Collect, digitize, and link with RVCAT essential metadata, primarily including cruise reports, float plans, and sops.

Great Lakes Aquatic GAP: The GLSC is constructing and housing the central database of this project. This is a five-year interagency project and is part of the National Biological Information Infrastructure (NBII).

Genetics: The GLSC Laboratory of Molecular Ecology generates genetics data on Great Lakes fish stocks. his data is currently entered into an array of spreadsheets and MS-Access database tables. A redesign of this data system has recently been completed in print form. Based on this specification, a cohesive Oracle 9i database will be created to establish a new genetics information system.

Commercial Catch (COMCAT): Daily fishing records of U.S. Waters of the Great Lakes. Data spans from 1971 to present and is served on the GLSC and NMFS web sites: http://www.glsc.usgs.gov/data.asp?ID=3 and http://www.st.nmfs.gov/st1/commercial/ .

Coded Wire Tag: Database housed in Ann Arbor. Contributors include OMNR, GLSC, MDEQ, FWS, CORA. Contains the history of captured Coded Wire Tag lake trout from Lake Huron.

Lake Erie Environmental Investigations: Contains data from a study done on Lake Erie Tributaries from the 1980s and 90s demonstrating the linkage between sediment contaminants and fish health – fish communities – invertebrate communities.

Lake Erie Near Shore - Contains (will contain) general ecological data spanning from 2000-2002. Includes larval and juvenile fish, benthic invertebrates, zooplankton, and limnological parameters using three different sampling designs.

Contaminant Chemistry – Contains fish tissue archive and organic pesticide and PCB results since the early 70s. Also contains some contaminant sediment data.

Interagency Cisco Database – Small mesh gillnet captures of Cisco (chubs) from Lake Superior, contributed by MN DNR, WI DNR, MI DNR, Kewanaw Bay & Redcliff tribes, CORA, USGS.

Interagency Predator Prey Database – Lake Superior returns of several predator species contributed by all agencies in Cisco database plus OMNR.

Card Image Data – Various collections of benthic invertebrates, Hexagenia, macrophytes, etc. from the 60s, 70s and 80s.

GIS – Site specific data sets such as Metzger Marsh, Lake Erie; maps of spawning habitats in the Great Lakes. GIS maps of terrestrial wetlands and aquatic habitats at Indiana Dunes National Lakeshore.

Statistical Support

The Center Statistician provides support for experimental and survey sample design, choice of statistical methods, data exploration, quality assurance of data, data manipulation, statistical analysis, interpretation and presentation of results, and the review of proposals and manuscripts.

John Van Oostan Library

The Van Oostan library contains one of the largest print collections of aquatic sciences literature in the world. This collection is electronically searchable through the use of Cuadra Star Associates database software. In addition, the library provides access for Center scientists to a variety of online literature search services, and obtains documents needed by scientists. The library plays a key role in tracking the manuscript publication process. The Center's manuscripts are referenced in an electronic database. All of the libraries electronic databases are searchable through a world wide web interface.

GLSC Web Site

The Great Lakes Science Center Web Site (http://www.glsc.usgs.gov) provides electronic access to the information produced by the Center. A full time position was established at the beginning of the current fiscal year to improve this vital resource. At the same time, a web committee was established to guide the ongoing development of the site.

National Biological Information Infrastructure

The NBII is a portal into the Nations biological information. The GLSC participates directly and indirectly in the NBII. Direct involvement includes participation in the Great Lakes Aquatic GAP regional project. Indirect involvement includes most of the science conducted at the Center. During the next five years, the GLSC will be exploring ways to become more directly involved in the NBII. Specifically, the Center will improve its participation in the production and posting of metadata. The Center will also explore the creation of a Great Lakes Regional NBII Node.

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Contaminant Biology Program

Contaminants in the Great Lakes Biota

Chemical stressors of many classes impact on fisheries in the Great Lakes to different degrees and on many levels, and are a priority with the U. S. Fish and Wildlife Service, the U. S. Environmental Protection Agency, and Great Lakes basin states, Canadian provinces, and their municipalities. The combination of the large surface area and volume; heavy concentration of agriculture, industry and municipal development; and the long hydraulic retention time of the Great Lakes make fisheries particularly susceptible to these stressors. For the past three decades, through cooperative agreements with numerous basin agencies and research programs, the Center program has provided sound science and needed information to the Great Lakes basin community through monitoring contaminant behavior, fate, and transport studies, as well as hazard assessment. Recent studies

Urban Development

traced the emergence and behavior of polybrominated diphenyl ethers, an emerging contaminant class of fire retardant chemicals. Also, recent studies of archived rainbow smelt tissue (1983-2002) helped determine species sensitivity to contaminated sediment in the basin, and provided critical Great Lakes food web data. We have developed a nonlethal tissue sampling method to provide necessary residue data to assist in lake sturgeon recruitment studies. The tissue data provided by this study supplement a meager lake sturgeon contaminant body burden database existing in the Great Lakes basin. The Center program has shifted emphasis recently from residue monitoring to food and energy web considerations, including the elucidation of chemical stressor trophic transfer patterns, bioaccumulation, and like problems important to the Center mission.

Lake Sturgeon

Current Program.

The present research efforts under this task have three interrelated concentrations: chemical stressor identification and pathway elucidation of trophic transfer interference, chemical property estimation, and risk/hazard assessment. There is need to elucidate the identity and trophic transfer pathways of many of these chemical stressors, which include both traditional and emerging issue contaminants as well as dietary components. Cause-and-effect linkages have been made for many chemical stressors with lethal and sub-lethal problems involving trophic transfer interferences through food and energy webs for fish and wildlife. The acquisition of both skills and ability to use the stable isotope technique to help investigate trophic transfer interferences has become a high priority.

Once identified, the hazard these stressors present to Great Lakes biota are assessed and communicated. However, data needed to reliably perform accurate hazard and risk assessments on the thousands of compounds in use and introduced yearly are available for only a small fraction these compounds. As time, equipment, and funding considerations make the requisite data collection impossible, there is urgent need to obtain reliable estimates of physical properties, potential hazard, and ultimate environmental fate. Quantitative structure-activity relationship (QSAR) investigations create models that correlate numerous types of chemical descriptors with published environmental activity and fate to provide, very quickly and very inexpensively, reliable data for hazard screening and other purposes. Periodic physical property determinations have been made for compounds (classes) for national contaminant oversight groups such as Interagency Testing Committee (ITC), and investigations of "hot topics", such as endocrine disruption, natural bioremediation, and emerging contaminant issues. Center QSAR investigations have resulted in prototype expert system software designed for estimation of physicochemical properties for stressors including toxic endpoints for organisms. This software, very useable by field personnel, allows for rapid toxicity and other property estimation for a very wide variety of environmental organic, organometallic, and inorganic/heavy metal contaminants. Estimation of even rudimentary metal environmental behavior has proven very difficult to date in QSAR investigations, and our investigations have put the Center on the cutting edge in this field.

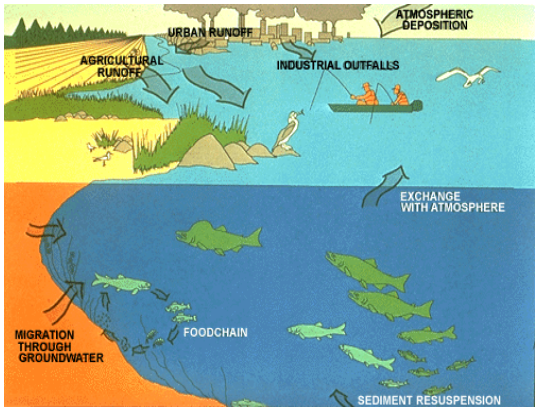
The third phase involves determination of risk associated with the contaminants found in the environment. The projects range from the cellular to population impacts. Fish, wildlife, and other aquatic biota of the Great Lakes watershed have been diminished by degraded habitats that have been chemically or physically altered by anthropogenic activity. We have been instrumental in establishing

Contaminated Brown Bullhead

guidelines and a protocol for aquatic risk assessment during work with the USEPA on Great Lakes Areas of Concern (AOC).

Future Directions.

The long-term goal of this Center program is to provide improved capability to assess the hazard and impact of thousands of observed and potential chemical stressors found in fish, sediment, and water on trophic transfer processes of the Great Lakes food and energy webs. In order to achieve the long-term goal, we 1) make analytical measurements of chemical stressors for identification and quantitation (where necessary), and elucidate stressor impacts on trophic transfer through food and energy webs, 2) either use existing or develop new (where needed) mathematical models and chemical property databases to help compile necessary physicochemical information to describe chemical stressor environmental behavior including toxicity, persistence and bioaccumulation potential, 3) develop a hazard ranking using additional literature data on toxicities, bioaccumulation, biodegradation, and sources, 4) assess risk of site-specific contamination to biota, and when possible 5) suggest remediation strategies.



Goals and 5-Year Objectives.

Goal 1. *Elucidate trophic transfer interferences and pathways of chemical in Great Lakes food webs.*

Objective 1. Collaborate research efforts, create viable database, develop laboratory assay capabilities for use in early mortality syndrome investigations in Great Lakes basin

Objective 2. Develop proficiency in and a mechanism for use of stable isotope analysis application to ecological problems.

Objective 3. Develop internal and external collaborations for the investigation of trophic transfer interferences from identified chemical stressors in Great Lakes biota.

Goal 2. *Develop QSARs where necessary for general field use to fill in critical data gaps, especially for inorganic and heavy metal species.*

Objective 1. Compile QSAR methodology and databases for a generic "toolbox" to assist ecosystem health investigations including fate, trophic transfer, and hazard assessment.

Objective 2 Develop needed QSAR-based risk and hazard assessment tools, such as metal property-prediction parameters, for field use. Distribute products, and utilize the CRADA process.

Goal 3. *Determine likely sources, exposure routes, speciation, bioavailability, and ultimate environmental fate (s) for critical chemical compounds*.

Objective 1. Understand derivation of existing quality criteria and improve by incorporating speciation and bioavailability factors for more accurate risk and hazard assessment.

Objective 2. Develop subsequent quality criteria database(s) reflecting these modifications.

Goal 4. *Apply compiled data, data estimation methods, and tools to risk and hazard assessment issues for more accurate and useable assessments.*

Objective 1. Compile "toolbox" of software and databases to facilitate risk and hazard assessments at affected sites and/or with national databases.

Objective 2. Work with BEST and NAWQA and other research consortia such as LEEI as part of their National Synthesis Teams, assisting with the analyses of their numerous databases, to promote more accurate risk and hazard assessment.

Goal 5. *Apply risk and hazard assessments to restoration and adaptive management frameworks for impaired ecosystems.*

Objective 1. Compile and understand needs of Great Lakes basin LaMPs and RAPs with the aim of fine-tuning research goals to answering the needs of the basin community.

Objective 2. Develop collaborations with appropriate committees and such to relay needed data as developed.

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Related Research Projects:

Project-Task	Primary Program	Title	PI
9TZ-46	Contaminant Biology	Contaminants in the Great Lakes Biota	Hickey
9IM-50	Biological Informatics	GAP Assessment – Year Two	Reader
9IN-13	Fisheries: Aquatic and Endangered Resources	Ecosystem Health, Great Lakes	Reader

Fisheries: Aquatic and Endangered Resources

Background

Anthropogenic activities have led to the decline and sometimes extinction of several species native to the Great Lakes. Species that were extirpated in some or all of the Great Lakes include lake trout, Atlantic salmon, blue pike, and several species of ciscoes. Species whose populations have dramatically declined include American eel, lake sturgeon, lake

Young lake sturgeon.

trout, lake whitefish, lake herring, coaster brook trout, deepwater sculpin, and several species of native unionid clams. Several of these species were historically used by Native American tribes for subsistence and ceremonial purposes.

No single factor led to the decline of native fish species in the Great Lakes. For migratory species such as Atlantic salmon and American eel, dams are thought to have severed historic migration routes. For other species, such as lake trout and blue pike, combinations of factors including over-harvest and predation by sea lamprey are considered the major causes of their declines. Alewife, an invasive marine species that is now a major prey species in several Great Lakes, is thought to have led to the decline of ciscoes and perhaps deepwater sculpin in some of the Great Lakes by a combination of predation and competition.

Because of the variety of anthropogenic activities that have led to the extinction and decline of native fish species in the Great Lakes and the complex life history strategies of these species, restoration efforts must be comprehensive and multi-faceted. Recent changes in the Great Lakes ecosystem brought about by a host of new invasive species including dreissenid mussels, Asian clams, ruffe, round goby, and *Phragmites* (common reed) make restoration attempts even more difficult. Restoration of native species must take into consideration many issues including genetics, strains, and disease. For example, genetic concerns will be less important in the case of extirpated species (i.e., Atlantic salmon) and strain evaluation will be a high priority. In the case of declining species (e.g., lake sturgeon), genetics will be a high priority to ensure that restoration activities do not adversely impact native gene pools (i.e., cause founder effects).

Native species recovery in the Great Lakes also includes the restoration of degraded habitats that have been chemically and/or physically altered by anthropogenic activities. For example, the nearshore area is an important spawning and nursery ground for over 100 fish species in the Great Lakes; however, this area is also most prone to human interference. Habitat restoration activities can be targeted to achieve ecological benefits at either the community or individual species level and are critical for preserving aquatic biodiversity throughout the Great Lakes. Developing a better understanding of how existing anthropogenic activities; such as water level control to support shipping and hydropower industries, hardening and development of shorelines, and modification of harbors and tributaries to facilitate vessel navigation; impact habitat and biological communities in the Great Lakes is a critical need of resource managers.

The ecological health of the Great Lakes is a priority concern for all the partners of the Great Lakes Science Center (GLSC). Consequently, developing indices to quickly and effectively identify the ecological health of deepwater, nearshore, and tributary ecosystems in the Great Lakes is important. Furthermore, establishing linkages among these ecosystems and with riparian and terrestrial landscapes will be necessary to provide resource managers with the information they need to effectively manage the world's largest freshwater ecosystem.

Current Program

The Great Lakes Science Center's Fisheries: Aquatic and Endangered Resources (FAER) research program places a heavy emphasis on field studies by scientists located at both Ann Arbor and our numerous field stations. Based largely on our partner needs, these studies vary in scope, complexity, and scale. Under the broad categorization of restoration ecology, GLSC scientists are involved with a wide range of studies that focus on habitat, fish, and mussels. The GLSC's habitat restoration research includes helping the Fish and Wildlife Service identify the most effective ways to restore wetlands at several national wildlife refuges throughout the basin. Center scientists are also carrying out risk assessment research associated with habitat restoration and remediation. Fisheries restoration research is directed at American eel, Atlantic salmon, lake sturgeon, and lake

American eel.

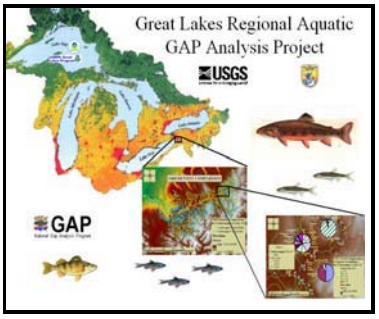
trout. Restoration research on native unionid mussels is being carried out in cooperation with several of our partners. Common to all restoration ecology research activities carried out by GLSC scientists is the elucidation of causal mechanisms contributing to the decline of associated species, which may aid in recovery efforts.

Center scientists are also working on a variety of research projects associated with aquatic ecosystem health. One of the Center's major efforts in this area involves thiamine deficiency of top fish predators in the Great Lakes. Thiamine deficiency is attributed to the consumption of the invasive alewife, a species

high in thiaminase, and has been shown to affect fry survival ("Early Mortality Syndrome") and, more recently, the migratory

Adult salmonid being injected with thiamine to treat thiamine deficiency caused by Early Mortality Syndrome.

ability of adult salmonids. GLSC research in this area is directed at both helping managers better understand the cause and linkages of thiamine deficiency and developing management techniques to circumvent the problem. Research linking nearshore ecosystems to deepwater, tributary, and terrestrial ecosystems is ongoing in the Great Lakes and involves teams of Ann Arbor and field station scientists. In Lake Erie, a research team is looking at how abiotic and biotic factors such as substrate type, water quality, invasive species, and watershed use may affect larval fish communities in nearshore nursery areas. The scope of this research can be expanded to include other life history variables, and the protocols developed may be used to implement similar comparison studies in the other Great Lakes and connecting channels. Center scientists are also conducting research to improve sampling protocols for and risk assessment of *E. coli* in nearshore waters of the Great Lakes and are examining the decline of *Diporeia* and associated causes. Several scientists at Ann Arbor and at field stations are working on the Great Lakes Regional Aquatic Gap Analysis project, which is attempting to determine the biodiversity within the basin and identify gaps in species distribution information and conservation coverage at the landscape scale.



Some research activities of GLSC scientists within the FAER research program lie beyond the central scope of restoration ecology or aquatic ecosystem health, but are undertaken in response to emerging needs of partners and incorporate the specialized skills and expertise of GLSC scientists. Center researchers are conducting studies to help resource managers determine the impacts of double-crested cormorants on fish populations as well as the effects of water level changes on key biotic resources. The center is also providing scientific leadership in using new technologies to better understand the life history patterns of several important deepwater salmonid species in the Great Lakes.

New Directions

The future direction of the FAER research program at the GLSC will be shaped to some extent by the rapid rate of change now occurring throughout the Great Lakes basin. Possibly never before in the history of this ecosystem has this rate been so rapid, nor the changes so dynamic. The changes have been greatly accelerated by invasive species, most notably dreissenid mussels. Consequently, charting a fixed course of action for the future at this time is probably imprudent. At best, an adaptive course can be plotted that responds to changes now underway in the ecosystem, with full recognition that new changes and challenges will arrive in the future and need to be addressed at that time.

In plotting this new and adaptive direction for the Center's FAER research program, it should be recognized that restoration ecology and aquatic ecosystem health will remain major thematic research areas. Our partners' interests in restoring native species and determining and improving aquatic ecosystem health will not diminish. The changes underway in the Great Lakes ecosystem will, however, very much determine what specific research the Center undertakes in these reas in the future. The rate of change in the Great Lakes ecosystem is probably most pronounced in the lower trophic levels. Consequently, food-web disruption should be anticipated and our research focus should attempt to examine if and how this disruption will infiltrate higher trophic levels. Will food web disruption vary among lakes, within lakes, among habitats between nearshore and offshore areas? The magnitude of these questions suggests that an integrated multi-disciplinary approach will be necessary to address them. Within the GLSC's own research staff, integration between deepwater science and nearshore science programs will certainly be required.

Perturbations at the lower trophic levels in the Great Lakes may also afford managers the opportunity to re-couple native food webs in some of the lakes by restoring native coregonid species. There is management interest in considering this in Lake Erie (lake herring) and Lake Ontario (bloater). The GLSC's FAER and deepwater science programs are highly capable at assisting managers with these unique and large-scale efforts, if undertaken.

The FAER research program of the GLSC is, and will continue to be, diverse. Similar to the deepwater science program, the strength of the Centers' FAER research program is that it is being carried out throughout the basin, by researchers located at both Ann Arbor and at field stations. The size, complexity, and rate of change in the Great Lakes ecosystem will require FAER research efforts in the future to have more robust sampling designs and modeling approaches leading to increased predictive capability, better integration with other scientific disciplines, increased innovation and use of new technologies, landscape or basin-wide scale studies, and new perspectives, new approaches and new partnerships.

Assessing the ecological health of nearshore communities.

