Great Lakes Restoration Initiative Action Plan
Science Advisory Board Review

Scientific Background of the GLRI Action Plan

Table of Contents

Sections:		page #
I.	Introduction	4
II.	Purpose	4
III.	Priorities Based on Scientific Planning and Coordination	4
	a. Great Lakes Regional Collaboration Strategy	5
	b. State of the Lakes Ecosystem Conference	9
	c. Great Lakes Binational Toxics Strategy	12
	d. Aquatic Nuisance Species (ANS) Task Force and Great Lakes Panel on ANS	14
	e. Joint Strategic Plan for Management of Great Lakes Fisheries	15
IV.	Review and Oversight of the Great Lakes Restoration Initiative	17
	a. Competitive Funding and Review Panels	17
	b. Reporting Mechanisms	17
	c. Great Lakes Accountability System	18
	d. Tracking Measures of Progress	18
V.	Science Advisory Board Review of the GLRI Action Plan	19
	a. Directive for Review of the GLRI Action Plan	19
	b. Problem Overview: Toxic Substances and Areas of Concern	19
	c. Toxic Substances and Areas of Concern Goals, Objectives, Measures and Actions in the GLRI Action Plan	25
	d. Problem Overview: Invasive Species	27
	e. Invasive Species Goals, Objectives, Measures and Actions in the GLRI Action Plan	31
	f. Problem Overview: Nearshore Health and Nonpoint Source Pollution	34
	g. Nearshore Health and Nonpoint Source Pollution Goals, Objectives, Measures and Actions in the GLRI Action Plan	36
	h. Problem Overview: Habitat and Wildlife Protection and Restoration	39
	i. Habitat and Wildlife Protection and Restoration Goals, Objectives, Measures and Actions in the GLRI Action Plan	44
	j. Problem Overview: Accountability, Education, Monitoring, Evaluation, Communication, and Partnerships	47
	k. Accountability, Education, Monitoring, Evaluation, Communication, and Partnerships Goals, Objectives, Measures and Actions in the GLRI Action Plan	49

Tables:

Table 1. Cross-walk of priorities of the GLRC Strategy (2005) and the GLRI Action Plan (2010)
Table 2. Cross-walk of highlights of the 2009 State of the Lakes Report and goals of the GLRI Action Plan
Table 3. Cross-walk between the goals of the GLBTS (1997) and the GLRI Action Plan (2010)
Table 4. Cross-walk between the recommendations of the Great Lakes Panel on Aquatic Nuisance Species and the goals of the GLRI Action Plan
Table 5. Cross-walk between recommendations by the Great Lakes Fisheries Commissions Joint Strategic Plan (1997) and the goals of the GLRI Action Plan (2010)
Table 6. GLRI Action Plan Goals, Objectives, Actions and Measures associated with Toxic Substances and Areas of Concern
Table 7. GLRI Action Plan Goals, Objectives, Actions and Measures associated with Invasive Species
Table 8. GLRI Action Plan Goals, Objectives, Actions and Measures associated with nearshore health and nonpoint source pollution
Table 9. GLRI Action Plan Goals, Objectives, Actions and Measures associated with habitat and wildlife protection and restoration
Table 10. GLRI Action Plan Goals, Objectives, Actions and Measures associated with accountability, education, monitoring, evaluation, communication, and partnerships

Figures:

Figure 1. Screen shot of the Great Lakes Accountability System database.

I. Introduction

In 2010, President Obama announced and Congress appropriated $475 million in new funding for the Great Lakes Restoration Initiative (GLRI or Initiative) to "protect and restore the chemical, biological, and physical integrity of the Great Lakes". The Great Lakes contain 20 percent of the world's surface freshwater, accounting for 95 percent of the surface freshwater in the United States. The watershed includes two nations, eight U.S. States, two Canadian provinces, more than 40 tribes, and more than one-tenth of the U.S. population. Led by the United States Environmental Protection Agency (EPA), the GLRI targets some of the most serious threats to the Great Lakes including invasive species, non-point source pollution, habitat degradation, and contaminated sediment.

To guide the efforts of the GLRI, EPA and our Federal partners, through the Great Lakes Interagency Task Force (IATF)[1] chaired by EPA Administrator Lisa Jackson, developed a comprehensive multi-year Action Plan. The GLRI Action Plan identifies goals, objectives, measurable ecological targets, and specific actions for five major focus areas:

- Toxic Substances and Areas of Concern
- Invasive Species
- Nearshore Health and Nonpoint Source Pollution
- Habitat and Wildlife Protection and Restoration
- Accountability, Education, Monitoring, Evaluation, Communication and Partnerships

II. Purpose

The purpose of the scientific background paper is to illustrate that the goals, objectives, actions, and measures in the GLRI Action Plan are based on the best available science and years of strategic planning and collaboration. The scientific background paper is not meant to be an authoritative state of the science for all the ecosystem problems in the Great Lakes. It is intended to provide the review panel with an overview of the key ecological problems for which we are seeking their input on, and help the panel navigate through the extensive literature, strategies, and plans that informed the GLRI Action Plan.

Section III provides a cross-walk of the GLRI Action Plan with the key strategic planning and coordination documents. The cross-walk illustrates that the goals of the GLRI Action Plan are based on years of strategic planning and collaboration. Section IV provides an overview of the review, oversight, and accountability that has been built into the Initiative. Section V provides a much more detailed overview of the ecological problems in the Great Lakes. The detailed problem statement for each focus area will provide the basis for the Charge Questions 4-11, and is intended to supplement the Problem Statement and Principal Actions to Achieve Progress sections in the Action Plan.

III. Priorities Based on Scientific Planning and Coordination

The Initiative builds upon extensive planning and collaboration over the previous three decades to protect the Great Lakes by a wide variety of federal, state, tribal, local, and non-governmental

[1] The Great Lakes Interagency Task Force (IATF) brings together eleven U.S. cabinet and Federal agency heads to coordinate restoration of the Great Lakes. Created by Executive Order from President Bush on May 18, 2004, the IATF is to focus on environmental outcomes like cleaner water and sustainable fisheries, and target measurable results. The IATF helps coordinate GLRI implementation. http://www.epa.gov/greatlakes/iatf/index.html

stakeholders. The challenges identified in the GLRI Action Plan are based on scientific evidence and consensus that has a strong foundation in the scientific community and are documented in many of the plans, strategies, and advisory panels from which the Action Plan draws many of its ecological priorities, goals, and objectives. The Action Plan serves as an action driver to integrate and align these plans, and it attempts to capture the broad consensus of the Great Lakes community's collective commitment to protect and restore the Great Lakes. These plans, programs, and panels include, but are not limited to, the following:

- Great Lakes Regional Collaboration Strategy to Restore and Protect the Great Lakes[2]
- State of the Lakes Ecosystem Conference and the *State of the Great Lakes 2009 Report*[3].
- Great Lakes Binational Toxics Strategy[4]
- Great Lakes Panel on Aquatic Nuisance Species[5]
- Joint Strategic Plan for Management of Great Lakes Fisheries[6]
- Great Lakes Water Quality Agreement
- State Wildlife Action Plans
- U.S. Fish and Wildlife (FWS) National Fish Habitat Action Plan
- North American Waterbird Conservation Plan
- North American Waterfowl Management Plan
- U.S. Shorebird Conservation Plan
- Great Lakes Coastal Wetland Monitoring Plan

The following sections will illustrate how the GLRI Action Plan integrated the ecological priorities and goals for the top five plans, programs and panels above. These represent the key strategic planning and collaborative tools for the Great Lakes. For more information on the remaining documents, please refer to the relevant website in the footnotes.

Great Lakes Regional Collaboration Strategy Formed the Basis of the GLRI Action Plan

In December 2005, the *Great Lakes Regional Collaboration Strategy to Restore and Protect the Great Lakes* (GLRC Strategy, http://www.glrc.us) was signed by the Governor of Ohio, the Administrator of the U.S. Environmental Protection Agency, the Mayor of Chicago, the Chairman of the Little Traverse Bay Band of Odawa Indians, and the Hon. Vernon Ehlers of the U. S. House of Representatives. These signatures represented the concurrence and resolve of the Great Lakes Governors, the Federal Agencies Great Lakes Task Force, the Great Lakes Mayors, The Great Lakes Tribal Caucus, and the Great Lakes Congressional Delegation to support efforts to protect and restore the Great Lakes through the collaboration effort.