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Invasive Species Program

Background

Since the 1800's, over 136 species of exotic algae, fish, invertebrates, and plants have become established in the Great Lakes. As human activity has increased in the region, particularly with the opening of the St. Lawrence Seaway, the rate of successful introduction of exotic species has surged. More than 1/3 of these invasive organisms were introduced since the 1960s and many now dominate the aquatic community in both numbers and biomass. The most problematic invasive species include alewife, common carp, Eurasian ruffe, Eurasian water milfoil, purple loosestrife, quagga mussel, rainbow smelt, round goby, rusty crayfish, sea lamprey, spiny waterflea, and the zebra mussel. These species alone have contributed to massive extinctions of native fauna, severe alterations in local food webs, and the zebra mussel alone

Zebra mussels impacting native clam.

has resulted in millions of dollars of damage to local water users such as municipalities and industries. While many of these exotics have been in the Great Lakes for over a decade, recent increases in disease outbreaks (e.g., botulism and thiamine deficiency syndrome); blue-green algal blooms; loss of key invertebrates such as *Diporeia* in lakes Michigan, Ontario, and Huron; decline in recruitment and body condition of important native fish such as lake whitefish in Lake Huron; and an expansion of the "dead zone" in Lake Erie, indicate severe ongoing ecosystem oscillations in many parts of the Great Lakes.

Exotic species in the Great Lakes are a concern to other watersheds in North America due to the interconnectivity of these waters through canals, commercial and private boat traffic, and recreational practices. A prime example of rapid expansion from a regional to a national issue can be seen with the invasion of the zebra mussel. Zebra mussels were first introduced into the Great Lakes around 1986. In less than 10 years, they have spread throughout the Great Lakes, into many small inland lakes and rivers in most of the states bordering the Great Lakes, and have moved into the Mississippi River and can be found all the way down to New Orleans. A second exotic species, the round goby, is poised to repeat this invasion pattern. There are also three exotic Asian carp species (bighead, black, and silver) poised to enter the Great Lakes watershed from the Mississippi River.

Once exotics become established, management efforts to limit expansion are generally costly and rarely successful. Prevention is the best management strategy. Targeted research on impact, prevention, and control strategies, and dissemination of this information to managers and resource users in a timely manner is needed. There a numerous other exotic species poised to enter the Great Lakes, and only rigorous prevention programs will prevent further damage to Great Lakes water resources. The Great Lakes Science Center, through its many partnerships with state, tribal, and U.S. and Canadian agencies, is critical to the efforts to increase the region's understanding of the impact of exotic species.

Current Program

The Great Lakes Science Center's exotic species research program is a well-balanced mixture of prevention, control, monitoring, and impact studies that vary in geographic scale and complexity depending on the species, region, and resource need. However, much of the research is integrated into ongoing Status and Trends or Fisheries programs, or through the Sea Lamprey program; very few studies are funded directly through the Invasive Species Program. The Center's sea lamprey program, based at

Sea lamprey

Hammond Bay, is unique in its structure and function. This is the oldest collaborative exotic species program in the Great Lakes and is also the only one that deals with eradication, as well as population monitoring and basic biology. Through substantial efforts of all partners, sea lamprey populations have been drastically reduced throughout the Great Lakes. This program is discussed in detail separately.

Research on other exotic species is more regionally based and tends to focus on basic information rather than eradication. The problem facing this research program is the large number of new invaders that have become established over the past 5-15 years, and species continue to be introduced. During the early years of an invasion, resource managers, user groups, and regulatory agencies need data on geographic distribution, population dynamics, basic biology, and predicted impact on native communities. The Center's long-term deep-water data sets have been instrumental in providing this key information on new invaders across much of the Great Lakes. This research is funded primarily under Status and Trends or Fisheries programs. As needed, additional research studies have been undertaken to address specific resource questions. This included work on population dynamics of European ruffe in Lake Superior, use of soft sediments as

habitat by dreissenids in lakes Erie and Ontario, characterizing the "dead zone" in Lake Erie, displacement of native benthic fish from spawning grounds by round gobies, predation on lake sturgeon eggs by round gobies, competitive interactions between different exotic species, and movement of round gobies and dreissenids into deeper waters of Lakes

Round goby.

Michigan and Huron. Some of this research has been funded through the Invasive Species Program; most have been funded through outside funding sources.

The Center has also provided critical research to support the control and prevention of exotic fish and invertebrates, though not to the degree seen with sea lamprey. Center biologists were instrumental in testing the electric barrier installed in the Illinois Waterway canal system to prevent movement of round gobies from the Great Lakes into the Mississippi River drainage. Research has also investigated the impact of zebra mussels on native unionids in enhanced or native refugia. Center biologists also assist partners such as the National Park Service in developing and implementing aquatic exotic species prevention programs, serve on national and international panels, and participate in regional, national, and international workshops.

1999 zebra mussel distribution.

New Directions

Through its partnerships and research capabilities, the GLSC is well positioned to continue to play an important role in exotic species research. This must remain a multi-layered, multi-disciplined program due to the fact that exotic species continue to enter and become established in the Great Lakes. Great Lakes managers and resource users will continue to need information on all aspects of new and existing exotic species, including basic biology, geographic distribution, and potential impact on existing biota. However, the ability to respond effectively to exotic species would be enhanced if the Center's research contained both proactive and ecosystem process components.

A proactive approach to exotic species would require development of predictive models capable of forecasting the next likely invader, vectors of invasion, primary points of entry, probable geographic spread, and risk to the existing community. Such a modeling program would enable strategies to be developed for research, containment and control, refugia for native species, etc., before the arrival of the next invader rather than after. The Center's extensive network with state, federal, Canadian, and tribal entities will enhance the efficacy of this type of program. At current funding and staffing levels, a proactive status will be difficult to achieve since the Center must continue to provide the basic information on current and new exotic species as needed by the regional resource managers and users.

More research into ecosystem processes and linkages is needed if the Center is to provide accurate information on the impact of an exotic species once it becomes established in the Great Lakes, particularly those occupying lower trophic levels. To date, the major portion of the Center's invasive species work has been a sideline of ongoing community status and trends research, which is usually regionally limited and/or focused on response of top predator fish stocks or changes in prey fish. This research focus provides sufficient data for changes in the top fish community and their prey fish, but not data on other changes in the lower trophic levels. GLSC is best situated to provide data on deepwater/nearshore ecosystem linkages and the changes brought about by the continued invasion of exotic species across all trophic levels. Additions to the long-term status and trends work will provide substantial information of critical need to the Great Lakes community. Such integrated ecosystem research is already ongoing in Lake Ontario and is proposed for other areas.

Continuing invasions of exotic species heightens the need for the development of better tools than what currently exists for preventing, controlling, and mitigating the impact these invasives have on the Great Lakes. A prime example of technology innovation and development is the work on non-chemical control of sea lamprey. The Center's work on the electric barrier in the Illinois Waterway canal system is also a good example of the type of cooperative effort in technology and partnerships needed to minimize inland spread. However, additional techniques are needed to prevent the initial establishment of invasive species. Further work in this area is critical for the continued survival of native fish and invertebrate communities within the Great Lakes.

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Sea Lamprey Research

Background

Lampricide Control

Together with the UMESC in LaCrosse, the Hammond Bay Biological Station has played a major role in the discovery of lampricides and the refinement of techniques for their use. We continue to provide technical assistance to that program by

supporting purchases of lampricide through a QA program, providing FWS personnel in the field with analytical support and standards, and through continuing research to refine our capability to predict safe and effect concentrations of lampricides in stream treatments.

Ecology and Assessment

Research done at Hammond Bay accounts for a significant part of our knowledge of the life cycle and ecology of sea lampreys in the Great Lakes, including effects on host species. Recent accomplishments include the first comprehensive analysis of parasitic growth, proof that there is no fidelity of sea lampreys to a natal stream, introduction of coded wire tags and mark recapture to estimate lake wide populations of parasites, estimates of attack lethality, and proof of the relationship between sea lamprey marks observed on fish and losses of lake trout. We contributed substantially to development of a spatial approach to assessment and treatment of sea lamprey larvae in the St. Marys River, resulting (in combination with sterile male releases, below) in lamprey populations in Lake Huron approaching fish community goals.

Alternative control methods

The station has played a key role in the development of several alternatives to lampricides. Initial development of barriers to block sea lampreys from spawning areas in stream was done at Hammond Bay. The most recent evolution of that technology, a combination of a low head barrier that blocks lampreys under normal spring flows and a pulsed-DC barrier that blocks them under flood conditions, was developed at the station. Nearly 30 years of research into the sterile male release technique resulted in successful implementation by the FWS on the St. Marys River and publication of proof of the effect on recruitment.

New Directions: Alternative control methods are the keys to future sea lamprey management

Sea Lamprey Pheromones

Exciting new discoveries in pheromone communication by sea lampreys promise new tools. In part due to fieldwork conducted at the HBBS over the last decade, Michigan State University and University of Minnesota researchers identified two pheromones. Larvae burrowed in streams excrete a "migratory" pheromone. HBBS scientists had previously shown that sea lampreys do not home to natal streams, yet spawners are consistently found in the same streams. Evidence from tests by Peter Sorensen in two-choice mazes in raceways at the HBBS suggests the migratory pheromone is the method of stream selection. Field tests in the Hammond Bay area will attempt to direct movements of migrating adult sea lampreys. A second "sex" pheromone is released only by spermiated (ripe) adult male sea lampreys. It appears to trigger ovulation in females, and later (but only after the females are ovulated), attracts ripe females to the ripe males. Recent tests by Weiming Li in the Ocqueoc River showed that every ovulated female that made a choice between traps containing a ripe or non-ripe male chose the ripe male. Both pheromones may disrupt sea lamprey migrations or reproduction, or enhance trapping.

The mouth of an adult sea lamprey.

Emerging Technologies in Telemetry to Address Knowledge Gaps in Fish Community Ecology

Most of what we know of species interaction on temporal, depth, or thermal scales are derived from point observations with fishing gear or hydroacoustics. Progress in telemetry will soon allow us to reveal these interactions on a scale not imagined a decade ago. We are currently using new data storage tags to gain new insights into the depths and temperatures occupied by different strains of lake trout and by lake whitefish, chinook salmon, lake sturgeon and sea lampreys. Currently, we are limited to studying species where commercial or sport exploitation produces tag recoveries. Depths and distance in the Great Lakes preclude conventional radio or ultrasonic telemetry. We are presently working with the GLFC and LOTEK to develop a new type of tag for use with unexploited species or populations.

Barriers reemerge

A combined low-head and electrical barrier was constructed on the Ocqueoc River, which functions effectively as a low-head barrier but also blocks sea lampreys during high water on this flood-prone stream. This combination of proven technologies allows effective blockage of migrating sea lampreys and passage of jumping fishes under a much broader range of stream flows. Under normal flows, the

low-head barrier is functional, no current flows to the electrical barrier, and jumping fish can pass. During flood conditions, when the low-head barrier is inundated, the electric barrier

Electric barrier combined with a low head dam to block, trap, and remove sea lamprey. (Image: Smith-Root Inc.)

automatically turns on and blocks sea lampreys. Scientists at HBBS will be working in the future with Robert McLaughlin and Gordon McDonald of the University of Guelph to better block sea lamprey migration and improve passage of other fishes at electrical, low-head, and inflatable barriers, and further reduce any negative effects of barriers on stream communities.

The Future:

Staffing to Carry on Sea Lamprey Research.

We currently have three scientists (one chemist and two biologists) and four technicians (one admin and three biological) at the station. With the addition of summer temporary positions, the technical staff is adequate. The scientific staff, however, has shrunk in recent years. Two biologist positions were transferred to MSU during the late 1990s as funding previously provided by the GLFC went to establish two new faculty positions at MSU under the Partners for Environmental Research and Management (PERM) agreement between the GLFC, USGS, and MSU. Productivity at HBBS is currently based on this successful partnership, but also depends on maintaining a stable team of research scientists at the station. The scientific staff is also aging and may soon turn over with potential retirements. We could quickly move from a cumulative 70 years of experience with sea lampreys to an inexperienced new staff. The future direction of the science program and staffing at Hammond Bay necessitates an ongoing dialog between USGS and the GLFC.

Funding Outlook The GLFC has been providing the funding necessary to carry out a dynamic program. For this to continue, we need to continue being responsive to the immediate needs of the program for research and technical assistance, and to look forward in developing new lines of research. The current organization of the sea lamprey management program, strong partnerships with the FWS, DFO, and PERM, and the firm commitment of the staff at Hammond Bay to sea lamprey management make our long-term relationship with the GLFC likely to continue.

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Status and Trends: Deep-water Science Program

The USGS Great Lakes Science Center (GLSC) has a long history of significant contributions to the understanding of aquatic resources in the Great Lakes, through partnerships and interactions with state, tribal, and U.S. and Canadian federal agencies. The main focus of the Center's research is on the long-term dynamics of native and non-native aquatic species and the sustainability of Great Lakes fisheries.

Background

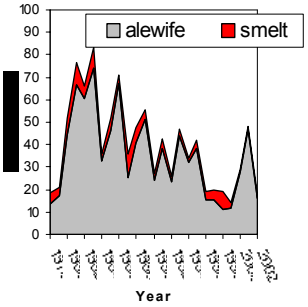
Prey fish

The GLSC conducts annual bottom trawl surveys in all five Great Lakes to assess the status of both predator and prey species, although much of our work is focused on prey fish populations. The prey fish assemblage, including alewife, gizzard shad, emerald shiner, rainbow smelt, bloater, sculpins, and lake herring is a vital trophic link in the aquatic ecosystem; prey fish populations may be limited both by their food supply and predators. Within and among the Great Lakes, prey fish abundance and species composition vary greatly annually. Adequate prey fish populations are required to sustain walleye, lake trout, Pacific salmon, and other salmonid top predators in the Great Lakes. The top predator populations support economically valuable fisheries and thus maintaining vigorous predator populations are of great concern to resource management agencies. An accurate assessment of the prey fish populations is vital in determining the appropriate management decisions regarding these top predators. Managers across the Great Lakes basin request our help in providing current information on the status of prey fish populations and rely on us to provide the understanding of population dynamics needed for anticipating future direction of prey fish populations. As a federal agency, we can conduct fish surveys at wide spatial scales that cross political boundaries and are viewed as an unbiased and objective source of information for resource managers. We are the only agency with true deepwater capabilities on all Great Lakes and can sample habitats and aquatic communities that are beyond reach of individual States and Canadian resource agencies.

R/V Kiyi, the Great Lakes Science Center's largest and newest vessel, conducts surveys and research on Lake Superior. The Center also has large ships on Lakes Erie, Huron, Michigan, and Ontario.

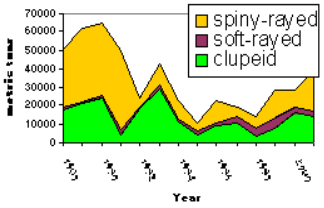
Fish community structure has changed substantially in the Great Lakes since the Center was established and research questions abound regarding understanding and predicting the dynamics of the prey fish communities. Species extinctions and establishment of invasive and non-native species (e.g., sea lamprey, alewife, rainbow smelt, ruffe, and gobies) have been observed in each lake. In addition, top predator fish species and abundance have changed dramatically through time with the loss of native lake trout and severe reduction of burbot populations throughout most of the basin, loss of Atlantic salmon in Lake Ontario, subsequent stocking of hatchery lake trout for restoration efforts, and the stocking of Pacific salmon to control alewife invasions. In general, Lake Erie, the warmest and shallowest lake, is the most productive and has the highest species diversity of prey fish. In contrast, Lake Superior is a deep, cold and relatively unproductive lake. Lake Ontario prey fish community is dominated by two non-native species, alewife and rainbow smelt. Lakes Michigan and Huron have lost a large complex of native ciscoes coincident with the alewife invasion. Both lakes are dominated by only a few species: alewife, rainbow smelt, bloater, sticklebacks, and sculpins.

Providing current information to fisheries managers is a highly visible and public aspect of our program, but of equal importance is research resulting from continual development of our long-term database, which now contains over 30 years of data for most of the lakes. Long-term data are being used to examine a diverse suite of ecological issues, including species extinctions and establishment of invasive species, effects of continued predator stocking on the prey fish community, identification of recruitment mechanisms that regulate prey fish abundance, and response of prey species to changes in food webs. Results of these studies have been published in peer-reviewed journals sine the 1960's.



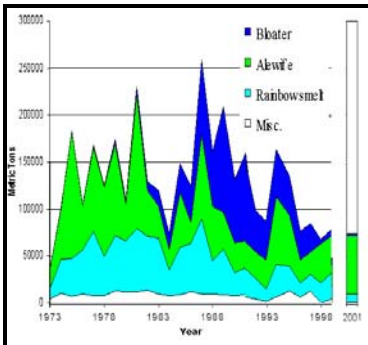
Lake Ontario's preyfish biomass, dominated by non-native alewife and smelt.

Fish community dynamics investigations are possible because of the multi-decade data series collected by the Center and are augmented by the ability to perform genetic analyses to identify

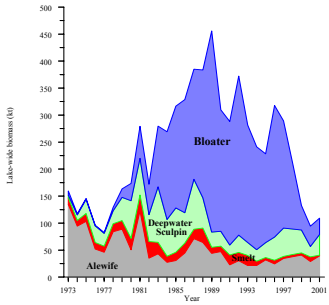


Lake Erie biomass of forage fish species.

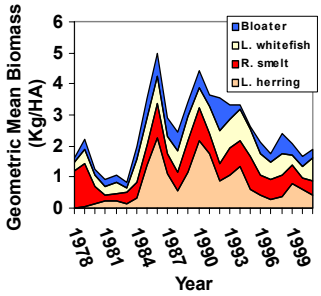
Spiny-rayed fish include young yellow perch, white perch and white bass; soft-rayed include trout perch and emerald and spottail shiners; and clupeid are young gizzard shad and alewife.



Lake Huron's prey fish biomass. Sampling not completed in the year 2000.



Lake Michigan prey fish biomass.



Lake Superior preyfish biomass

population substructure and patterns of gene flow. A variety of techniques are used at the Center to investigate spatial and temporal genetic relationships within and among Great Lakes fish populations. Center researchers are using genetic methods to monitor the success of stocking programs designed to rehabilitate top predators like lake trout. Center scientists are also focusing on the use of non-lethal tissue extraction techniques and archival material to survey endangered fish species.

Lake trout

The lake trout, a federal trust species, was historically the top native predator fish in the Great Lakes and the mainstay of the early commercial fishery. A combination of over-fishing and predation by the exotic sea lamprey along with other contributing factors caused extinction of

lake trout in all of the Great Lakes except Lake Superior where populations were greatly diminished and Lake Huron where an isolated, remnant population persisted. Managers have been deeply concerned about the lake trout and have instituted a variety of rehabilitation efforts. Because lake trout are a long-lived fish, effectiveness of management efforts are only determined through a long-term surveillance. Hence, the GLSC has conducted long-term gillnet assessment of native lake trout in Lake Superior and of hatchery-reared lake trout in all of the Great Lakes to evaluate the status of lake trout rehabilitation. As with our prey fish long-term data series, the lake trout database can provide a wealth of information in understanding lake trout population dynamics and movements. In addition, intensive research has been done on factors suspected of adversely influencing the establishment of self-reproducing, sustainable stocks of lake trout in the Great Lakes. Research has included evaluating the effect of various factors on survival of hatchery-reared trout, including rearing density, life stage at stocking, adult abundance on juvenile survival, season of stocking, genetic strain, and stocking method and location. Other research has included population modeling, observing geographic and bathythermal distribution and movements of adults and juveniles, verifying contaminant and energy uptake with laboratory and field diets and bioenergetic modeling, measuring growth and maturity, determining factors affecting fecundity, and understanding the role of thiamine deficiency in lake trout survival. Although many of the factors thought to influence survival of hatchery fish have been investigated, these studies have to be repeated periodically as fish communities change. We also demonstrated differential survival among genetic strains of lake trout in vulnerability to and survival from sea lamprey attack. As a consequence, hatcheries switched strain of lake trout used in rehabilitation program. Because of our observance of naturally produced larval lake trout on a mid-lake spawning reef in Lake Huron, that reef was declared a refuge.

Invertebrates

Aquatic invertebrates provide an important food source for most prey fish as well as for juvenile top fish predators. Understanding diets is essential in identifying the competition among native and non-native fish species. Invertebrate communities have also suffered from the invasion of non-native fish and invertebrate species because invasives have altered food webs and may sequester energy. Currently, zooplankton and benthic invertebrate populations and fish diets are analyzed in studies complementing ongoing long-term fish surveys. In addition, baseline information is used to document the impact of new invasive invertebrate species. As a result, Center researchers are developing bioenergetic models of recently-introduced mussels.

One problem encountered by most ecologists studying invertebrates is lack of current taxonomic expertise. Center researchers have created an interactive web key that describes over 100 species of free-living and parasitic copepods. Information regarding species identification, distribution, ecology, and literature references is centralized on a web site providing a reference tool for managers and researchers in the Great Lakes basin. Ongoing efforts also involve preparation of keys for rotifers and aquatic insects distribution around the Great Lakes.

New Directions

Prey fish ecology

Our annual bottom trawl estimates have documented wide fluctuation in the Great Lakes prey fish communities. This important long-term data set can be used for a variety of long term ecological studies. Future research efforts will be directed at understanding the mechanisms underlying these changes to better address the managers' information needs.

Specifically, the prey fish studies will be enhanced to provide more accurate abundance estimates and to allow better predictions of recruitment, growth, and survival. To improve surveys, Center researchers and peers will be scrutinizing sampling designs to improve the accuracy of biomass and abundance estimates and to allow statistical comparisons of data through time within and between the lakes. This will undoubtedly require some gear standardization and trawl comparison surveys that link modern gears with ones used historically. We are also incorporating remote sensing technology, particularly hydroacoustics, to complement bottom trawl information and provide more information about pelagic fish. Hydroacoustic surveys were initiated in Lake Michigan in the 1990s, and plans are currently underway to incorporate hydroacoustic surveys in each of the Great Lakes.

Fish sampling using a bottom trawl.

To better understand the factors influencing the prey fish community, we will incorporate value-added sampling of lower trophic levels to the overall survey design. We have begun documenting changes in the invertebrate community that affect the food base of prey fish by taking concurrent benthic samples with bottom trawls, and by sampling zooplankton communities concurrently with hydroacoustic surveys. Inclusion of benthic invertebrate samples can document the rapidly changing benthic invertebrate community in the Great Lakes with subsequent repercussions throughout the food web. Stable isotope analyses can complement direct diet analyses to document energy flow through the food web. In Lake Ontario, we are starting to track energy density of prey fish to detect consequences of food web disruption and impact on upper trophic levels. Habitat features such as depth and temperature are routinely obtained, but other factors such as nutrient content and substrate type can be incorporated in the survey designs. Larval fish investigations can complement typical surveys and enhance the understanding of prey fish recruitment.

Colonization of the Great Lakes by zebra and quagga mussels has shunted production to the benthos while at the same time reducing our ability to sample benthic fishes with our traditional bottom trawls. Moreover, round gobies, an exotic benthic fish, are increasing in abundance and poised to become a major part of the prey fish community. We need to develop tools to sample benthic fishes in those broad areas of the Great Lakes infested with dreissenids.

Lake trout and other predator fish

Center researchers are still investigating the important factors affecting the status of lake trout, a keystone species, in the Great Lakes. In Lake Superior in which stocking of supplemental lake trout are not required, investigators are interested in better understanding the deepwater forms of lake trout and their impact on the forage fish community. In the other lakes, a variety of factors are under investigation. Surveys of lake trout will continue to aid in development of management plans and will evaluate the effects and consequences of new management strategies. The influence of stocking methods on survivorship is being reevaluating in light of recent ecosystem changes. Factors affecting egg quality are being studied and energetic conditions of lake trout throughout the Great Lakes basin are being compared. The importance of a refuge from fishing pressure in aiding recruitment of lake trout is still an unanswered question in the Great Lakes. Studies involve documenting refuge use and movement patterns in and out of the refuge. The importance of early mortality syndrome on lake trout survival is being addressed in an initiative lead by the Center. The thermal regime used by different lake trout strains and their sea lamprey predators is producing surprising results that will lead to better understanding of lake trout survival. Center researchers are also studying the impacts of non-native fish and invertebrates on lake trout early life history. In addition, researchers are working on the population dynamics of other top predators such as burbot.

Fish sorting on the R/V Kiyi.

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Related Research Projects

Project-Task	Primary Program	Title	PI
9IM-01	Status and Trends	Lake Michigan Fishes	Madenjian, Charles
9IM-02	Status and Trends	Lake Superior Fishes	Gorman, Owen
9IM-03	Status and Trends	Lake Huron Fishes	Schaeffer, Jeff
9IM-04	Status and Trends	Lake Ontario Fishes	O'Gorman, Robert
9IM-05	Status and Trends	Lake Erie Fishes	Bur, Michael
9IM-06	Status and Trends	Biodiversity of Fishes in the GL	Todd, Thomas
9IM-07	Status and Trends	Biodiversity of Aquatic Invertebrates in the GL	Davis, Bruce

Terrestrial, Freshwater, and Marine Ecosystems

Research Theme – Coastal Ecosystems

The coastal zone of the Great Lakes (defined here as those onshore and nearshore areas that are or were at one time influenced by coastal and aeolian processes) includes wetlands, drowned river mouths, shallow water habitats, oak savannas, beaches, dunes, relict coastal features and deposits, and abandoned dune fields. These coastal ecosystems offer diverse habitats that support a myriad of plant, fish, and wildlife species.

Drowned river mouth wetland.

The economy of many coastal areas is dependent on the recreational value of these habitats and the sport fishing, commercial fishing, hunting, birdwatching, and swimming and hiking activities associated with them. Large numbers of seasonal tourists spend millions of dollars on lodging, food, sporting goods, boat and vehicle rentals, gasoline, and personal items, which often represent the major source of income to coastal communities. The ecosystems that supply the fish, wildlife, and recreational facilities underlying that economy have been severely impacted in number, area, and quality. Degradation is often associated with human activity in the coastal zone, including industrial, commercial, residential, and agricultural development, as well as alteration of littoral and other coastal processes that supply the sediments that form and maintain natural features such as dunes, beaches, and sand spits. Yet, surprisingly little is known about the relationships between protection of natural habitat and biota and environmental factors such as water-level change, coastal sediment dynamics, coastal tributary sediment dynamics and hydrology, and ground-water contributions in the coastal zone. Understanding the interactive role of biology, geology, and hydrology in protection and maintenance of coastal features is critical to the survival of the resources important to the people living in and enjoying the coastal zone.

Overview of Center Research

Within the Great Lakes Science Center, interdisciplinary research on coastal ecosystems of the Great Lakes is carried out by the Coastal and Wetland Ecology Branch. Current wetland research efforts fall into three categories, although they are all linked by the common thread of hydrologic fluctuations in the Great Lakes. 1) Long-term studies of the relations between Great Lakes water levels and wetlands have progressed to a five-year study that evaluates the effects on wetland plant communities of water-level regulation on Lake Ontario, develops predictive models for testing a variety of proposed new regulation plans, and helps develop an environmentally sensitive regulation plan. 2) Global climate change studies of wetlands across chronosequences of beach ridges and intervening swales in lakes Michigan and Superior have used coastal sedimentology methods to produce a 4700-yr record of past lake levels that serves as a proxy for climate change, paleoecological and modern plant ecology studies to tie this proxy to plant community changes, and hydrology studies to help

Plant communities in Lake Ontario

explain the interactions between climate change, lake levels, and wetland response. Continuing work will focus heavily on the role of ground-water hydrology and refining proxies for climate change. 3) Wetland restoration and management studies focus largely on FWS refuge lands and ties to hydrology, especially the need for natural hydrologic processes. Restoration of Metzger Marsh in Ottawa NWR in western Lake

Metzgar Marsh in western Lake Erie before and after restoration.

Erie uses a water-control structure (containing a fish passageway) in the lakeside dike to retain hydrologic connections to the lake; techniques such as use of a temporary aqua-dam are being tested for restoration of adjacent Crane Creek in Ottawa NWR, a drowned-river-mouth wetland that suffered many types of human-induced degradation, continues to be lake-connected, and is bordered by numerous diked wetlands.

The public lands and aquatic ecology programs currently emphasize research on priority topics in support of public lands management, especially management of Great Lakes' national parks and wildlife refuges in the coastal zone, as well as management of national forests and state and municipal conservation and recreational properties. Investigations are characterized by partnerships with Department of Interior management bureaus, other federal, state, and local resource management agencies, and universities. These investigations recognize the fragmented and highly modified nature of many ecosystems in the Great Lakes region and relate historical patterns of ecological change to contemporary patterns. Research emphasizes four areas. 1) Conservation and restoration of dune ecosystems require a sound knowledge of ecosystem history. Lake-level histories derived from beach ridge chronosequences have been linked qualitatively with the Holocene history of coastal and inland sand dunes. These dunes also have been shown to influence coastal streams, lakes, and wetlands. Continuing studies help to place present processes in paleoecological perspective and to demonstrate a scale of stochastic

events not observed previously but clearly prominent in the earth system's record. 2) Savanna habitats once dominated much of the terrestrial landscape in the western Great Lakes basin but have since been severely diminished and degraded. Fire is central to maintaining and reconstituting these ecosystems. Studies document the effects of different fire regimes on animal and plant populations in historic savanna areas. Degradation of savanna habitats is typically associated with changes in woody vegetation density. Relationships between woody vegetation and animal and plant communities are assessed and the conservation value of different animal and plant assemblages potentially emerging from restoration is evaluated. 3) Beach closures due to bacterial contamination have significant economic and social costs in the Great Lakes coastal zone. Ongoing studies explore the sources and patterns of contamination and examine methods to improve contaminant monitoring. Persistent non-point sources of bacteria are being documented in many environments throughout watersheds in the southern Lake Michigan basin as a potential cause of beach contamination. Currently accepted protocols for assessing bacterial levels at beaches have been systematically evaluated and found to be lacking in effectiveness. Therefore, new monitoring technologies and sampling procedures are being developed and evaluated. 4) Aggressive invasive plant species can have major negative effects on native terrestrial and wetland ecosystems. The distribution, abundance, and patterns of spread of invasive plant species are documented in Great Lakes national parks to assess the role these invasives play in modifying native plant communities. Research studies evaluate potential methods for controlling invasives and assess the importance of factors that might increase susceptibility to invasion, such as land-use history, disturbance, community diversity, and dispersal corridors. Finally, the public lands and aquatic ecology programs also provide research and technical support to public land managers to improve the efficacy of monitoring both biotic and abiotic components of terrestrial and wetland ecosystems. A wide range of species, from bacteria to plants and animals, are investigated, and the relationships of these species to native and disturbed habitats are evaluated.

Studies within the corridor extending from southern Lake Huron through the St. Clair River, Lake St. Clair, the Detroit River, and into western Lake Erie currently focus on assessing fish and wildlife resources and their habitats. This research provided much of the justification for establishing the new Detroit River International Wildlife Refuge, which will protect remnant stocks of native fish and wildlife and their essential habitats, including lake sturgeon, burrowing mayflies, and over three million migratory waterfowl and the wild celery they depend upon for food. Current initiatives include creation of spawning habitat for lake sturgeon in the Detroit River and use of aquatic remote sensing technologies to evaluate the extent and quality of essential habitats within the corridor. Successful application of such technologies and restoration of aquatic resources will demonstrate to others how they could restore those species to ecosystems elsewhere in the Great Lakes Basin. After being restored in the Huron/Erie corridor, lake sturgeon are expected to recolonize Lake Erie where they once provided a high-value fishery. The restoration of mayflies in the Huron/Erie corridor could be a model for restoration of these benthic insects throughout the Great Lakes basin.

Lake sturgeon.

Future Directions

The Great Lakes Science Center will engage in interdisciplinary research to address high priority management issues in coastal ecosystems of the Great Lakes, with continued emphasis on Department of the Interior and other public lands. Coastal ecosystems function at multiple spatial and temporal scales and cannot be divorced from their surrounding watersheds, landscapes, and developmental histories. Understanding of natural functions in coastal ecosystems is necessary to provide support for knowledgeable management decisions; an understanding of the landscape settings and developmental processes that dictate the manner in which those ecosystems operate today is required. Despite its importance, limited information of this type is currently available. Filling that gap in knowledge is the foundation of GLSC future research on coastal ecosystems. Upon that foundation, the interactions between physical and biological processes will be assessed and the effects of natural stressors of coastal ecosystems will be studied. With appropriate background information, the role of human stressors and disturbances can then be evaluated and quantified, including the influence of the increasingly urban matrix in which natural areas are embedded. Efforts will be made to improve the usefulness of research results through communications with natural resource managers, who may then make informed decisions on actions to halt unnatural disturbances and to initiate mitigation or restoration programs. The GLSC will provide scientific guidance to support those management actions, including evaluation of the potential for success, development of methods that are compatible with the natural functions and processes of the ecosystems, evaluation of success in on-land applications, and follow-up studies to support adaptive management such that successful results can be retained. Looking further into the future, the GLSC will evaluate probable long-term evolution of the Great Lakes shoreline, coastal processes, and coastal ecosystems to develop trajectories and models for predicting how the altered coastal zone will behave in the future.

Satellite image of coastal wetlands

Goals and Five-Year Objectives

Goal 1. Increase scientific understanding of the development, structure, dynamics, and functions of Great Lakes coastal ecosystems (e.g., wetlands, shallow waters, beaches, dunes, oak savannas) in relation to surrounding landscapes.

Objective 1. Develop an understanding of landscape setting, underlying geology, resultant hydrology, ensuing biological development, time scale of development, and interactions in Great Lakes coastal ecosystems.

Objective 2. Apply knowledge of

development of coastal ecosystems to understanding of naturally sustainable functions.

Objective 3. Develop reference sites and long-term datasets that can be used to document the structure, dynamics, and natural functions of coastal ecosystems across spatial and temporal scales.

Objective 4. Develop models of coastal ecosystems that demonstrate natural processes and functions and provide managers with knowledge of the resources they manage.

Goal 2. Increase scientific understanding of how interactions between physical and biological processes affect coastal ecosystems.

Objective 1. Improve characterization of the chemical and physical properties of coastal ecosystems across the continuum from upland to aquatic environments.

Objective 2. Improve understanding of how landscape setting, geology, and hydrology affect distribution of biological components of Great Lakes coastal ecosystems.

Objective 3. Identify natural stressors to coastal ecosystems, including stressor feedbacks among biological, chemical, and physical properties.

Objective 4. Develop spatial models of coastal ecosystems that incorporate landscape heterogeneity, fragmentation, connectivity, and barriers to biological movement between, within, and among components.

Goal 3. Increase scientific understanding of effects of anthropogenic disturbance on coastal ecosystems.

Objective 1. Develop an understanding of the effects of human stressors, such as climate change, disruption of upland-to-aquatic linkages, shoreline modification, altered sediment supply and transport, altered hydrology, land-use change, development on uplands, chemical and microbiological alterations, invasive species and introduction of non-native organisms, and disruption of fire regime on habitats in the coastal zone.

Objective 2. Evaluate the temporal implications of disturbance regimes, including length of disturbance events, frequency of recurrence, severity, and long-term effects.

Objective 3. Develop methods to quantify the effects of disturbance, including interaction of multiple threats, and develop predictive tools and indicators for evaluating disturbance effects.

Objective 4. Develop mechanistic models for coastal processes and disturbance effects that enable managers to understand the implications of disturbance regimes to habitats, biota, public health, and critical processes that extend beyond the coastal zone.

Goal 4. Increase scientific understanding of restoration, mitigation, and management methodologies for conservation of coastal ecosystems.

Objective 1. Determine the realistic possibilities for reversing physical and biological changes or restoring degraded ecosystems, thus allowing sound goals for restoration to be set.

Objective 2. Develop new and improved methods for restoring, rehabilitating, managing, protecting, and creating coastal ecosystems and their component flora and fauna that incorporate an ecosystem approach and establish or retain connectivity across the landscape.

Objective 3. Develop models for predicting success of pro jects, including indicators and performance criteria that quantify ecological responses and risk-assessment models, especially in the field of public health.

Objective 4. Work in partnership with managers to evaluate the success of on-land applications of management practices, including development of monitoring programs tailored to allow adaptive management that retains successes achieved.

Goal 5. Increase scientific understanding of the potential future of coastal ecosystems.

Objective 1. Evaluate the probable long-term evolution of the shoreline, coastal processes, and coastal ecosystems in the absence of human disturbance to understand how the natural system might have behaved if not disturbed.

Objective 2. Develop landscape and successional trajectories and models that predict and project how the altered coastal zone will behave in the future.

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Terrestrial, Freshwater, and Marine Ecosystems — Related Research Projects

Project	Primary Program	Title	PI
9IN-12	Freshwater and Anadromous Fishes and Invertebrates	Coastal Wetlands Ecology	D. Wilcox K. Kowalski
A30-22	Restoration Science for Damaged or Degraded Eastern Ecosystems	Aquatic Ecology: Lake Michigan Watershed	R. Whitman
A30-24	Restoration Science for Damaged or Degraded Eastern Ecosystems	Ecology of Public Lands/ Terrestrial Systems, Michigan	W. Loope
A30-22	Restoration Science for Damaged or Degraded Eastern Ecosystems	Ecology of Public Lands/ Terrestrial Systems, Indiana	R. Grundel N. Pavlovic
A30-22	Restoration Science for Damaged or Degraded Eastern Ecosystems	Benthic Habitats of the Detroit River and Lake Erie	B. Manny D. Schloesser G. Kennedy
AFB-17	Global Change Research-Biology	Spatial and Temporal Effects of Climate Change on Great Lakes Wetlands	D. Wilcox

Great Lakes Science Center Initiatives

Thiamine Initiative
Huron/Erie Corridor Initiative
Coastal Ecosystems Initiative

Thiamine Initiative

Thiamine Deficiency Complex

Workshop Prospectus

Purpose

Early mortality syndrome (EMS) is the phrase used to describe an embryonic mortality affecting the offspring of salmonids (coho salmon, chinook salmon, steelhead trout, brown trout, and lake trout) in Lakes Michigan and Ontario and to a lesser extent in Lakes Huron and Erie. At its worst, EMS has the potential to bring affected stocks to extinction. Studies have implicated a lack of thiamine as a cause of EMS. This nutritional deficiency is believed to be the result of consumption of non-native forage fish, including the invasive alewife and rainbow smelt. There are two other examples of similar diseases that exhibit characteristics of EMS: M74 affects salmon in the Baltic Sea, and Cuyaga Syndrome is prevalent in Atlantic salmon in the Finger Lakes of New York. Low egg thiamine levels and improved survival following thiamine treatment of eggs and fry characterize all three diseases (GLFC 1999). In addition to eggs and fry, it has now been reported that adult fish are affected by thiamine deficiency. Furthermore, thiamine deficiency may affect other aquatic top predators, such as walleye and alligator. Given the diversity of ecosystems (Great Lakes, Baltic Sea, state waters (NY, TN, SD), and Florida lakes) and the fact that this problem is impinging on more than one life stage of an affected species, we are placing these syndromes under one umbrella as a thiamine deficiency complex (TDC). The complexity, scope, and seriousness of TDC demand that natural resource agencies work together and devise an approach to move forward aggressively on an integrated research and monitoring program to better understand TDC and to propose and evaluate possible solutions.