The GLRC Strategy had been developed over a period of two years through a partnership of federal, state, and local governments, tribes, NGOs, researchers and other scientific experts, and other stakeholders with a "goal of restoring and protecting the Great Lakes ecosystem for this and future generations". Eight Strategy Teams comprised of scientific experts developed recommendations for

[2] http://www.glrc.us
[3] The State of the Great Lakes Report is developed through the State of the Ecosystem Conference (SOLEC) process. SOLEC was established by the governments of Canada and the United States in response to requirements of the Great Lakes Water Quality Agreement (GLWQA) for regular reporting on progress toward Agreement goals and objectives. http://epa.gov/greatlakes/solec/index.html
[4] http://www.epa.gov/bns
[5] http://www.glc.org/ans/panel.html
[6] http://www.glfc.org/fishmgmt/jsp97.pdf

actions across the priority areas that had been identified by the Great Lakes Governors. The recommendations and detailed plans were identified by teams of scientists and environmental managers with input from key stakeholders groups across the basin. More than 1500 people, including most of the scientific experts and ecosystem managers from the U. S. side of the Great Lakes basin, participated in this endeavor. The draft strategy was released for public comment in July, 2005; thousands of suggestions and comments were received and ultimately informed the final document.

Although pollution in the Great Lakes began to be addressed in the early 1970s through national legislation, such as the Clean Air Act and the Clean Water Act, and through agreements between the U.S. and Canada, including the Great Lakes Water Quality Agreement, expectations for environmental restoration and protection were not fully realized. In 2003, the Great Lakes Congressional Delegation encouraged the Great Lakes Governors to identify their environmental priorities for Great Lakes protection and restoration. This began a number of activities within the U. S. and in partnership with Canadian Provinces. President Bush, in 2004, signed an Executive Order, recognizing the Great Lakes as a "national treasure" and creating a Federal Great Lakes Interagency Task Force to improve coordination and collaboration among the federal agencies. The Executive Order also directed the U. S. Environmental Protection Agency to convene a "regional collaboration of national significance for the Great Lakes".

The Great Lakes Regional Collaboration created eight Strategy Teams, comprised largely of scientific experts, but also included a spectrum of environmental managers and environmental stakeholders. The Strategy Teams worked to characterize the environmental problems in the Great Lakes; they incorporated issues of ecosystem health, human health, tribal interests and perspectives, and research knowledge and needs. The recommendations, aligned with the topical priorities that had been identified by the Great Lakes Governors, included actions to:

- Stop the introduction and spread of aquatic invasive species,
- Improve habitat conservation and species management,
- Eliminate inadequately treated waste to Great Lakes basin waters,
- Restore all Great Lakes Areas of Concern,
- Reduce non-point sources of pollutants and protect and restore wetlands,
- Maintain the chemical integrity of the Great Lakes basin ecosystem,
- Support scientific information that informs stakeholders and decision-makers through monitoring and observing systems and information management,
- Promote a strong and vibrant Great Lakes economy, meeting societal and cultural needs in balance with resilient ecosystems, using sustainability as a guide

The Federal Interagency Task Force was established to coordinate federal activities associated with the GLRC Strategy and other drivers, and it continues to collaborate and coordinate activities under the GLRI Action Plan. The Action Plan derived its priorities directly from the GLRC Strategy. The GLRI Action Plan significantly benefitted from the extensive scientific expertise and work of the GLRC Strategy Teams in identifying the environmental problems in the Great Lakes and priority actions to address them. The following table provides a cross-walk of the priorities of the GLRC Strategy with those of the GLRI Action Plan.