Many groups within the Great Lakes scientific community have identified TDC as an important issue. For example, the Strategic Vision for the Great Lakes Fishery Commission (GLFC, 1997) states that research will examine fish diseases such as early mortality syndrome. Several GLFC committees have also highlighted EMS and thiamine deficiency as key problems. Lake committees and their technical committees for both Lake Huron and Lake Michigan have listed EMS as a possible reproductive impediment for predatory species that requires further research. EMS also has implications for aspects of two theme areas of the GLFC Board of Technical Experts (BOTE) committee: a) Reintroduction of Native Fishes to the Great Lakes Proper and b) Exotic Invertebrates and Food-Web Disruption. Reintroduction of self-sustaining populations of native lake trout and Atlantic salmon will depend upon low levels of EMS in offspring and unaffected adult behavior. With respect to the restoration of native species such as Atlantic salmon and lake trout, the binational Lake Ontario Technical Committee met recently, and EMS and food web research were high on the list of priorities (Marion Daniels, OMNR, pers comm). TDC affects efforts to restore and re-introduce native species such as lake trout and Atlantic salmon in the Great Lakes. It may also affect objectives to maintain or enhance wild production of naturalized species such as rainbow trout.

Further, in a recent report on Great Lakes fish health research commissioned by the GLFC, Stephen and Thorburn (2002) identified EMS as an important research priority. These authors noted that the immediate issue concerns impacts on fish reproduction. Stephen and Thorburn also observed that EMS is linked to the issue of exotic species (macro and microorganisms) and their effects on disease ecology and food web dynamics. Discussion at the recent Great Lakes Fish Health Committee February 2003 meeting in South Bend, IN, reaffirmed that understanding the role of thiamine deficiencies, thiaminase and other nutrients in Great Lakes fishes were top research priorities. Finally, the International Joint Commission's Great Lakes Science Advisory Board identified EMS as an important issue in its 2001-2003 report.

As evident from above, the Great Lakes scientific community recognizes that fish health has implications for the restoration of fish populations. The purpose of this workshop is to develop a plan for advancing a coordinated TDC research and monitoring program, including a funding framework, which addresses high priority needs applicable to the Great Lakes and beyond. Previous workshops, especially those sponsored by the GLFC in 1998, 2000, and 2002, summarized existing EMS research, articulated key research questions, and identified short- and long-term priorities. This workshop will build on and further these valuable efforts. The main purpose of this

workshop is to reach consensus on the elements of a proposal to advance a research and monitoring agenda to begin in 2005.

Introduction

EMS is characterized by loss of equilibrium, hyperexcitability, anorexia, and eventually death in affected salmonid swim-up fry. The non-indigenous species alewife and smelt are major components of salmonid diets in Lakes Michigan and Ontario. These fish contain a thiamine-destroying enzyme, thiaminase. Adult salmonines that were fed alewife have been shown to produce thiamine-deficient fry. EMS was first observed in fish in the late 1960's and early 1970's, but it may have been present prior to this time. Anecdotal information from Lake Michigan commercial lake trout fishermen referred to lethargic and dying fish in their gill nets as having "smelt toxicity." Although EMS probably existed shortly after the arrival of alewife and smelt, recognition of the syndrome was obscured by toxicity of chlorinated organic compounds (dioxin, PCB, DDT, etc.) present in the 1950's and 1960's. Supporting documentation reports that sediment levels of these contaminants were sufficient to have caused the death of nearly all salmonid fry during this period based on the toxicity of these compounds described in contemporary research (Phil Cook, EPA, in press). Research has not yet identified a specific causal agent for TDC. However, this may be due to the fact that most studies have been short-term or have not considered interactions among the many variables at work within the ecosystem. A long-term research and monitoring program is needed to identify the potential links between anthropogenetic factors (photosynthetic inhibitors, human pharmaceuticals, flame-retardants), climatic factors, and the increasing number of invasive species entering the Great Lakes. Monitoring is critical in order to identify the key causes of early mortality diseases, to evaluate the outcome of present and future solutions, and to adjust research efforts based on new findings.

Key Factors Contributing to TDC: Invasive Species and Food-Web Disruption

Recent increases in EMS in Lake Michigan salmonines (J. Hnath pers. comm., M. Wolmagood, pers. comm., Fitzsimons et al 1999) have occurred at the same time as declines in the important benthic macro-invertebrate *Diporeia*. These in turn have been linked with the invasion and massive increase in dreissenids although no biological mechanism has yet been found. Nevertheless the possibility exists that dreissenids may be affecting both the decline in *Diporeia* and the increase in EMS.

The commonality of declines in *Diporeia* and increases in EMS may relate to the effects of dreissenids on lipid dynamics. *Diporeia* obtain an important part of their lipid stores in spring from the annual diatom bloom (Gardner et al. 1989, Cavaletto et al. 1996). The invasion of dreissenids has severely reduced and dampened out this important source of nutrition for *Diporiea*. Although the relationship between lipid levels and mortality in *Diporeia* is not known, older *Diporeia* appear to tightly regulate lipid levels suggesting that the lack of *Diporeia* with intermediate or low lipid levels in some populations may be the result of mortality (Guiguer and Barton 2002). Similarly but somewhat removed from the direct effects on *Diporeia* are the effects of dreissenids on alewife lipid content and in turn its effect on thiamine nutrition of salmonine predators. Alewives are obligate zooplanktinovores so are strongly dependant on zooplankton that are in turn dependant on phytoplankton (Mills et al. 1992)). In Lake Ontario, large populations of dreissenids that have co-occurred with nutrient reductions have severely reduced phytoplankton biomass (Mills et al. 2003). At the same time, there have been declines in the energy density that is strongly correlated with lipid content, for Lake Ontario alewives (Rand et al. 1994). This may increase the potential for alewives to cause a thiamine deficiency since a negative correlation between lipid content and thiaminase has been observed for Finger Lakes alewives (J. Fitzsimons, unpub. data). Diets comprised largely of alewives that have twice the thiaminase of rainbow smelt (J. Zajicek, unpub. data), have been associated with much greater declines in lake trout egg thiamine than lake trout subsisting on smelt (Fitzsimons et al. 1998). A diet consisting of 35% alewives was associated with a 95% decline in lake trout egg thiamine relative to controls whereas a diet consisting of 100% alewives resulted in a 97% decline (D. Honeyfield, unpub. data)

The Role of Contaminants

While contaminants may play a role in thiamine deficiency complex (TDC), several researchers failed to demonstrate their involvement in the thiamine deficiency syndrome that occurs in Atlantic salmon in Cayuga Lake or high, remote Adirondack Mountain lakes (Fisher et al 1996; and Fisher et al 1998; others) or other species in the Great Lakes. History shows that declines in Atlantic salmon occurred in the late 1800's and thereby predate suspect contaminants (Ketola, et al. 2000). That decline was associated with an invasion of alewives. Therefore, TDC may often simply be thiamine deficiency caused by consumption of exotic invaders (such as alewives and smelt) containing the anti-vitamin thiaminase.

Fitzsimons et al (1995) was unable to find a relationship between a range of contaminants (PCBS, pesticides, dioxins, furans, PAHs and trace metals) and EMS in lake trout eggs from Lake Ontario, probably the most contaminated of all of the Great Lakes. Moreover Fitzsimons (1995) concluded that contaminant levels in lake trout eggs throughout the Great Lakes were below those required to alone cause reduced hatching and blue-sac disease. This author, however, could not rule out that contaminant levels may still be sufficient to interact with other factors and cause mortality.

Although no routinely monitored contaminant has been linked to EMS (Honeyfield et al., 1998; other refs.), the effects of several chemicals should be monitored and assessed. Some of these may ultimately lead to death or to reduced fitness of affected fish.

Future Approaches to Dealing with TDC

While there may still be some uncertainty as to the full complement of factors causing the TDC, in practically all cases a thiaminase containing prey species is involved. This ranges from alewives in the case of EMS and Cayuga Syndrome, to gizzard shad in the case of alligator reproductive problems, and to herring and sprat in the case of M74. Whatever else is done, at a minimum the situation argues for a change in diet away from thiaminase containing prey and this is likely accomplished by a change in prey. This, however, by no means ensures that the new prey will be eaten as evidenced by Lake Michigan. Despite a relatively high abundance of bloaters in Lake Michigan during the early 1990s, lake trout continued to feed on alewives, according to lake trout egg thiamine concentrations, despite the fact that alewife abundance was relatively low at the time (Fitzsimons et al. 1998, Madenjian et al 2002).

A change in prey for most salmonines and for most of the Great Lakes is at present a moot point. Many of the native prey species on which native species like lake trout relied have been driven to extinction or their abundance otherwise reduced to the extent that they are currently no more than of a mere remnant status. While still open to interpretation many of the declines in native prey fish have been circumstantially linked to the negative effects of alewives and smelt.

As a first step in providing an alternate thiaminase-free prey, a workshop funded under the Fish and Wildlife Restoration Act, has been organized for the summer of 2003 to evaluate prospects for restoration of lake herring in the Great Lakes. This cisco species is currently found throughout the Great Lakes although abundance has been seriously reduced in all of the Great Lakes except Lake Superior.

Positive effects on the thiamine status of a predator like lake trout may occur with only a modest recovery of lake herring because the spread between egg thiamine levels associated with EMS and other effects that result from an alewife diet (eg. <3 nmol/g), and that associated with a lake herring diet (e.g. >20 nmol/g) is so broad. (J. Fitzsimons, unpub. data, Fitzsimons et al. 1998, Brown et al. 1998). These effects may be greatest if lake herring occur in the diet part of the time and in the absence of other thiaminase-containing prey, and at a time when they result in the maximum transfer of thiamine to the developing ovaries. The benefits of a partially restored lake herring population may also be enhanced by the particular strain of lake trout used since lake herring exhibit temperature preferenda that differ from alewives and there is evidence that some strains like the Seneca Lake strain, occur at colder temperatures at greater depths. In Lake Superior, the greater feeding depths occupied by siscowets inferred from stable-isotope analysis, were associated with less smelt in the diet than for lean lake trout (Harvey and Kitchell 2000)

Recent studies of the Cayuga Lake fishes linked thiaminase-induced deficiency to impaired migratory ability in pre-spawning steelhead and reduced male fertility in Atlantic salmon (Ketola and NYS-DEC). While impacts on eggs have been recognized, reduced male fertility presents another obstacle to restoration efforts. Impaired migration limits the availability of spawning habitat and spawning success of anadromous fishes and consequently the distribution of their fry and the habitat they encounter. Therefore, a better understanding of the factors affecting (1) thiaminase activity and abundance of key forage fishes and (2) the magnitude of the impacts of thiaminase in wild predatory fishes is needed.

To reduce losses, an increasing number of hatcheries routinely practice thiamine immersions of affected fry of lake trout, coho salmon and steelhead after they develop thiamine-deficiency signs. It is not known if subtle effects of deficiency persist after affected fry are immersed. Because chronic deficiency of thiamine in other animals can cause lasting neurological injury, it seems likely that there may be yet unrecognized lasting neurological or behavioral impacts on affected fish after stocking. Therefore, studies are needed to better understand any lasting physiological and behavioral impacts of thiamine deficiency in deficient immersed in thiamine in hatcheries.

Landlocked salmon reared in a hatchery on the Saint Marie's River and released in the river grow well and later return to spawn; however, approximately half produce viable eggs containing abundant thiamine and half produce non-viable eggs containing inadequate thiamine (Ketola and coworkers). These fish apparently eat different diets although they have the same general genetic and historical background. Landlocked salmon in Maine coexist in lakes with alewives without apparent impact. Investigation of these observations and other similar ones could provide valuable insights into why some fish which would be expected to be susceptible to thiamine deficiency but do not develop any deficiency.

We propose that studies should include systematic monitoring of the thiaminase status of key forage fishes and the thiamine status of important predators in several Great Lakes as well as key potential indicator inland lakes (i.e., Cayuga Lake) in order to establish the magnitude, trend lines and directions for the EMS syndrome which are essential to demonstrate any effects of future restoration efforts. We also propose that studies to better understand how various important species of fish are affected by thiamine deficiency and how adults, juveniles and embryos are impacted. Impacts evaluated should include but not be limited to--reproduction, physiology, behavior, and ecological impacts. Also, in order to better identify and manage fisheries, studies are needed to determine critical levels of thiamine in eggs and tissues indicative of supporting normal health of the important species of fishes. The New York State-owned fish ladder on Cayuga Inlet has served as an excellent natural laboratory for the study in thiaminase-induced deficiency in Atlantic salmon and steelhead (Fisher et al. 1996; Ketola et al. 2000) and should continue to provide an excellent model for the study of the impacts of thiaminase-induced deficiencies in feral adults, eggs, embryos and juvenile Atlantic salmon and steelhead that exhibit thiaminase-induced deficiency of thiamine.

Steering Committee Mandate

Prior to the workshop, the Steering Committee will:

- complete the draft prospectus
- develop a preliminary ecosystem model showing the pathways affected by TDC
- prepare the workshop agenda and plan facilitated breakout groups
- help select workshop participants

Following the meeting, the Steering Committee will:

- design a mechanism to move forward on the research and monitoring agenda and associated funding options
- oversee the preparation of the workshop report

Workshop Objectives

There are several objectives for this workshop:

1. To develop a research and monitoring program that meets the following criteria:

   a.) addresses critical short- and long-term research needs based on a consensus of workshop participants
   b.) takes into account the variability among lakes and between sub-populations of fish
   c.) identifies ideas that are feasible to pursue and that have a good potential to be funded

2. To use the Great Lakes as a prototype for developing a larger ecosystem model to apply to all systems

3. To examine means of mitigating or reducing TDC in impacted ecosystems

4. To design a mechanism to continue cooperation and to communicate progress following the workshop.

In order to help participants meet the workshop objectives, the meeting will begin with an overview of the state of our knowledge regarding EMS and related diseases. From here, attendees will identify those areas that meet objective 1 above.

In addition, by attending the workshop, participants will become more aware of other regional views as well as broad scale issues. This will help them to direct their own research and monitoring efforts in order to fill information gaps while avoiding redundancies and harmonizing issues of scale.

Workshop Products

The main product of the workshop will be the articulation of a coordinated research and monitoring program and the development of a funding framework. The funding framework will identify and list specific sources of potential support.

A workshop report will be produced for distribution to aquatic resource management and research agencies. It will include:

- a description of the process used to identify research and monitoring needs and to achieve consensus on these areas
- a description and rationale for the elements put forth in the coordinated research and monitoring program proposal
- a description of the next steps
- a list of potential funding sources

Application of Workshop Products

Funding initiative
Development of a coordinated research and monitoring program

Post Workshop Activities

Steering Committees will be formed to prepare the funding initiative and to guide the research and monitoring program.

Time and Place

The workshop is scheduled to take place in Ann Arbor, Michigan on September 16-17, 2003.

Approximately 50 participants will be invited to the workshop. A mixture of agency representatives and research scientists is needed to achieve a plan that identifies high priority research areas, that meets the needs of multiple, geographically-dispersed management agencies, and that is attractive to potential funding sources.

A detailed agenda for the workshop and links to relevant literature will be made available to invited participants in advance of the workshop.

Steering Committee
Leon Carl, co-chair (U.S. Geological Survey-Great Lakes Science Center)
Dale Honeyfield, co-chair (U.S. Geological Survey-Leetown Science Center)
Scott Brown (Environment Canada-National Water Research Institute)
Marion Daniels (Ontario Ministry of Natural Resources-Lake Ontario Management Unit)
Mohamed Faisal (Michigan State University-Colleges of Vet. Med. and Ag. & Natural Res.)
John Fitzsimons (Canada Department of Fisheries and Oceans-Bayfield Institute)
Mark Holey (U.S. Fish and Wildlife Service)
George Ketola (U.S. Geological Survey-Great Lakes Science Center)
Charles Krueger (Great Lakes Fishery Commission)
Steven LaPan (New York Dept. of Environmental Conservation-Lake Ontario Unit)
Michael Mac (U.S. Geological Survey-Columbia Environmental Research Center)
Susan Marcquenski (Wisconsin Department of Natural Resources)
Doran Mason (National Oceanic & Atmospheric Admin.-Great Lakes Environ. Res. Lab.)
Scott McKinley (University of British Columbia-Centre for Aquaculture and the Environment)
Daniel O'Connor (U.S. Geological Survey-Great Lakes Science Center)
David Reid (Ontario Ministry of Natural Resources-Upper Great Lakes Manage. Unit-Lake Huron)
Chris Vandergoot (Ohio Department of Natural Resources-Sandusky Fish Research Unit)
Greg Wright (Chippewa-Ottawa Resource Authority)

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The Huron-Erie Corridor Initiative

The Huron-Erie Corridor Initiative is being proposed by the USGS Great Lakes Science Center (GLSC) to address highest priority research issues affecting the aquatic resources and their environment and to provide needed scientific information for sound management of valuable natural resources and their habitats in this part of the Great Lakes. We will work with our partners and build on current Center projects to understand issues identified by natural resource managers and to leverage funds already devoted to widely-recognized research at the Center, such as a) Conservation biology of native species; b) Threats posed to native species by exotic, invasive species; c) Alteration of habitats used by native threatened and endangered species; and, d) Restoration of habitats for native fish and wildlife. Sixteen threatened or endangered species of fish are found in the Huron Erie Corridor (HEC). The lake sturgeon, a living dinosaur that is native to North America, is one of our current research interests. Collaborative research on remnant lake sturgeon and their habitats in the HEC has attracted grant support to gather the relevant scientific information needed for successful management of this rare but valuable fish. Other relevant research includes the effects of invasive round goby and zebra mussels on native fish and bivalve mussels, their foods, and their essential habitats.

The HEC includes southern Lake Huron, the St. Clair River, Lake St. Clair, the Detroit River, western Lake Erie, the Detroit River International Wildlife Refuge, and the Ottawa National Wildlife Refuge. Habitat in these waters is part of the central Great Lakes flyway for millions of migratory waterfowl. It is also used by over 60 species of spawning fish, and contains the largest and most diverse wetlands in the region. Over 5 million people live within an hour's drive of this Corridor. It includes one of the busiest navigation centers in our Nation (the Port of Detroit) and is the play ground for over 500,000 boats registered in Michigan for sport fishing and recreation.

Our Center is uniquely suited to lead this effort. Center scientists have extensive experience studying the wetlands, fish, benthic invertebrates, aquatic plants and their habitats in the HEC. In addition, Center scientists already collaborate with researchers in other USGS disciplines and with many local, state, federal and provincial organizations, municipalities, and industries that have a stake in this ecosystem. The effects of invasive species and habitat alteration on native biota and loss of native biodiversity are among topics that are being addressed, as part of this international, integrated, and interdisciplinary research and monitoring effort. Parts of this research have already been featured on our Center's web site, fact sheets, power point presentations, and in news media reports.

Following a consensus building process for framing broad-based, scientific initiatives, (Gillespie et al. 2002. Design Standards for Improving Fish Habitat Management. Canadian Manuscript Report of Fisheries and Aquatic Sciences No. 2592, 89 pp.), we are identifying people who will serve on a steering committee to frame the hypotheses, evaluate experimental protocols, and prepare for a workshop to discuss this HEC research initiative. Members of the steering committee provide expertise in natural resource management, field biology, experimental design, adaptive management, and workshop design and facilitation. This workshop will clarify objectives of the initiative, identify areas of needed scientific expertise, design initial experiments in each of the research focus areas, and develop a set of preliminary hypotheses that illustrate the ecological pathways affected by each facet of the initiative. The workshop will also a) Develop a flexible scientific study design with example assessment, monitoring, and development activities, b) Identify significant areas of uncertainty where effort is needed to fill information gaps, and c) Define aspects of the experimental design that require the expertise and commitment of Center research staff.

An interesting hypothesis developed in this initiative is the idea that the HEC ecosystem can be "reset" to enhance populations of native fish and wildlife, at the expense of invasive exotic species. This experiment would evaluate heavy stocking of lake sturgeon to drive down the abundance of their preferred foods, exotic round gobies and zebra mussels, creating more stable and healthy ecological relationships. In the process, a robust, self-sustaining population of lake sturgeon population could be restored that could support increased sport and commercial harvest for the first time in decades.

Our initiative is expected to provide scientific information that we know is needed for success by the following activities in the Corridor:

a. Management of The Detroit River International Wildlife Refuge and the Ottawa National Wildlife Refuge, including Cedar Point and West Sister Island National Wildlife Refuges of the U.S. Fish and Wildlife Service.
b. The Canadian and American Heritage Detroit River Initiatives.
c. The Binational Remedial Action Plan (RAP) for the St. Clair and Detroit Rivers.

d. The Detroit River Biodiversity Investment Area and The Great Lakes Sustainability Conference of the U.S. Environmental Protection Agency.
e. The Lake St. Clair Binational Management Plan, The Lake St. Clair Coastal Habitat Characterization and Restoration Project, and The Great Lakes Program to Ensure Environmental and Economic Prosperity of the Great Lakes Commission.
f. The Great Lakes Regional Aquatic Gap Program, the Integrated Research on Water and Habitat Quality in Great Lakes Nearshore Environments Project, the Ground Water Withdrawals and Affects on Great Lakes Nearshore Water and Habitat Quality Project, the Recreational Water Quality Project, and the Crains Creek Coastal Wetland Habitat Restoration and Exploration Project of the U.S. Geological Survey.
g. Fish community goals for Lakes Huron, St. Clair, and Erie and the Sea Lamprey Control Program of the Great Lakes Fishery Commission and,
h. The Canadian-US Islands Initiative of The Nature Conservancy.

Our partners in this Huron-Erie Corridor Initiative include:

BASF Corp. - Adam Bickel, Jack Lanigan on sturgeon habitat creation.
City of Detroit Recreation Department - Richard Houtou
DTE Energy - Robert Reider, Roberta Urbani on sturgeon habitat creation.
Great Lakes Fishery Commission - Chris Goddard, Nancy Leonard, Bill Lafferty on sturgeon restoration.
Great Lakes Fishery Trust - Mark Holey, Bill Taylor on lake sturgeon restoration.
Great Lakes Commission - Victoria Pebbles, Tom Rayburn on management of Lake St. Clair.
Michigan DNR – Bob Haas, Liz Hay, Pat Lederle, Kurt Newman, Mike Thomas, Gary Towns and Paul Seelbach on lake sturgeon restoration and management.
Michigan DEQ - Andrew Hartz, Lynda Sanchez on sturgeon habitat creation.
Michigan Sea Grant - Jennifer Read, Mark Breederland on sturgeon biology and habitat creation.
Mississippi State University. - Dan O'Keefe on endangered sucker restoration.
NOAA/GLERL – Tom Nalepa and Ray Assel on bivalve mussels and ice cover in the Detroit River.
Ontario Ministry of Natural Resosurces/Essex Region Conservation Authority – Bob Lange, Matthew Childs, and Lloyd Mohr on sturgeon movements and stock size.
Purdy Fisheries, Limited - Tim Purdy
SmithGroup JJR - Doug Denison, Terry Heatlie, Paul Risher, Joe Wywrot on sturgeon habitat creation.
University of Georgia - Doug Peterson on lake sturgeon spawning and restoration.
University of Michigan- Mike Wiley on sturgeon and wetlands restoration.
University of Wisconsin - Fred Binkowski on lake sturgeon culture and stocking.
USACOE - Stan Cowton, Jim Galloway, Jeff Weiser on sturgeon habitat creation.
US Coast Guard - Belle Isle Station, Commander Jeff Bradbury
USEPA – Rose Ellison, Rich Greenwood, and Karen Rodriguez on sustaining native biodiversity.
USFWS – Jim Boase, Dan Frisk, Tracy Hill, Barb Hosler, Robert Lumadue, Jerry McClain, Lisa Williams, and Emily Zollweg (on sturgeon restoration); Doug Brewer (Ottawa and Detroit River International Wildllife Refuge needs); and Chris Castiglione of the USFWS Lower Great Lakes Fishery Resources Office (Great Lakes Aquatic Gap Analysis).
USGS – Jeff Allen, Linda Begnoche, Roger Bergstedt, Mike Burr, Leon Carl, Jaquie Craig, Dawn Dittman, John French, Jim Hickey, Greg Kennedy, Kurt Kowalski, Jim McKenna, Jerri Nichols, Dan O'Connor, Dora Reader, Jaci Savino, Don Schloesser, Rich Stickle and Doug Wilcox (Great Lakes Science Center); Sheridan Haack, Dave Holtschlag and Jim Nicholas (Water Division) Jim Preacher and Stephen B. Smith (Reston); Leslie Bartels (Midwest Science Center); and Jill Jenkins (National Wetlands Research Center) collaborating primarily on sturgeon and wetlands restoration.
Wisconsin DNR- Ron Bruch on lake sturgeon stocking, restoration, and management.

All of the Huron-Erie Corridor Initiative addresses the goals of the USGS Annual Program Direction for FY04 and is compatible with our Center's 5-year Science Plan. It is oriented toward science information needed by our partners for natural resource management and emerging science issues on the Great Lakes. Lastly, it is a template that scientists at the Center can use to build partnerships, establish collaborations, and pursue research funding opportunities. We look forward to sharing more of the initiative with you.

Great Lakes Coastal Initiative

Introduction

The coastal zone of the Great Lakes (defined here as those onshore and nearshore areas that are or were at one time influenced by coastal and aeolian processes) includes wetlands, drowned river mouths, shallow water habitats, oak savannas, beaches, dunes, relict coastal features and deposits, and abandoned dune fields. These coastal ecosystems offer diverse habitats that support a myriad of plant, fish, and wildlife species. The economy of many coastal areas is dependent on the recreational value of these habitats and the sport fishing, commercial fishing, hunting, birdwatching, and swimming and hiking activities associated with them. Large numbers of seasonal tourists spend millions of dollars on lodging, food, sporting goods, boat and vehicle rentals, gasoline, and personal items, which often represent the major source of income to coastal communities. The ecosystems that supply the fish, wildlife, and recreational facilities underlying that economy have been severely impacted in number, area, and quality. Degradation is often associated with human activity in the coastal zone, including industrial, commercial, residential, and agricultural development, as well as alteration of littoral and other coastal processes that supply the sediments that form and maintain natural features such as dunes, beaches, and sand spits. Yet, surprisingly little is known about the relationships between protection of natural habitat and biota and environmental factors such as water-level change, coastal sediment dynamics, coastal tributary sediment dynamics and hydrology, and ground-water contributions in the coastal zone. Understanding the interactive role of biology, geology, and hydrology in protection and maintenance of coastal features is critical to the survival of the resources important to the people living in and enjoying the coastal zone.

Current Program

Within the Great Lakes Science Center, interdisciplinary research on coastal ecosystems of the Great Lakes is carried out by the Coastal and Wetland Ecology Branch. Current wetland research efforts fall into three categories, although they are all linked by the common thread of hydrologic fluctuations in the Great Lakes. 1) Long-term studies of the relations between Great Lakes water levels and wetlands have progressed to a five-year study that evaluates the effects on wetland plant communities of water-level regulation on Lake Ontario, develops predictive models for testing a variety of proposed new regulation plans, and helps develop an environmentally sensitive regulation plan. 2) Global climate change studies of wetlands across chronosequences of beach ridges and intervening swales in lakes Michigan and Superior have used coastal sedimentology methods to produce a 4700-yr record of past lake levels that serves as a proxy for climate change, paleoecological and modern plant ecology studies to tie this proxy to plant community changes, and hydrology studies to help explain the interactions between climate change, lake levels, and wetland response. Continuing work will focus heavily on the role of ground-water hydrology and refining proxies for climate change. 3) Wetland restoration and management studies focus largely on FWS refuge lands and ties to hydrology, especially the need for natural hydrologic processes. Restoration of Metzger Marsh in Ottawa NWR in western Lake Erie uses a water-control structure (containing a fish passageway) in the lakeside dike to retain hydrologic connections to the lake; techniques such as use of a temporary aqua-dam are being tested for restoration of adjacent Crane Creek in Ottawa NWR, a drowned-river-mouth wetland that suffered many types of human-induced degradation, continues to be lake-connected, and is bordered by numerous diked wetlands.

The public lands and aquatic ecology programs currently emphasize research on priority topics in support of public lands management, especially management of Great Lakes' national parks and wildlife refuges in the coastal zone, as well as management of national forests and state and municipal conservation and recreational properties. Investigations are characterized by partnerships with Department of Interior management bureaus, other federal, state, and local resource management agencies, and universities. These investigations recognize the fragmented and highly modified nature of many ecosystems in the Great Lakes region and relate historical patterns of ecological change to contemporary patterns. Research emphasizes four areas. 1) Conservation and restoration of dune ecosystems require a sound knowledge of ecosystem history. Lake-level histories derived from beach ridge chronosequences have been linked qualitatively with the Holocene history of coastal and inland sand dunes. These dunes also have been shown to influence coastal streams, lakes, and wetlands. Continuing studies help to place

present processes in paleoecological perspective and to demonstrate a scale of stochastic events not observed previously but clearly prominent in the earth system's record. 2) Savanna habitats once dominated much of the terrestrial landscape in the western Great Lakes basin but have since been severely diminished and degraded. Fire is central to maintaining and reconstituting these ecosystems. Studies document the effects of different fire regimes on animal and plant populations in historic savanna areas. Degradation of savanna habitats is typically associated with changes in woody vegetation density. Relationships between woody vegetation and animal and plant communities are assessed and the conservation value of different animal and plant assemblages potentially emerging from restoration is evaluated. 3) Beach closures due to bacterial contamination have significant economic and social costs in the Great Lakes coastal zone. Ongoing studies explore the sources and patterns of contamination and examine methods to improve contaminant monitoring. Persistent non-point sources of bacteria are being documented in many environments throughout watersheds in the southern Lake Michigan basin as a potential cause of beach contamination. Currently accepted protocols for assessing bacterial levels at beaches have been systematically evaluated and found to be lacking in effectiveness. Therefore, new monitoring technologies and sampling procedures are being developed and evaluated. 4) Aggressive invasive plant species can have major negative effects on native terrestrial and wetland ecosystems. The distribution, abundance, and patterns of spread of invasive plant species are documented in Great Lakes national parks to assess the role these invasives play in modifying native plant communities. Research studies evaluate potential methods for controlling invasives and assess the importance of factors that might increase susceptibility to invasion, such as land-use history, disturbance, community diversity, and dispersal corridors. Finally, the public lands and aquatic ecology programs also provide research and technical support to public land managers to improve the efficacy of monitoring both biotic and abiotic components of terrestrial and wetland ecosystems. A wide range of species, from bacteria to plants and animals, are investigated, and the relationships of these species to native and disturbed habitats are evaluated.

Studies within the corridor extending from southern Lake Huron through the St. Clair River, Lake St. Clair, the Detroit River, and into western Lake Erie currently focus on assessing fish and wildlife resources and their habitats. This research provided much of the justification for establishing the new Detroit River International Wildlife Refuge, which will protect remnant stocks of native fish and wildlife and their essential habitats, including lake sturgeon, burrowing mayflies, and over three million migratory waterfowl and the wild celery they depend upon for food. Current initiatives include creation of spawning habitat for lake sturgeon in the Detroit River and use of aquatic remote sensing technologies to evaluate the extent and quality of essential habitats within the corridor. Successful application of such technologies and restoration of aquatic resources will demonstrate to others how they could restore those species to ecosystems elsewhere in the Great Lakes Basin. After being restored in the Huron/Erie corridor, lake sturgeon are expected to recolonize Lake Erie where they once provided a high-value fishery. The restoration of mayflies in the Huron/Erie corridor could be a model for restoration of these benthic insects throughout the Great Lakes basin.

Future Directions

The Great Lakes Science Center will engage in interdisciplinary research to address high priority management issues in coastal ecosystems of the Great Lakes, with continued emphasis on Department of the Interior and other public lands. Coastal ecosystems function at multiple spatial and temporal scales and cannot be divorced from their surrounding watersheds, landscapes, and developmental histories. Understanding of natural functions in coastal ecosystems is necessary to provide support for knowledgeable management decisions; an understanding of the landscape settings and developmental processes that dictate the manner in which those ecosystems operate today is required. Despite its importance, limited information of this type is currently available. Filling that gap in knowledge is the foundation of GLSC future research on coastal ecosystems. Upon that foundation, the interactions between physical and biological processes will be assessed and the effects of natural stressors of coastal ecosystems will be studied. With appropriate background information, the role of human stressors and disturbances can then be evaluated and quantified, including the influence of the increasingly urban matrix in which natural areas are embedded. Efforts will be made to improve the usefulness of research results through communications with natural resource managers, who may then make informed decisions on actions to halt unnatural disturbances and to initiate mitigation or restoration programs. The GLSC will provide scientific guidance to support those management actions, including evaluation of the potential for success, development of methods that are compatible with the natural functions and processes of the ecosystems, evaluation of success in on-land applications, and follow-up studies to support adaptive management such that successful results can be retained. Looking further into the future,

the GLSC will evaluate probable long-term evolution of the Great Lakes shoreline, coastal processes, and coastal ecosystems to develop trajectories and models for predicting how the altered coastal zone will behave in the future.

Goals and Five-Year Objectives

Goal 1. Increase scientific understanding of the development, structure, dynamics, and functions of Great Lakes coastal ecosystems (e.g., wetlands, shallow waters, beaches, dunes, oak savannas) in relation to surrounding landscapes.

Objective 1. Develop an understanding of landscape setting, underlying geology, resultant hydrology, ensuing biological development, time scale of development, and interactions in Great Lakes coastal ecosystems.
Objective 2. Apply knowledge of development of coastal ecosystems to understanding of naturally sustainable functions.
Objective 3. Develop reference sites and long-term datasets that can be used to document the structure, dynamics, and natural functions of coastal ecosystems across spatial and temporal scales.
Objective 4. Develop models of coastal ecosystems that demonstrate natural processes and functions and provide managers with knowledge of the resources they manage.

Goal 2. Increase scientific understanding of how interactions between physical and biological processes affect coastal ecosystems.

Objective 1. Improve characterization of the chemical and physical properties of coastal ecosystems across the continuum from upland to aquatic environments.
Objective 2. Improve understanding of how landscape setting, geology, and hydrology affect distribution of biological components of Great Lakes coastal ecosystems.
Objective 3. Identify natural stressors to coastal ecosystems, including stressor feedbacks among biological, chemical, and physical properties.
Objective 4. Develop spatial models of coastal ecosystems that incorporate landscape heterogeneity, fragmentation, connectivity, and barriers to biological movement between, within, and among components.

Goal 3. Increase scientific understanding of effects of anthropogenic disturbance on coastal ecosystems.

Objective 1. Develop an understanding of the effects of human stressors, such as climate change, disruption of upland-to-aquatic linkages, shoreline modification, altered sediment supply and transport, altered hydrology, land-use change, development on uplands, chemical and microbiological alterations, invasive species and introduction of non-native organisms, and disruption of fire regime on habitats in the coastal zone.
Objective 2. Evaluate the temporal implications of disturbance regimes, including length of disturbance events, frequency of recurrence, severity, and long-term effects.
Objective 3. Develop methods to quantify the effects of disturbance, including interaction of multiple threats, and develop predictive tools and indicators for evaluating disturbance effects.
Objective 4. Develop mechanistic models for coastal processes and disturbance effects that enable managers to understand the implications of disturbance regimes to habitats, biota, public health, and critical processes that extend beyond the coastal zone.

Goal 4. Increase scientific understanding of restoration, mitigation, and management methodologies for conservation of coastal ecosystems.

Objective 1. Determine the realistic possibilities for reversing physical and biological changes or restoring degraded ecosystems, thus allowing sound goals for restoration to be set.
Objective 2. Develop new and improved methods for restoring, rehabilitating, managing, protecting, and creating coastal ecosystems and their component flora and fauna that incorporate an ecosystem approach and establish or retain connectivity across the landscape.
Objective 3. Develop models for predicting success of projects, including indicators and performance criteria that quantify ecological responses and risk-assessment models, especially in the field

of public health.

Objective 4. Work in partnership with managers to evaluate the success of on-land applications of management practices, including development of monitoring programs tailored to allow adaptive management that retains successes achieved.

Goal 5. Increase scientific understanding of the potential future of coastal ecosystems.

Objective 1. Evaluate the probable long-term evolution of the shoreline, coastal processes, and coastal ecosystems in the absence of human disturbance to understand how the natural system might have behaved if not disturbed.

Objective 2. Develop landscape and successional trajectories and models that predict and project how the altered coastal zone will behave in the future.

Center Publications for the Last 5 Years

USGS Biology Programs
Great Lakes Science Center Publications

Contaminant Biology Program

Point of Contact: Sarah Gerould (sgerould@usgs.gov; 703-648-6895)

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Contaminants/QSAR/Toxicity testing.

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Contaminants/Toxicity testing.

Landrum, Peter F., Susan W. Fisher, Haejo Hwang, and James P. Hickey. 1999. Hazard evaluation of ten organophosphorous insecticides against the midge, *Chironomus riparius* via QSAR. SAR and QSAR in Environmental Research 10: 423-450.
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Contaminants/Fishes--effect of water pollution on/Fishes--mortality/Great Lakes/Lake trout.

Status and Trends of Biological Resources

Point of Contact: Paul Dresler (paul_dresler@usgs.gov; 703-648-4114)

Blackwell, Bradley F., Martin A. Stapanian, and D. V. Chip Weseloh. 2002. Dynamics of the double-crested cormorant population on Lake Ontario. Wildlife Society Bulletin 30(2): 345-353.
Cormorants/Fishes--mortality/Lake Ontario/Mathematical models/Predation.

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Fish stocking/Lake Huron/Lake Ontario/Lake Superior/Lake trout/Otoliths.

Bronte, C. R., G. W. Fleischer, S. G. Maistrenko, and N. M. Pronin. 1999. Stock structure of Lake Baikal omul as determined by whole-body morphology. Journal of Fish Biology 54(4): 787-798.
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Brown, Edward H. Jr., Thomas R. Busiahn, Michael L. Jones, and Ray L. Argyle. 1999. Allocating Great Lakes forage bases in response to multiple demand. Pages 355-394 in Taylor, William W. and C. Paola Ferreri, editors. Great Lakes fishery policy and management: A binational perspective. Michigan State University Press, East Lansing, MI.
Alewife/Bloater/Fish populations/Fishery management/Great Lakes/Lake herring/Lake trout/Rainbow smelt/Salmon/Sculpin.

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Cormorants/Emerald shiner/Fishes--food/Freshwater Drum/Gizzard shad/Lake Erie/Predation/Walleye.

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Chordas, Stephen W. III, Eric G. Chapman, Patrick L. Hudson, Margret A. Chriscinske, and Richard L. Stewart Jr. 2002. New Midwestern state records of aquatic Hemiptera (Corixidae: Notonectidae). Entomological News 113(5): 310-314.
Aquatic organisms/Great Lakes/Hemiptera.

Chordas, Stephen W. III and Patrick L. Hudson. 1999. A list of Michigan Corixidae (Hemiptera) with four new state records from the Great Lakes of Michigan. Entomological News 110(4): 246-250.
Hemiptera/Invertebrates.

Desorcie, Timothy J. and Charles A. Bowen II. 2003. Evidence of offshore lake trout reproduction in Lake Huron. North American Journal of Fisheries Management 23(4): 1253-1256.
Lake trout/Lake Huron/Reproduction.