Table 1. Cross-walk of priorities of the GLRC Strategy (2005) and the GLRI Action Plan (2010)

Great Lakes Regional Collaboration Strategy (2005)	**Great Lakes Restoration Initiative Action Plan (2010)**
Aquatic Invasive Species Goals ▪ Prevent all new introductions of AIS into the Great Lakes ▪ Stop the spread of AIS within the basin, extirpate harmful AIS, or if impossible, control to levels that ensure sustainable ecosystems and the social economic and cultural uses they support	Invasive Species Goals • The introduction of new invasive species to the Great Lakes basin ecosystem is eliminated, reflecting a "zero tolerance policy" toward invasives. • The risk of introduction of species, which are imported for various uses, into the Great Lakes is minimized. • The spread of invasive species, by means of recreational activities, connecting waterways, and other vectors, beyond their current range is prevented. • A comprehensive program for detection and tracking newly identified invasive species in the Great Lakes is developed and provides up-to-date critical information needed by decision makers for evaluating potential rapid response actions. • An effective, efficient and environmentally sound program of integrated pest management for invasive species is developed and implemented, including program functions of containment, eradication, control and mitigation.
Habitat / Species Goals ▪ Continue progress on recovering state and federal listed species and communities as well as taking proactive steps to prevent future listings. ▪ Create a process to prioritize conservation actions, and the actions recommended should consider the full range of habitat and species biodiversity and be scientifically justified with measureable outcomes. (many specific long-term goals specified in the strategy for open / nearshore waters, wetlands, riverine habitats and riparian areas, and coastal and upland habitats)	Habitat and Wildlife Protection and Restoration Goals • Protection and restoration of Great Lakes aquatic and terrestrial habitats, including physical, chemical, and biological processes and ecosystem functions, maintain or improve the conditions of native fish and wildlife. • Critical management activities (such as stocking native fish and other aquatic species, restoring access of migratory fish species at fish passage barriers, and identifying and addressing diseases) protect and conserve important fish and wildlife populations. • Sound decision making is facilitated by accessible, site specific and landscape-scale baseline status and trend information about fish and wildlife resources and their habitats. • High priority actions identified in strategic plans (such as state and federal species management, restoration and recovery plans, Lakewide Management Plans, Remedial Action Plans, and others) are implemented, lead to the achievement of plan goals, and reduce the loss of fish and wildlife and their habitats. • Development activities are planned and implemented in ways that are sensitive to environmental considerations and compatible with fish and wildlife and their habitats.