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Terrestrial, Freshwater and Marine Ecosystems

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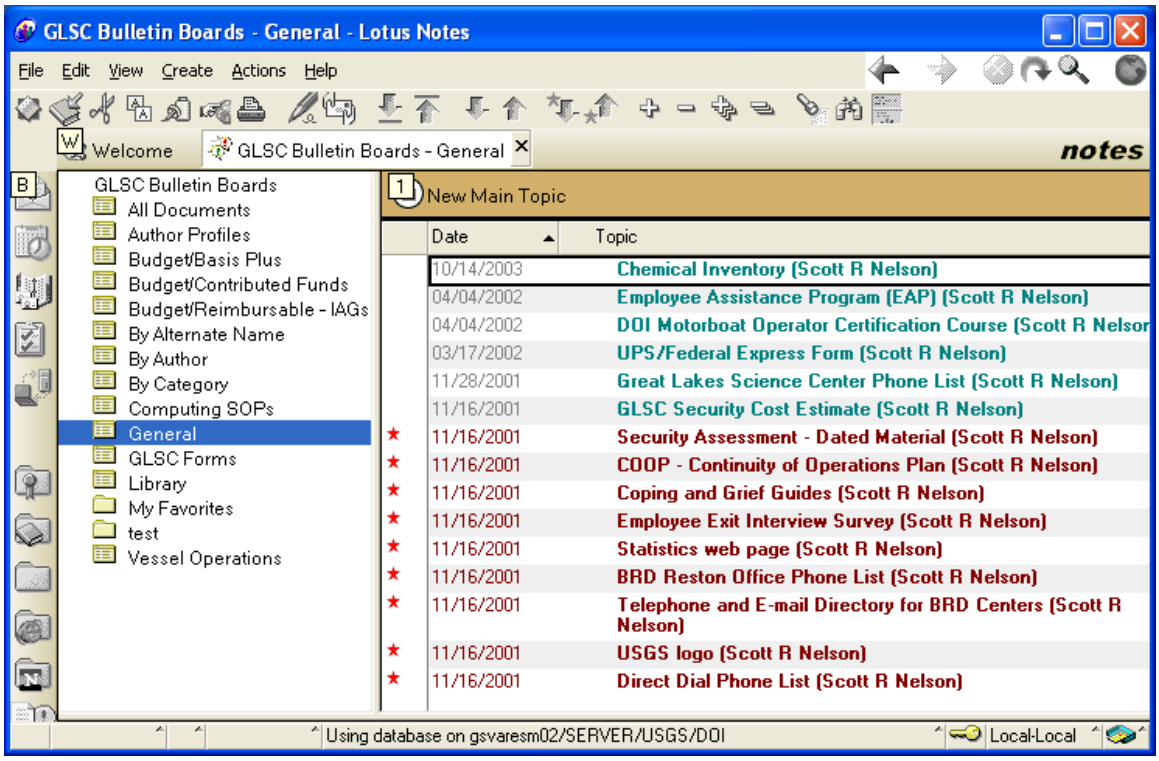
Communicating Our Science

Internal Communications

The Great Lakes Science Center conducts internal communications using a variety of technologies. One of those technologies is Lotus Notes. Lotus Notes provides email access to internal and external cooperators. Centrally accessible mailing lists facilitate communication within subgroups. In addition, two Lotus Notes databases have been established to exchange vital information. The reservations database provides the means to reserve resources such as conference rooms and digital projector. The bulletin board database provides a central store of documents in the following categories: Budget, SOPs, Forms, Recent Publications – Library, and Vessel Operations.



Example of Our GLSC Weekly Highlights, sent to all employees GLSC-wide, and to the USGS/BRD Eastern Region

Great Lakes Science Center Highlights, September 29 – October 3, 2003
I. Departmental/Bureau News

A. Upcoming
Presentations at Interagency Meeting: Robert O'Gorman, Randy Owens, and Brian Lantry, USGS Great Lakes Science Center, Lake Ontario Biological Station, will present preliminary results of deep water research conducted on Lake Ontario during 2003 at a meeting of the New York Department of Environmental Conservation's Great Lakes Section in Oswego, NY on Oct 7-8, 2003. The meeting is a forum for cooperating agencies to share information and an opportunity to plan work for the 2004 field season.
(Robert O'Gorman, Oswego, NY; 315-343-3951, ext. 22)

Outreach: USGS scientist Robert O'Gorman, will present an overview of recent changes in the deep water food web of Lake Ontario at the annual meeting of the Great Lakes Sport Fishing Council in Port Clinton, OH on October 18, 2003.
(Robert O'Gorman, Oswego, NY; 315-343-3951, ext. 22)

B. Current
Educational Outreach: USGS scientist Roger Bergstedt was an invited speaker on the subject of invasive species at a session of the Michigan Sea Grant's Fishery Academy for Lake Huron NGOs, Alpena Michigan, September 27, 2003.
(Roger Bergstedt, Millersburg, MI; 989-734-8336, ext. 114)

Centennial Refuge Celebration: On September 26 & 27, 2003, Bruce Manny represented the USGS Great Lakes Science Center at the Detroit River International Wildlife Refuge Centennial Celebration on Fighting Island and at the Lake Erie MetroPark near Wyandotte and Gibraltar, Michigan respectively. The celebration was attended by Congressman John Dingell, Secretary of the Interior, Gale Norton, Steven A. Williams, Director, U.S. Fish and Wildlife Service (USFWS), and Robyn Thorson, Director, Region 3, USFWS. Other attendees included representatives of major industries along the Detroit River such as BASF Corp., Ford Motor Co., Comcast Cable Communications, and the Metropolitan Affairs Coalition. Local representatives, community leaders, and thousands of local citizens also participated in the event. Dr. Manny manned a live-sturgeon display of his collaborative research with James Boase of the USFWS concerning the restoration of lake sturgeon in the Detroit River and International Refuge and gave a presentation on this work to the public.
(Bruce Manny, Ann Arbor, MI; 734-214-7255,)

Poster Presentation: Myers DN, Passino-Reader DR, Morrison SS, McKenna JE, Stewart J, Aichele S, Scudder BC, Lohman K. "Aquatic GAP Analysis in the Great Lakes Region”" Poster presentation, Meeting of the Project Management Team, Lake St. Clair Coastal Habitat, Walpole Island First Nation, Wallaceburg, Ontario, Canada, September 24, 2003.
(Dora Passino-Reader, Ann Arbor, MI; 734-214-7229)

Press Inquiries/Media
USGS scientist Noel Pavlovic was interviewed by Wendy Smith from the National Park Service's Great Lakes Research and Education Center for an article to be published in the Singing Sands. Dr. Pavlovic shared information regarding research, monitoring, and detection systems relating to the establishment and invasion of non-indigenous exotic plants in parks of the Great Lakes coastal zone. Highlights of research examining the distribution of exotic plants in four Great Lakes national parks, conducted in cooperation with USGS scientist Walter Loope, was also discussed.
(Noel Pavlovic, Porter, IN; 219-926-8336, x428)

Library and Information Services

Information for Research
A quality research program depends on accurate and timely information. Scientists require information at many points in the research process--while forming a hypothesis, in preparation of research proposals, while developing a study plan, during the study, and once the study is complete and results are being written to share with other members of the research community. A good information program informs scientists about existing knowledge and avoids duplication of research efforts. The mission of the USGS Great Lakes Science Center's John Van Oosten Library is to provide information services to meet all these needs.

A Tradition of Service
The Library, named in honor of Dr. John Van Oosten, the Center's first director, was officially dedicated in 1966. Since that time, the collection has grown, and electronic tools that enhance and speed information delivery increasingly replace print resources. In the midst of these many changes, the Library's focus on service has remained unaltered. Using all the tools, people, and print and electronic resources at their disposal, the two-person Library staff provides reference and literature searching services, obtains documents needed by scientists, maintains a collection of materials in various formats, provides training in the use of new information resources, and works toward improving access to Library collections and services by taking advantage of today's technologies. The Library staff also distributes Center-authored publications and manages the internal manuscript process.

Service Where the Science Is
Nearly half of the Center's staff is located at one of its eight field locations. The Library staff makes an extra effort to deliver information to researchers who are not able to visit the Library in person by researching, copying, and sending information via mail, e-mail, phone, and fax. Electronic networks that speed communication and information delivery are improving the Library's capability to respond to the special needs of scientists located in the field.

A Unique Collection
A specialized collection of technical materials supports the research activities of the Center. This collection includes books, print and electronic journals, reprints, photographs, archival materials, and computerized databases. The Library's resources are used daily by the Center's scientific staff. The value of the collection's unique resources is also reflected in its wide use by others. Through its participation in a shared computer network, the Library staff responds to requests from other libraries for copies or loans of material from its collection. Other users visit, call, or e-mail the Library for information.

Times They Are A Changin'
Everyday we hear about the new ways in which information is being stored, accessed, delivered, and managed. In order to provide better access to information about publications authored by GLSC scientists, the Library staff created a searchable database available from the Center's Web site. From the Library's Web page, Center scientists can access electronic databases and journals, and people from around the world can search the Library's catalog and find out more about the Library's collections and services.

Looking to the Future
The Library will continue using appropriate tools and technologies to make increasing amounts and types of information available in the ways that best serve Center scientists, our partners, and the public. One thing that will remain unchanged, no matter what the future brings, is the Library's focus on service in support of the Center's mission.

External Communications

USGS
science for a changing world

Great Lakes Science Center, Restoring the Greatness

The **Great Lakes Science Center (GLSC)** meets the Nation's need for scientific information for restoring, enhancing, managing, and protecting the living resources and their habitats in the Great Lakes. Since 1927 the Center's research has provided critical information for the sound management of Great Lakes fish populations and other important natural resources (e.g coastal wetlands and aquatic biota) in the basin.

The GLSC uses an interdisciplinary approach, teams, and collaboration to provide the information needed to solve the complex biological issues (e.g., exotic species impacts) and natural resource management problems (e.g., fisheries allocations) facing the Great Lakes. Working in partnership with resource management agencies, GLSC provides unbiased scientific information on Great Lakes biological and habitat resources, and determines the effectiveness of resource management and ecological restoration efforts.

Lake Erie shoreline.

A Vision of Greatness

In 2001, the Great Lakes Commission, working with regional science and resource management communities, identified seven major themes of restoration in the Great Lakes that needed action. These themes helped form a blueprint for securing a clean environment, a strong economy and a high quality of life for Great Lakes residents and businesses.

Three of the themes fit into the Great Lakes Science Center's mission of restoring, enhancing and protecting the living resources and habitats of the Great Lakes.

Preventing further exotic species invasions

- Presently there are upwards of 160 invasive species in the Great Lakes, some impacting our natural systems catastrophically. Partnerships through the state, regional and local levels are essential developing programs to prevent further invasions.

A round goby, a Great Lakes exotic species.

The Center operates research vessels for fisheries and habitat research. (R/V *Grayling)*

Ensuring the sustainable use of aquatic resources

- Development and implementation of programs at the state and provincial level to ensure safe and sustainable use of our aquatic resources.

Seining along Lake Michigan's coastline.

Restoring and conserving wetlands and critical coastal habitats

- Restoration and conservation of the Great Lakes few remaining wetlands and coastal marshes is essential to protect the enormous value they have to fish, wildlife and recreation.

Wetland monitoring.

Great Lakes Science Center's Role in Restoration

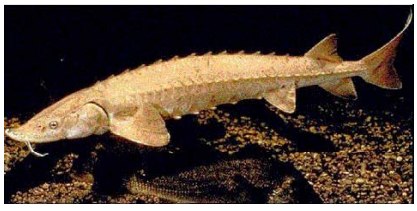
The Great Lakes Science Center continues to provide crucial research and information towards the restoration of valuable Great Lakes resources, such as lake trout and lake sturgeon, as well as important Great Lakes wetland areas within National Wildlife Refuges and parklands.

A lake trout, a valuable Great Lakes sport, commercial and tribal fish.

Native Fish Restoration

The lake trout has been impacted by invasive species and overexploitation, and the lake sturgeon by habitat degradation and overexploitation. At the GLSC, efforts to restore both species are under way through research into spawning habits, diet and the exotic species that affect them.

Recent research located spawning sites for lake sturgeon in the Detroit and St. Clair Rivers and identified preferred spawning substrate, which could lead to the restoration of other spawning sites throughout the Great Lakes.



A lake sturgeon, a primitive fish native to the Great Lakes

Invasive Species

One of the most profound problems facing the Great Lakes today is the introduction of non-native species, and preventing further introduction

A native clam colonized by zebra mussels.

is a goal of the Great Lakes Commission, Great Lakes Science Center and other Great Lakes agencies. At the GLSC, research focuses on sea lamprey, zebra mussels, round gobies, and ruffe, which are economically damaging through the effect they have on sport fish and the tourism industry. Recently, research conducted at the GLSC station at Hammond Bay, along with partners at the Great Lakes Fishery Commission and the Fish and Wildlife Service, led to a special time-release lampricide treatment for sea lamprey control. This application will benefit the St. Mary's River system and northern Lake Huron, which has been resistant to conventional lampricide treatments.

Aquatic Habitat Restoration

A cooperative effort, the Lake Erie Ecologicial Investigations project, initiated by the USGS, includes: the National Water Quality Assessment (NAWQA) program; the Biomonitoring of Environmental Status and Trends (BEST) program; the Leetown (WV) and Great Lakes (MI) Science centers; the U.S. Fish and Wildlife Service; the EPA Great Lakes National Program Office; and the states of Ohio and Pennsylvannia. This project will provide information to managers to support strategies for dredging and other remediation options for contaminated sediments and will establish a database for future evaluation by Remedial Action Plan Committees and site managers. The suite of tools developed in this investigation can be applied to Areas of Concern throughout the Great Lakes and other aquatic areas.

Wetlands Restoration

Research conducted by the Great Lakes Science Center research at Metzger Marsh, a diked wetland on Lake Erie, led to the restoration of the area, which had a long history of human disturbance from farming, draining and channelization. Information collected during the study provided managers with important information that lead to improved wetland management that benefited both fish and wildlife. The research is designed to allow the results of the restoration effort to be applied at other diked wetland sites throughout the Great Lakes region.

Metzger Marsh before restoration

Meztger Marsh after restoration

Volunteer Field and Laboratory Assistants

In FY 2003 the Great Lakes Science Center had 15 volunteers that contributed around 600 hours of their time. Volunteers have provided valuable expertise and assistance in a variety of projects including: Trophic Interactions of Fish and Invertebrates of the Great Lakes, Nearshore Juvenile Fish and Invertebrates of Lake Erie, Ecology and Control of Invasive Fishes of the Great Lakes, Lake Trout Immunology Studies, Studies of Contaminants in Great Lakes Smelt, Genetic Studies of Great Lakes Fishes, Biodiversity of Aquatic Insects in the Great Lakes, Lake Huron Prey Fish, Detroit River Lake Sturgeon Research and Oracle Database Development.

Public Outreach Activities at GLSC and Field Stations

The following is a list of examples of the many kinds of public outreach activities that employees at the Ann Arbor Lab and its field stations take part in:

Ann Arbor Laboratory

- Science Fairs
  - Annual judging at National Ocean Sciences Bowl
  - Judging at annual Southeast Michigan Science Fair
  - Judging at the Science and Engineering Fair of Metro Detroit
- Career Days
  - Numerous local public schools and universities – all levels
  - Annual "Explorathon" presentations
- Presentations/Lectures to Local Groups and Organizations
  - Great Lakes Sport Fishing Council
  - Lake Huron Citizens Advisory Council
  - Saginaw Bay Walleye Club
  - Wild Ones Native Plant Group
  - Les Cheneaux National Resources Task Force
- Laboratory Tours
  - Annual lecture and tour for Concordia College students
  - Numerous tours for local school groups and general public
- Annual Activities/Festivals
  - Huron River Clean Up
  - Earth Day Celebration
  - Bi-annual Great Lakes Congressional Tour
  - 75th Anniversary Celebration for the Center
- Miscellaneous
  - Organizing volunteers for local organism counts/monitoring
  - Loaning of organism collections for use in identification training of students and public
  - Numerous local newspaper interviews regarding Great Lakes issues

Cheboygan Vessel Base

- Laboratory/Vessel Tours
  - Annually take University of Michigan Bio Station students out on R/V Grayling
- Annual Activities/Festivals
  - Participate in Lighthouse Festival, Alpena, MI – includes tours of R/V Grayling
- Miscellaneous
  - Attend the annual spring Blessing of the Fleet in Sault St. Marie, MI

Hammond Bay Biological Station

- Presentations/Lectures to Local Groups and Organizations
  - Lecture on sea lamprey management and issues:
    - Presque Isle County Sportsmen's Club
    - GM Retirees Club
    - Local Audubon Society and Rotary Club
    - Local summer camp students
- Laboratory Tours
  - Numerous weekly tours by local science classes and the general public
- Miscellaneous
  - Provided technical info for Discovery Channel show, "Bloodsuckers!"
  - Numerous local newspaper and radio interviews regarding Great Lakes issues

Lake Erie Biological Station

· Science Fairs
  Judging at science fairs at Norwalk Middle School and Heidelburg College
· Career Days
  Assist with a Wetlands Workshop at Bowling Green State Univ.
· Presentations/Lectures to Local Groups and Organizations
  Talks to local Audubon Society, Rotary Club, Senior YMCA, others
· Laboratory/Vessel Tours
  Tour of facilities at NASA Open House
  Tours of the R/V Musky II at local events
  Tour of the R/V Musky II to a member of U.S. Congress and her aid
· Miscellaneous
  Invited to professional seminars at Ohio University and Ohio State University
  Newspaper and NPR radio interviews regarding Great Lakes issues

Lake Michigan Ecological Station

· Science Fairs
  Judging local school Science Fairs
· Career Days
  Invited to speak in local school classrooms
· Annual Activities/Festivals
  Organizing volunteers for yearly organism counts – Marsh Monitoring Program
· Miscellaneous
  Host Girl Scout nature walks
  Volunteer at the Indiana Dunes Learning Center
  Staff booths at Indiana Dunes Beach Safety Awareness events

Lake Ontario Biological Station

· Career Days
  Hosted biology classes from Utica College and Cornell University
· Presentations/Lectures to Local Groups and Organizations
  Annual updates on status of prey fish community to local and regional angling clubs
  Annual presentations at State-of-the-Lake seminars, hosted by NY Dept. of Env. Cons.
· Laboratory/Vessel Tours
  Tours of R/V Kaho during Focus on Fishing and Tourism days
· Miscellaneous
  Front page article in USA Today on rediscovery of deepwater sculpin
  Numerous local and regional newspaper interviews on changing Great Lakes biota
  Interview on local TV segment covering invasive species

Lake Superior Biological Station

· Career Days
  Attend Northland College's Career Day
  Hosted high school students for Northland College's Wild Careers Summer Program
  Hosted local high school classes studying Lake Superior
· Presentations/Lectures to Local Groups and Organizations
  Brule River Sportsman Club
  Public lectures for Isle Royale National Park
  Public lecture series for Duluth Aquarium

Special lectures and presentations at Northland College
Presentations at Sea Grant leadership workshop
Ashland City Council, Ashland County Commissioners

· Laboratory/Vessel Tours

Open Boat, Duluth Gales of November, Duluth Entertainment and Convention Center
Numerous tours aboard R/V Kiyi
Host classes aboard R/V Kiyi

Tunison Laboratory of Aquatic Science

· Science Fairs

Holds Annual Fair at Hartnett Elementary School

· Career Days

Field trips for local schools

· Annual Activities/Festivals

Host the annual Finger Lakes Fishing Festival

· Miscellaneous

Job shadowing with local students
Public interaction at Lime Hollow Nature Center
Teach an Environmental Studies class at the lab

Cheboygan Vessel Base Outreach

Ninth Annual Memorial Service

in memory of

Great Lakes Mariners

and the

Blessing of the Fleet

Faith Lutheran Church

Sault Ste. Marie, MI

16 March, 2003

A Brief History of The International Shipmasters' Association

The I.S.M.A. traces its origin to the city of Buffalo, New York where in the winter, *of* 1886, the death of a local captain resulted in the formation of the Excelsior Marine Benevolent Association. This association was set up to establish an endowment fund to assist financially, the survivors of mariners who had passed on.

In hopes of expanding membership, mariners in other ports were contacted concerning the benefits of belonging to the association. Soon, other branches or lodges of the organization began to form around the, Great Lakes.

The first convention of the Association was convened in Buffalo, New York on January 8, 1891 where the Grand Lodge was officially organized with a Constitution, By-laws and Ritual. During the third convention in Port Huron, Michigan, with nine lodges in attendance, the name of the organization was changed to "Shipmasters Association."

With the passage of-time, lodges proliferated (find in some cases merged), and with the addition of many Canadian members, the organization became truly "International" in scope. In 1916 at the Grand Lodge Convention held in Toronto, Ontario, the name "International Shipmasters' Association of the Great Lakes" was officially adopted.

While the association no longer has a benevolent fund, the continuing purpose of the I.S.M.A. is clearly stated in the constitution.

Section 3. *The purpose of this association shall be to unite all shipmasters and licensed merchant marine officers of the Great Lakes and tributary waters: of good moral character, to elevate the character of its members and their profession; and to utilize their professional experience to promote the safety of the Great lakes sailing profession.*

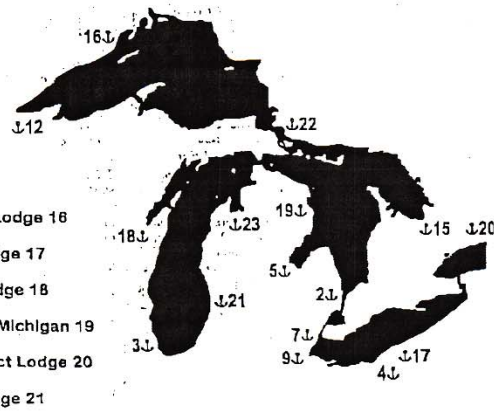
Hence, the Association itself is neither a bargaining agent nor a labor union, but rather a professional association" that cooperates with vessel owners and management to achieve optimum efficiency in vessel operations, and to collaborate with the Coast Guard. Weather Bureau and other Government agencies in both the United States and Canada for maximum safety on the Great Lakes.

Since its very beginnings, the L.S.M.A. has enjoyed the most cordial and fruitful relationship with shipping management and the recommendations of the Grand Lodge Navigation and the Legislation Committees have been considerable assistance to the Coast Guard in its efforts to most effectively utilize all aids to navigation.

The International Shipmasters' Association has been of great benefit to its members by the dissemination of the helpful professional information and by its dedication to the welfare of the shipping industry amid its personnel. It continues to solicit new members 'and new lodges around the Great Lakes. A fraternal closeness between the various lodges and its members has been, important element in the success and continued growth of the Association.

(With special thanks to the writing of our late member Captain Herbert C. Dosey which. appeared in the quarterly Journal of the Great Lakes Historical Society, Inland Seas, Vol. 33; No.4, Winter - 1977).

Local Lodges



Port Huron Lodge 2	Thunder Bay Lodge 16
Chicago Lodge 3	Ashtabula Lodge 17
Cleveland Lodge 4	Green Bay Lodge 18
Bay City Lodge 5	Northeastern Michigan 19
Detroit Lodge 7	Niagara District Lodge 20
Toledo Lodge 9	Muskegon Lodge 21
Twin Ports Lodge 12	Twin Sault Lodge 22
Georgian Bay-Huronia 15	Grand Traverse Lodge 23

Tunison Laboratory of Aquatic Science Finger Lakes Fishing Festival

Saving the Lake Sturgeon, Belle Isle, Detroit, Michigan

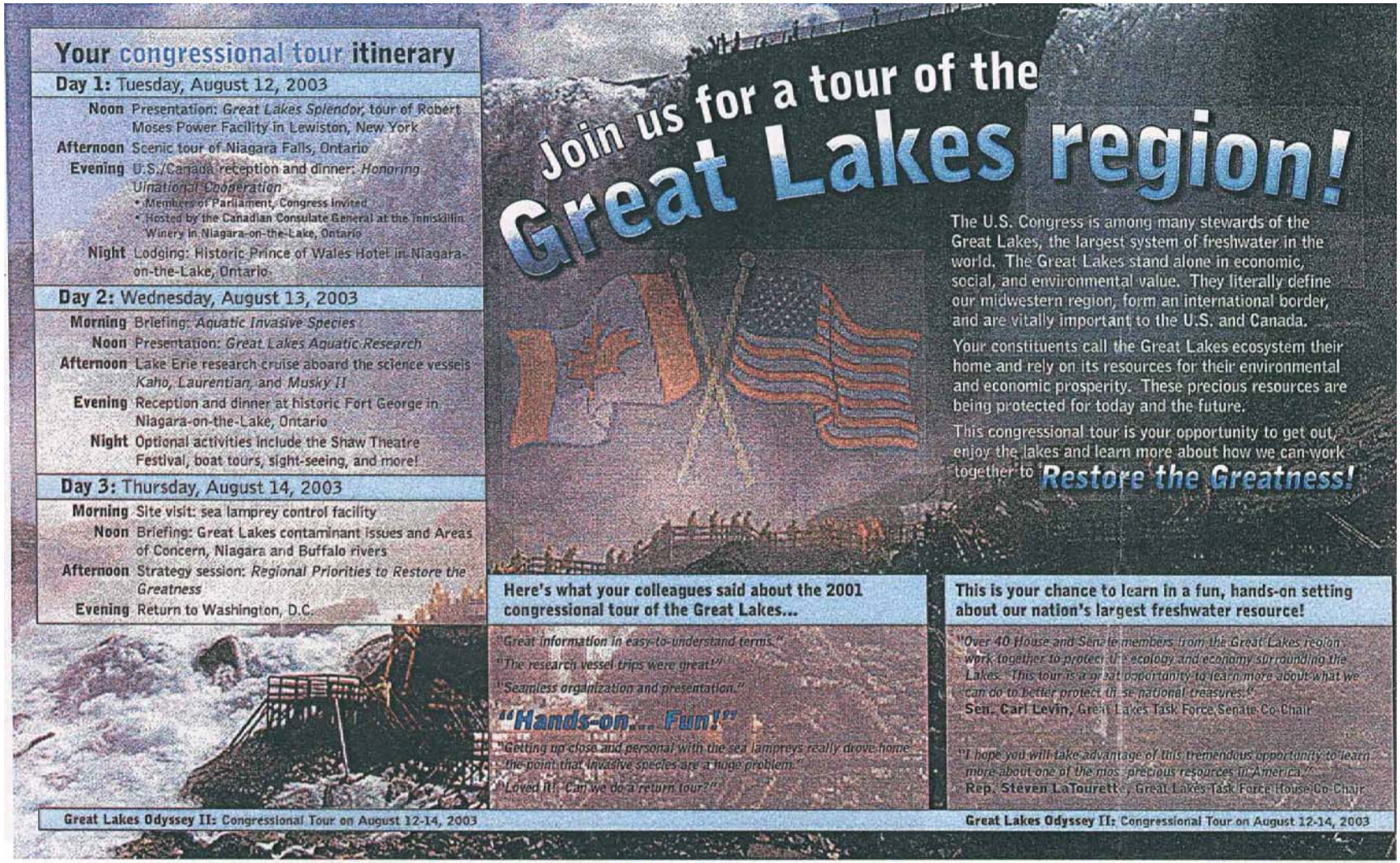
Nate Caswell, holding large female lake sturgeon, Detroit River in the background

Biologists with the U.S. Geological Survey are trying to bring Lake Sturgeon back to the Detroit River. The giant fish once spawned in the riverbed every spring before moving on to Lake Erie. Now, the sturgeon are rapidly disappearing. **Detroit Public Radio's Celeste Headlee reports**:

Fish biologist Bruce Manny says sturgeon were once abundant in the Great Lakes. Back in 1880, in one month's time, fishermen pulled four thousand of them from the Detroit River.

Manny assembled a team of biologists from the U.S. Geological Survey. They started trapping and then tracking sturgeon with electronic transmitters. Manny says he was surprised when his team caught only 86 fish over course of four years. Manny says he realized the sturgeon were in serious trouble and he obtained grants to investigate further. USGS scientists followed the tagged fish for two years, and their patience was eventually rewarded. Manny found the first known spawning site ever documented in Detroit River in modern times.

Excerpt from the Great Lakes Radio Consortium Radio Broadcast


Join us for a tour of the
Great Lakes region!
Your congressional tour itinerary
Day 1: Tuesday, August 12, 2003
Noon Presentation: Great Lakes Splendor, tour of Robert Moses Power Facility in Lewiston, New York
Afternoon Scenic tour of Niagara Falls, Ontario
Evening U.S./Canada reception and dinner: Honoring Binational Cooperation
• Members of Parliament, Congress invited
• Hosted by the Canadian Consulate General at the Inniskillin Winery in Niagara-on-the-Lake, Ontario
Night Lodging: Historic Prince of Wales Hotel in Niagara-on-the-Lake, Ontario
Day 2: Wednesday, August 13, 2003
Morning Briefing: Aquatic Invasive Species
Noon Presentation: Great Lakes Aquatic Research
Afternoon Lake Erie research cruise aboard the science vessels Kaho, Laurentian, and Musky II
Evening Reception and dinner at historic Fort George in Niagara-on-the-Lake, Ontario
Night Optional activities include the Shaw Theatre Festival, boat tours, sight-seeing, and more!
Day 3: Thursday, August 14, 2003
Morning Site visit: sea lamprey control facility
Noon Briefing: Great Lakes contaminant issues and Areas of Concern, Niagara and Buffalo rivers
Afternoon Strategy session: Regional Priorities to Restore the Greatness
Evening Return to Washington, D.C.
The U.S. Congress is among many stewards of the Great Lakes, the largest system of freshwater in the world. The Great Lakes stand alone in economic, social, and environmental value. They literally define our midwestern region, form an international border, and are vitally important to the U.S. and Canada.
Your constituents call the Great Lakes ecosystem their home and rely on its resources for their environmental and economic prosperity. These precious resources are being protected for today and the future.
This congressional tour is your opportunity to get out, enjoy the lakes and learn more about how we can work together to Restore the Greatness!
Here's what your colleagues said about the 2001 congressional tour of the Great Lakes...
"Great information in easy-to-understand terms."
"The research vessel trips were great!"
"Seamless organization and presentation."
"Hands-on... Fun!"
"Getting up close and personal with the sea lampreys really drove home the point that invasive species are a huge problem."
"Loved it! Can we do a return tour?"
This is your chance to learn in a fun, hands-on setting about our nation's largest freshwater resource!
"Over 40 House and Senate members from the Great Lakes region work together to protect the ecology and economy surrounding the Lakes. This tour is a great opportunity to learn more about what we can do to better protect these national treasures."
Sen. Carl Levin, Great Lakes Task Force Senate Co-Chair
"I hope you will take advantage of this tremendous opportunity to learn more about one of the most precious resources in America."
Rep. Steven LaTourette, Great Lakes Task Force House Co-Chair
Great Lakes Odyssey II: Congressional Tour on August 12-14, 2003
Great Lakes Odyssey II: Congressional Tour on August 12-14, 2003

Registration form

Please complete and return this form by **June 1** to attend ***Great Lakes Odyssey II: Restore the Greatness!***

Yes! I want to join the Great Lakes Odyssey...

Name	
Title	
Member/Committee	
Telephone	
E-mail address	
Special meal request *Please specify*	
Smoking room *Please circle one*	Yes / No

Tour options:
Niagara Falls
Choose one event for Tuesday during free time

- ☐ *Maid of the Mist* boat cruise
- ☐ Walk behind Niagara Falls
- ☐ I want to explore on my own

Return this form by fax or mail to:

Mike Quigley, NOAA Great Lakes Environmental Research Laboratory
2205 Commonwealth Blvd.
Ann Arbor, MI 48105-2945
Fax: 734-741-2003

Protecting our Great Lakes!

- Aquatic Invasive Species
- Areas of Concern (AOCs)
- Contaminant Issues
- Great Lakes Research
- Great Lakes Splendor
- U.S./Canada Cooperation

House and Senate rules allow for government agencies to underwrite travel in the U.S. and Canada for congressional staff on tours lasting no longer than three days. Portions of this tour will be paid for by the Government of Canada.

Need more information?

If you would like more information about attending ***Great Lakes Odyssey II: Restore the Greatness!*** on August 12-14, 2003, please contact:

NOAA Great Lakes Environmental Research Laboratory
Mike Quigley — Phone: 734-741-2149
2205 Commonwealth Blvd. — Fax: 734-741-2003
Ann Arbor, MI 48105-2945 — Michael.A.Quigley@noaa.gov

Photo credits:

Cover, back cover, and registration form photos courtesy Dave Brenner, Michigan Sea Grant; interior photo of Niagara Falls courtesy Thomas C. Payne.

Great Lakes Odyssey II: Congressional Tour on August 12-14, 2003

Great Lakes Odyssey II:

Restore the Greatness!

Congressional Tour
August 12-14, 2003

Restore the Greatness!

Hosted by:
Great Lakes Commission
Great Lakes Fishery Commission
USGS Great Lakes Science Center

Erica Sutton (left), an eighth-grader at Brandon Middle School, looks through a microscope as Margret Chriscinske, a biological science technician at the USGS Great Lakes Science Center in Ann Arbor, gives directions

Girls experiment with science fields

By BOB GROSS
Of The Oakland Press

Amanda Frantzen concentrates as she carefully pushes a purple fluid through a syringe. A pink fluid drips out the other end.

BIRMINGHAM

Amanda, a junior at Henry Ford II High School in Sterling Heights, was doing a hands-on experiment as part of Explorathon 2002, a science career day for girls.

About 900 high school students from southeastern Michigan attended the event on Thursday at Birmingham Seaholm High School.

Amanda's hands-on workshop was in liquid chromatography, a technique used to separate the components of a mixture. The purple fluid was Faygo Grape Soda, and the students were separating out the dyes from the carbonated water.

It's the kind of work that Amanda wants to do some day, she said.

"Because I want to go into forensic science, I came here to get hands-on experience," Amanda said.

"I was originally going to start with art, and I found it wasn't that interesting — then I took chem and that was very interesting."

Talbert Spence, director of the Cranbrook Institute of Science, said events such as Explorathon let young women know that science isn't exclusively a men's club.

"You look at, in the past 25 years there has been a terrific amount of discussion about careers in science and young women," he said.

High school is a transitional stage, he said, where career interests often are shaped. By exposing young women to science, the option is put in front of them.

Educators are working to "demystify the stereotype about who can do science," he said.

"Young women need to know there are women out there who are doing great things."

Explorathon grew from an earlier program called Yes You Can, started 21 years ago at Cranbrook by the Birmingham branch of the American Association of University Women, said Cynthia Burdakin, an AAUW member.

"So many of us came up against obstacles when we wanted to study science and math," she said. "We were steered into the more 'feminine' areas."

Oakland Press photos/VAUGHN GURGANIAN

Amanda Frantzen, a junior at Henry Ford II High School in Sterling Heights, works on a science experiment during Explorathon 2002

High school, she said, is too early to start closing doors on options.

"(Science) is a door that they need keep open with classes in high school," she said. "If they shut down math at algebra I, they may never get the classes they may need in college when they find they have another interest."

Mary Kay Pflum, a chemistry professor at Wayne State University and the event's keynote speaker, showed a slide of her high school yearbook photo from the 1980s — big hair, oversized sweater and all — to show how interests change.

"Science is not just something we do in high school," she said. "Science is something that is all around us."

New spawning reef could turn Detroit River into a love nest

Project off Belle Isle to help sturgeon breed

By HUGH McDIARMID JR.
FREE PRESS STAFF WRITER

The Great Lakes lake sturgeon — a monster-sized fish with prehistoric lineage, a life span of 150 years and a face only a momma sturgeon could love — is being invited to fool around in the Detroit River.

A $500,000 artificial spawning reef just offshore of Belle Isle will be ready in time for the sturgeon's spawning run next spring, local, state and federal officials announced Thursday.

They also announced a $350,000 upgrade to the island's Blue Heron Lagoon. The lagoon, an ecological treasure trove, will be more accessible to the public after the restoration of a 9-acre natural area and construction of access points including fishing areas.

But the lagoon plan was overshadowed by the sturgeon news Thursday at a gathering of fisheries experts on Belle Isle.

The goal: Bring back natural breeding that has been virtually nonexistent in the river since the 1900s.

"There is very limited evidence that they are successfully spawning at all" in the river, said John Hartig, Detroit River navigator.

It wasn't always so.

In the late 1800s, fishermen's nets were clogged with the ugly, hard-scaled fish that can grow as large as 7 feet. In June of 1880, 4,000 sturgeon, each more than 100 pounds, were pulled from the river and lower Lake St. Clair.

Fast forward to the years 1999-2003: For weeks on end each year, researchers throw huge lines with 200 baited hooks into the river's current, but average only 20 sturgeon each year. The ones they catch are tagged and returned to the river. But they are big, older sturgeon — virtually no youngsters that would indicate natural reproduction is taking place.

The reason is simple, said

Please see **STURGEON, Page 4B**

LAKE STURGEON

➤ **Latin name:** Acipenser fulvescens

➤ **Description:** At an average weight of 8 to 30 pounds in Michigan, it is the largest indigenous freshwater fish in the Great Lakes. The record sturgeon for Michigan is 193 pounds; the largest on record weighed 320 pounds.

➤ **Habitat:** It prefers shallow areas and warm water.

➤ **Lifespan:** Males typically live about 55 years; females may live up to 150 years.

➤ **Diet:** Small invertebrates such as insect larvae, crayfish, snails, clams and leeches.

➤ **Reproduction:** A spawning female sturgeon's body weight may be 40 percent eggs. After laying up to 4 million eggs, a 100-pound female may swim away weighing merely 60 pounds. Females typically lay eggs once every five to nine years.

➤ **Status:** It is considered endangered or threatened in 19 of the 20 states in its original range.

Sources: www.midwest.fws.gov; "Fishing Michigan" by Eric Sharp

MARTHA THIERRY/Detroit Free Press

STURGEON | Spawning reef planned

From Page 1B

Bruce Manny, a fishery biologist with the U.S. Geological Survey.

"We mined out the gravel by dredging the river for shipping, and for building the buildings you see in Detroit today," said Manny. "No gravel, no spawning. Left with nothing but the mucky, spongy bottom of the river, the females simply never lay eggs."

Scientists recorded sturgeon spawning in other areas of Michigan — the St. Clair River near Port Huron and near Algonac, the Black River near Cheboygan, the St. Mary's River in the Upper Peninsula and some tributaries to Lake Michigan.

But the Detroit River was long considered barren of sturgeon spawning habitat.

Then, on May 9, 2001, a eureka moment.

Central Michigan University researcher Nathan Caswel, was stalking two male sturgeon tagged with sound-emitting devices. They were leaking sperm, but their odds of finding a female ready to lay eggs was virtually zero.

Alone in an 18-foot aluminum boat with an outboard motor, Caswel used an underwater microphone to follow the fish to a heavily polluted section of the river near Zug Island. Surrounded by the smokestacks and flame-spewing steel factories, Caswel's equipment picked up a third fish. The three came together on top of a man-made pile of coal cinders.

Caswel's adrenaline surged and he dialed up Manny and told him he *knew* this is a menage a trois. "It was on one of the armpits of the Detroit River," Manny recalled later, shaking his head.

Manny droped everything and rushed to Home Depot to construct something he'd only read about — an egg-gathering device made from a 60-cent cinder block covered with furnace-filter material. Within hours, they dropped the homemade trap on the spot where the three sturgeon tangoed. Up came eggs.

"It was hallelujah. It was the first verified instance of sturgeon spawning in the Detroit River," Manny said. "Then we got the idea, why not build them some substrate of their own?"