Great Lakes Regional Collaboration Strategy (2005)	Great Lakes Restoration Initiative Action Plan (2010)
Coastal Health Goals ▪ Eliminate inputs of untreated or inadequately treated human and industrial waste to Great Lakes basin waters from municipal wastewater treatment systems and on-site disposal systems. ▪ At the local level, individual contamination events will occur no more than 5% of available days per bathing season, sources of these contamination events will be identified through standardized sanitary surveys, and remediation measures will be in place to address these events. ▪ The quality of Great Lakes basin drinking water from coastal and tributary sources will be protected from chronic and episodic threats of chemical and biological contamination that pose unacceptable risk following conventional water treatments. Nonpoint Source Goals ▪ Protect existing wetlands and restore wetlands in both urban and rural areas so that rivers, streams and lakes across the Great Lakes region function as healthy ecosystems ▪ Measurably reduce at least hundreds of thousands of tons of sediment, pounds of phosphorous loading, and pounds of nitrogen loading into the Great Lakes basin ▪ Reduce the amount of sediment reaching the Great Lakes through installation and continued use of management practices on cropland, especially those that increase crop residue left on the surface ▪ Reduce livestock agriculture's contribution to nonpoint source loading by 40-70 percent through comprehensive nutrient management planning and practice implementation ▪ Improve flow regimes to meet sediment reduction goals and restore sustainable biological communities	Nearshore Health and Nonpoint Source Pollution • Nearshore aquatic communities consist of healthy, self-sustaining plant and animal populations dominated by native and naturalized species. • Land use, recreation and economic activities are managed to ensure that nearshore aquatic, wetland and upland habitats will sustain the health and function of natural communities. • The presence of bacteria, viruses, pathogens, nuisance growths of plants or animals, objectionable taste or odors, or other risks to human health are reduced to levels in which water quality standards are met and beneficial uses attained to protect human use and enjoyment of the nearshore areas. • High quality bathing beach opportunities are maintained by eliminating impairments from bacterial, algal and chemical contamination; effective monitoring for pathogens; effective modeling of environmental conditions, where appropriate; and timely communications to the public about beach health and daily swimming conditions. • A significant reduction in soil erosion and the loading of sediments, nutrients and pollutants into tributaries is achieved through greater implementation of practices that conserve soil and slow overland flow in agriculture, forestry and urban areas. • High quality, timely and relevant information about the nearshore areas is readily available to assess progress and to inform enlightened decision making.
Areas of Concern / Sediments Goals ▪ Restore all of the US Great Lakes AOCs Toxic Pollutant Goals ▪ Virtually eliminate the discharge of any or all persistent toxic substances to the Great Lakes basin ecosystem ▪ Significantly reduce exposure to persistent toxic chemicals from historically contaminated sources through source reduction and other exposure reduction methods ▪ Reduce environmental levels of toxic chemicals to the point that all restrictions on the consumption of Great Lakes fish can be lifted. ▪ Protect the health and integrity of wildlife populations and habitat from adverse chemical and biological effects associated with the release of persistent toxic substances.	Toxic Substances and Areas of Concern Goals • Areas of Concern are cleaned up, restoring the areas and removing the beneficial use impairments. • The release of toxic substances in toxic amounts is prevented and the release of any or all persistent toxic substances (PTS) to the Great Lakes basin ecosystem is virtually eliminated. • Exposure to toxic substances from historically contaminated sources is significantly reduced through source reduction and other exposure reduction methods. • Environmental levels of toxic chemicals are reduced to the point that all restrictions on the consumption of Great Lakes fish can be lifted. • The health and integrity of wildlife populations and habitat are protected from adverse chemical and biological effects associated with the presence of toxic substances in the Great Lake Basin.

Great Lakes Regional Collaboration Strategy (2005)	Great Lakes Restoration Initiative Action Plan (2010)
Indicators and Information Goals ▪ Stakeholders and decision makers will widely recognize and accept that physical, chemical, biological, socio-economic research and scientific information needs to be conducted / collected and disseminated ▪ A widespread network of monitoring / observing systems will provide a steady stream of data and scientific findings that are translated into practical information and products for decision makers, educators and the public. ▪ Robust information gathering and integration tools will be made available to support scientifically informed decisions. ▪ Great Lakes research programs will be conducted in a comprehensive, strategically coordinated manner and designed to meet user needs. ▪ Progress achieved in the design of the scientifically – verified set of indicators for the Great Lakes ecosystem will be exploited. ▪ Standardized information management systems will be implemented by organizations within the region and connected through an integrated network of information systems.	Accountability, Education, Monitoring, Evaluation, Communication and Partnerships Goals • A cooperative monitoring and observing system provides a comprehensive assessment of the Great Lakes ecosystem. • The necessary technology and programmatic infrastructure supports monitoring and reporting, including Great Lakes • Restoration Initiative project deliverables by all agencies and participating stakeholders. Data and information are provided in reports that are public friendly, timely and available on the Internet. Reports present integrated and scaled data from watersheds to lakes to Great Lakes basinwide. • Increase outreach and education for the Great Lakes, and provide ongoing K-12 education for students to understand the benefits and ecosystem functions of the Great Lakes so they are able to make decisions to ensure that restoration investments are enhanced over time. • Expand the range of opportunities for Great Lakes stakeholders and citizens to provide input to the governments and participate in Great Lakes issues and concerns. • Work under the goals and objectives of the Great Lakes Water Quality Agreement is coordinated between the U.S. and Canada through Lakewide Management Plans (LaMP) and other binational processes, programs, and plans.