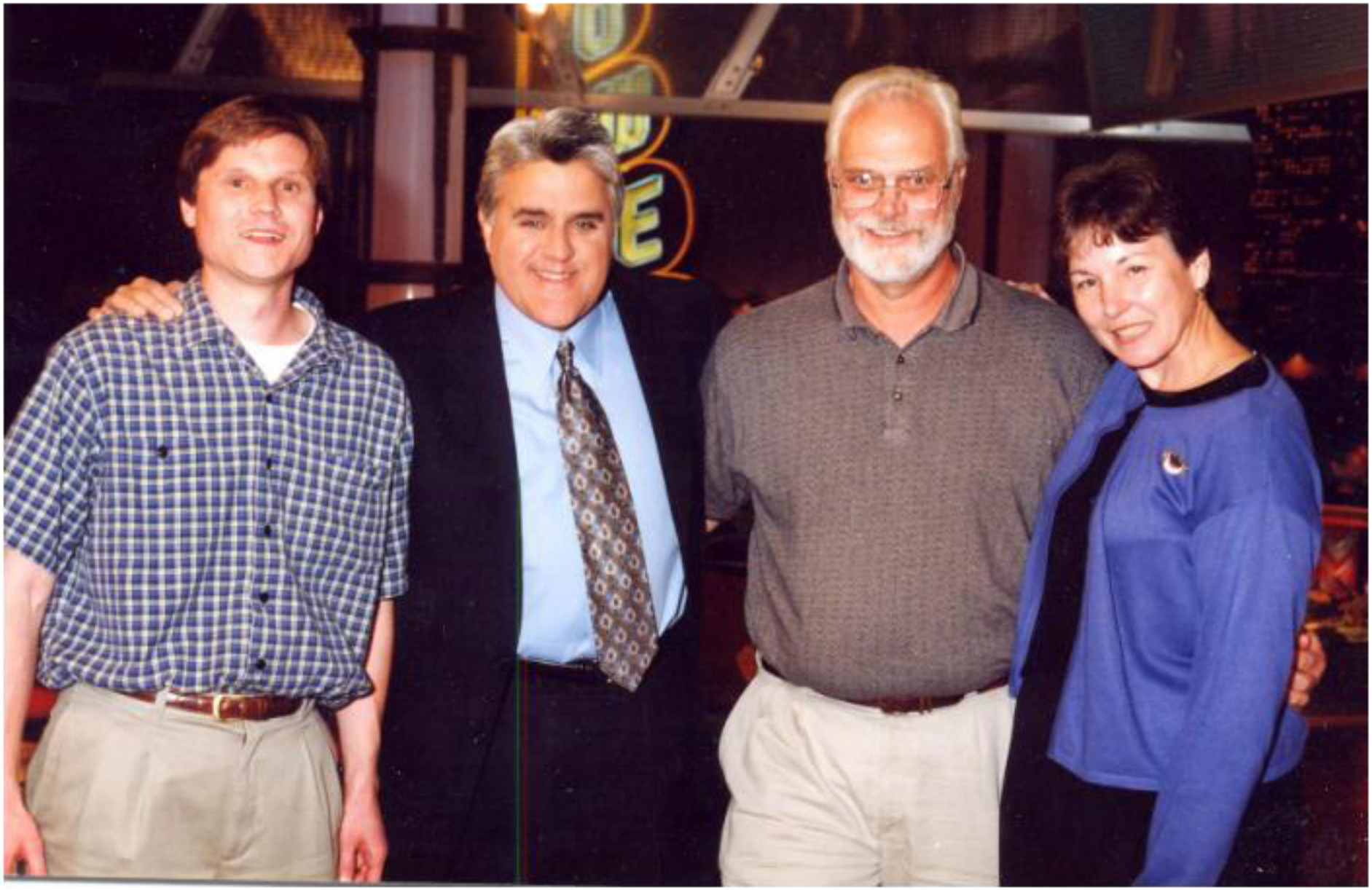
The result is the federally funded project to create three 50-by-80 foot squares of rock and gravel under 20 to 28 feet of water in a fast-moving section of the river. Partly in deference to the 2001 discovery, one of the squares will be filled with coal cinders.

Manny said plans may include a permanent video camera so that anyone with Internet access can watch the sturgeon on the gravel bars.

"If we build it, they will come. Like that movie," Manny predicted.

Contact **HUGH McDIARMID JR.** *at 248-351-3295 or mcdiarmidjr@freepress.com.*

Television Appearance



Roger Bergstedt (second from right), USGS, and Marc Gaden (far left), GL Fish Commission, meet Jay Leno to talk about sea lamprey on the Tonight Show November 1, 2000

Getting Business Done with and through Partners

Great Lakes Science Center – Ann Arbor, MI

Collaborations and Partnerships

USGS Disciplines

Interdisciplinary coastal study with WRD and GD researchers
U.S. Geological Survey, BRD, Leetown
U.S. Geological Survey, BRD, Reston, VA
U.S. Geological Survey, GD, Denver, CO
U.S. Geological Survey, WRD, Columbus, OH
U.S. Geological Survey, WRD, Indianapolis, IN
U.S. Geological Survey, WRD, Lansing, MI
U.S. Geological Survey, WRD, Middleton, WI
U.S. Geological Survey, WRD, Sacramento, CA
U.S. Geological Survey, WRD, Urbana, IL

DOI Agencies

National Park Service
U.S. Fish and Wildlife Service, Alpena Fisheries Resource Office
U.S. Fish and Wildlife Service, Cortland, NY
U.S. Fish and Wildlife Service, Detroit River International Wildlife Refuge
U.S. Fish and Wildlife Service, Ecological Services Office, East Lansing, MI
U.S. Fish and Wildlife Service, Great Lakes Ecosystem Basin Team
U.S. Fish & Wildlife Service, Lower Great Lakes Fishery Resources Office, Amherst, NY
U.S. Fish and Wildlife Service, Ottawa National Wildlife Refuge
U.S. Fish and Wildlife Service, Seney National Wildlife Refuge
U.S. Fish and Wildlife Service, Shiawasee National Wildlife Refuge

Other U.S. Federal Agencies

U.S. Army Corps of Engineers, Buffalo District
U.S. Army Corps of Engineers, Detroit District
U.S. Army Corps of Engineers, Regulatory Division
U.S. Coast Guard, Belle Isle Station
USDA Forest Service, Chequamegon-Nicolet NF
USDA, NRCS
U.S. Environmental Protection Agency, Great Lakes Station
U.S. Environmental Protection Agency, Region 5, Great Lakes National Program Office
U.S. Environmental Protection Agency, Region 5, Water Division
NOAA Great Lakes Coastal Restoration Grant Program

State Agencies

Michigan Department of Environmental Quality, Surface Water Quality Division
Michigan Department of Natural Resources
Michigan Department of Natural Resources – Fisheries Division
New York State Department of Environmental Conservation
Southeast Wisconsin Regional Planning Commission
Wisconsin Department of Natural Resources, Madison, WI
Wisconsin Department of Natural Resources, Bureau of Endangered Resources, Natural Heritage Inventory

Wisconsin Department of Natural Resources, Bureau of Integrated Science Services
Wisconsin Department of Natural Resources, Bureau of Watershed Management

International Agencies

Fisheries and Oceans Canada
Environment Canada
Essex Region Conservation Authority
Ontario Ministry of the Environment
Ontario Ministry of Natural Resources

Academic Institutions

Central Michigan University
Cornell University
Eastern Michigan University
Indiana University
James Madison University
Michigan Sea Grant College Program at Michigan State University
Michigan Sea Grant College Program at University of Michigan
Michigan State University
Michigan State University, Extension Service
New York State Museum
Northland College
Ohio State University, School of Natural Resources
University of Guelph
University of Michigan's Undergraduate Research Opportunity Program
University of Toledo
University of Wisconsin
University of Wisconsin – Stevens Point, Green Bay, and Milwaukee
University of Wisconsin, Water Institute
University of Wyoming

International Commissions

Great Lakes Commission
Great Lakes Fishery Commission
International Joint Commission

Non-governmental organizations

BASF Corporation
City of Detroit Recreation Department
DTE Energy Corporation
Detroit Zoological Institute
Ducks Unlimited
Enviro-Science Inc.
Faust Corporation
Friends of Belle Isle
Friends of the Detroit River
Great Lakes Fishery Trust
Greater Detroit American Heritage River Initiative
Grosse Ile Nature and Land Conservancy
Hamilton Anderson Associates

Midwest Biodiversity Institute
National Fish and Wildlife Foundation
National Wildlife Federation
Purdy Fisheries Limited
Smith Group JJR
Sturgeon for Tomorrow (Black Lake Michigan Chapter)
The Nature Conservancy
The Nature Conservancy, Great Lakes Office
The Nature Conservancy, Wisconsin Chapter

Tribal and First Nations

Grand Traverse Band of Chippewa and Ottawa Indians
Ho-Chunk Nation
Oneida Nation
Wyandotte of Anderdon Nation

Adjunct Professorships

Adjunct Associate Professor, Eastern Michigan University, Department of Biology
Adjunct Professor, Eastern Michigan University, Department of Biology
Adjunct Associate Professor, University of Michigan, School of Natural Resources and Environment, Ann Arbor, MI
Adjunct Associate Professor, University of Michigan, School of Public Health, Ann Arbor, MI

Committees, Teams, and Workgroups

American Institute of Fishery Research Biologists
Binational Detroit River Remedial Action Team
BIO-ONE, Publishers Advisory Committee
Editorial Board, Polish Academy of Sciences, *Polskie Archiwum Hydrobiologie*
Great Lakes Basin Ecosystem Team GIS/DSS Group, U.S. Fish and Wildlife Service
Great Lakes Commission

- Great Lakes Information Network Advisory Board
- Exotic Species Research Committee
- Exotic Species Rapid Response Committee
- GIS Online Project Advisory Board
- Great Lakes Coastal Wetland Consortium, Project Management Team
- Great Lakes Information Network Advisory Board
- Great Lakes Panel on Aquatic Nuisance Species
- Lake Michigan Exotic Species Monitoring Committee
- Lake St. Clair, Project Management Team
- Science Vessel Coordination Steering Committee

Great Lakes Fishery Commission

- Lake Erie Research Coordination Working Group
- Lake Huron Technical Committee
- Lake Michigan Technical Committee

Lake Ontario Plan Formulation Team, International Joint Commission
Shortjaw Cisco Recovery Team, Fisheries and Oceans Canada, Winnipeg, Manitoba

Society of Wetland Scientists
- Board of Directors
- International Committee
- Membership Committee
- Publications Committee
- Wetland Concerns Committee

Steering Committee, International Symposium on the Biology and Management of Coregonid Fishes
Wetlands Science Planning Team, U.S. Geological Survey

Memberships
American Association for the Advancement of Science
American Chemical Society
American Federation of Government Employees, AFL-CIO, Local 723
American Fisheries Society
American Institute of Fishery Research Biologists
American Society of Ichthyologists and Herpetologists
American Society of Photogrammetry and Remote Sensing
Association of American Geographers
Gamma Theta Upsilon, International Geographical Honor Society
Geological Society of America
International Association for Great Lakes Research
President-Elect, North Central Chapter, Society of Wetland Scientists
Professional Wetland Scientist Certification, Society of Wetland Scientists
Society of Environmental Toxicology and Chemistry
Society of Wetland Scientists

Cooperative and Interagency Agreements
Case Western Reserve University, New York funded by Great Lakes National Program Office, Chicago, Lake Erie Trophic Studies
Eastern Michigan University
Environmental Protection Agency, GLNPO, Chicago, IL
Great Lakes Commission
Indiana University
Michigan Department of Natural Resources, Institute for Fisheries Research, Ann Arbor, MI
Michigan DEQ, Surface Water Division
Michigan State University
National Features Inventory
National Water Research Institute, Burlington, Canada funded by Fish and Wildlife Service implemented by Great Lakes Fishery Commission
New York State Department of Environmental Conservation
Northland College
U.S. Army Corps of Engineers, Buffalo District
U.S. Fish and Wildlife Service, Lower Great Lakes Fishery Resources Office, Amherst, NY
U.S. Geological Survey, Geological Discipline, Denver, CO
University of Michigan, Museum of Zoology

University of Michigan, School of Natural Resources and Environment

Hammond Bay Biological Station – Millersburg, MI

Collaborations and Partnerships
Great Lakes Fishery Commission

Cooperative Agreements
Great Lakes Fishery Commission

Lake Erie Biological Station – Sandusky, OH

Committees, Teams, and Workgroups
Advisory boards - Great Lakes Wetland Birds
Advisory boards - Ohio GAP (OSU, USGS-WR, and Ohio DNR)
Associate editor - Journal of Great Lakes Research
Coldwater Task Group, Lake Erie Committee
Forage Task Group, Lake Erie Committee
Lake Erie LaMP, Indicators task group
Lake Erie LaMP, Beneficial Use and Impairment committee

Adjunct Professorships
Adjunct Associate Professor, The Ohio State University, Dept. of Evolution, Ecology, and Organismal Biology

Collaborations and Partnerships
Ohio DNR (comparative yellow perch aging study)
Ohio DNR and Ontario Ministry of Natural Resources (hydroacoustics study)
Ohio DNR and Ontario Ministry of Natural Resources (interagency trawl comparison study)
Ontario Ministry of Natural Resources, Pennsylvania Fish and Boat Commission, and NY Dept. of Conservation (eastern basin coldwater fish assessment)
U.S.D.A. Forest Service (Durham, NH), Oregon State University and OAO Corporation (Corvallis, OR)--forest health monitoring

Memberships
American Ecological Society
American Fisheries Society
International Association of Great Lakes Researchers

Cooperative and Interagency Agreements
Great Lakes Fishery Commission (burbot aging study)
Heidelberg College (mayfly study)
North Shore Environmental, Thunder Bay, ON (burbot study)
Ontario Ministry of Natural Resources and University of Guelph (burbot study)
The Ohio State University (wetland breeding bird study)
U.S. EPA (GLNPO) (central basin DO/temperature collections)

Lake Michigan Ecological Research Station – Porter, IN

Committees, Teams, and Workgroups

Deer Technical Advisory Committee
E. coli Task Force
Environment Policy Management Committee for NW Indiana
Northern Indiana Power Supply Company (NIPSCO) Grant Committee
Office of Research and Development EPA advisory committees on Recreational waters (EMPACT, Modeling and Sampling)

Collaborations and Partnerships

Chicago River Plan
Chicago Water Quality Initiative
Collaboration with Dr. Kathryn McEachern (USGS), Marlin Bowles (The Morton Arboretum) and Dr. Tim Bell on long-term research concerning the federally threatened Pitcher's thistle (*Cirsium pitcheri*).
Collaboration with Joan Elias, National Park Service Great Lakes Inventory and Monitoring network, research on rare plant distribution and exotic plants at Sleeping Bear Dunes and Indiana
Crystal River Monitoring Plan
Delaware River Source Identification Plan
Door County Coastal Monitoring Strategy
Dunes National Lakeshore
Indiana Department of Natural Resources
Indiana Dunes National Lakeshore
Indiana State University
Milwaukee Monitoring and Coastal Protection Plan
National Park Service

Memberships

American Libraries Association
Great Lakes Beach Association (President 2000-2003)
Special Libraries Association

Interagency Agreements

IAG Contract: ACOE, Chicago,
Gary, Indiana Dept. Env. Management
Indiana Dept. National Resources
Interagency Agreement for creation of vegetation Access database from permanent plot data from Lincoln Boyhood National Memorial, 2001-2003
National Park Service (INDU, SLBE, MWRO)
Save the Dunes Conservation Fund
U.S. EPA (ORD, Region 5, GLNPO)
U.S. Geological Survey –Water Resources Division

Lake Ontario Biological Station – Oswego, NY

Committees, Teams, and Workgroups
Lake Ontario lake trout stocking workgroup
Lake Ontario Monitoring Committee (U.S. EPA and Environment Canada)
Lake Ontario Technical Committee
Scientific Organizing Committee, GLOW IV Symposium (Aquatic Ecosystem Health Management Society)

Collaborators and Partners
Cornell University (lake trout population modeling, lower trophic level and *Mysis* studies, biomonitoring)
Environment Canada (*Mysis* studies)
Fisheries and Oceans Canada (zooplankton and *Mysis* studies)
New York Department of Environmental Conservation (prey fish and lake trout assessment, biomonitoring)
Ontario Ministry of Natural Resources (*Mysis* studies)
State University of New York College of Environmental Science and Forestry at Syracuse University (lake trout growth dynamics)
U.S. Fish and Wildlife Service – Lower Great Lakes FRO and Allegheny Fish Hatchery (lake trout restoration)

Memberships
American Fisheries Society
Aquatic Ecosystem Health Management Society
International Association of Great Lakes Research
Phi Kappa Phi
Sigma Xi

Interagency Agreements
Great Lakes Fishery Commission (lake herring workshop)
NY Sea Grant (*Mysis* studies)
U.S. EPA (GLNPO; *Diporeia* study and contaminant collections)

Lake Superior Biological Station – Ashland, WI

Collaborations and Partnerships

DOI Agencies

National Park Service (Isle Royale and Apostle Islands Park Units)
U.S. Fish and Wildlife Service (Ashland Fishery Resources Office)

Other Federal Agencies

U.S. Environmental Protection Agency – Duluth Laboratory

State Agencies

Michigan Department of Natural Resources
Minnesota Department of Natural Resources
Wisconsin Department of Natural Resources

International Agencies

Ontario Ministry of Natural Resources
Fisheries and Oceans Canada

Academic Institutions

Michigan State University
Michigan Technical University
Northland College
University of Minnesota – Duluth
University of Wisconsin-Madison
University of Wisconsin-Stevens Point
University of Wisconsin-Superior

Tribal and First Nations

Bad River Band of Lake Superior Chippewa
Bay Mills Indian Community
Chippewa-Ottawa Resource Authority
Great Lakes Indian Fish and Wildlife Commission
Keweenaw Bay Indian Community
Red Cliff Band of Lake Superior Chippewa

Committees, Teams, and Workgroups

Aquatic Habitat Committee, Lake Superior Bi-National Program
Chippewa-Ottawa Treaty Fishery Management Authority
Cisco Recovery Workshop, Fisheries and Oceans Canada
Coaster Brook Trout Workshop
Fish Community Committee, Lake Superior Bi-National Program
Great Lakes Fishery Commission
Great Lakes Indian Fish and Wildlife Commission
Isle Royale Fishery Management Workgroup
Lake Superior Technical Committee – Great Lakes Fishery Commission
Minnesota Department of Natural Resources
Ontario Ministry of Natural Resources
Ruffe Control Committee
Wisconsin Department of Natural Resources

Memberships
American Fishery Society
American Fishery Society – Wisconsin Chapter
American Society of Ichthyologists and Herpetologists

Cooperative and Interagency Agreements
National Park Service, Great Lakes Project Office, Ashland
Ontario Ministry of Natural Resources, Thunder Bay and Sault Ste. Marie Offices
U.S. Fish and Wildlife Service, Great Lakes Restoration Act
U.S. Fish and Wildlife Service, East Lansing Ecological Services Office

Tunison Laboratory of Aquatic Science – Cortland, NY

Committees, Teams, and Workgroups
American Eel Working Group
Finger Lakes Initiative Working Group
New York Lake Sturgeon Working Group

Collaborations and Partnerships
USGS Disciplines
U.S. Geological Survey, WRD, Ithaca, NY
DOI Agencies
U.S. Fish and Wildlife Service
State Agencies
New York State Department of Environmental Conservation
New York State Parks
International Agencies
Ontario Ministry of Natural Resources
Tribal and First Nations
Mohawk Council of Akwesasne
St. Regis Mohawk Tribe

Memberships
National American Fish and Wildlife Society

Interagency Agreements
Akwesane Mohawks, Canada
Bard College
Michigan Department of Natural Resources
Mohawk tribe
New York State Department of Environmental Conservation
NOAA
Ohio Department of Natural Resources

Ohio Environmental Protection Agency
St. Regis Mohawk Environment Division
SUNY College of Environmental Science and Forestry
U.S. Army Corps of Engineers
U.S. Environmental Protection Agency, Great Lakes National Program Office
U.S. Fish and Wildlife Service