State of the Lakes Ecosystem Conference provides scientific framework to assess the status and trends of the Great Lakes

The State of the Lakes Ecosystem Conference (SOLEC) was first implemented in 1994 as a biennial assessment of the environmental status and trends of the Great Lakes basin ecosystem. The purpose for SOLEC is to synthesize science-based reports on the state of the environment. The reports do not address the efficacy of various governmental programs. They are intended to strengthen decision-making and environmental management by providing information on the status and trends of environmental conditions of the Great Lakes. The SOLEC process depends on consultation and collaboration between federal, state, provincial and local government agencies; environmental groups; industry; academia; and the public. Over 40 agencies and organizations and over 150 subject experts are involved with the preparation of indicator reports, conference planning and implementation, and final report preparation and dissemination. In 2008, a three-year assessment cycle was introduced. The most recent assessment is presented in the report *State of the Great Lakes 2009*[7]. The next SOLEC will be held in October, 2011, and the *State of the Great Lakes* 2012 report will be released in 2012.

In 1993, an international panel of six experts conducted a peer review of the SOLEC process. One of their conclusions was that SOLEC is a "world leader" in indicator development. The suite of Great Lakes indicators reported through SOLEC was also reviewed by independent panels in 1994 and in 2010. On both occasions, improvements to the indicators were suggested and implemented.

SOLEC relies heavily on data from a variety of sources to form the basis of the indicator reports. In addition to the assurances from each agency or organization regarding the quality of its data, each indicator author is asked to include an evaluation of data quality in the report. On a continuum from "Strongly Agree" to "Strongly Disagree," the authors are asked to assess the following statements:

- Data are documented, validated, or quality-assured by a recognized agency or organization

[7] http://www.epa.gov/solec/

- Data are traceable to original sources
- The source of the data is a known, reliable and respected generator of data
- Geographic coverage and scale of data are appropriate to the Great Lakes basin
- Data are obtained from sources within the U.S. are comparable to those from Canada
- Uncertainty and variability in the data are documented and within acceptable limits for this indicator report
- In this way, the general quality and confidence in the data are documented for each State of the Great Lakes Report.

Information provided through SOLEC reporting provides a documented record of environmental conditions and trends for many of the Great Lakes ecosystem components. When the GLRI Action Plan was being created, many of the SOLEC indicator categories translated directly into GLRI focus areas.

Table 2. Cross-walk of highlights of the 2009 State of the Lakes Report and goals of the GLRI Action Plan

State of the Lakes Conference Highlights (2009)	Great Lakes Restoration Initiative Action Plan (2010)
Coastal Zone and Aquatic Habitats Status: Mixed and Undetermined. Threats from alteration in lake level fluctuations, high levels of shoreline hardening in St. Clair, Detroit and Niagara Rivers and along Lake Erie; shoreline human development is impacting cobble beaches and sand dunes and islands. Management Challenges: • Regulate water levels in a manner that allows for healthy aquatic habitats • Protect and restore wetlands, islands, alvars, cobble beaches, sand dunes, and aquatic habitats • Implement established binational coastal wetland monitoring programs and protocols • Develop indicators for all aquatic habitats: open and nearshore waters, groundwater, rivers and streams, inland lakes and wetlands	Nearshore Health and Nonpoint Source Pollution • Nearshore aquatic communities consist of healthy, self-sustaining plant and animal populations dominated by native and naturalized species. • Land use, recreation and economic activities are managed to ensure that nearshore aquatic, wetland and upland habitats will sustain the health and function of natural communities. • The presence of bacteria, viruses, pathogens, nuisance growths of plants or animals, objectionable taste or odors, or other risks to human health are reduced to levels in which water quality standards are met and beneficial uses attained to protect human use and enjoyment of the nearshore areas. • High quality bathing beach opportunities are maintained by eliminating impairments from bacterial, algal and chemical contamination; effective monitoring for pathogens; effective modeling of environmental conditions, where appropriate; and timely communications to the public about beach health and daily swimming conditions. • A significant reduction in soil erosion and the loading of sediments, nutrients and pollutants into tributaries is achieved through greater implementation of practices that conserve soil and slow overland flow in agriculture, forestry and urban areas. • High quality, timely and relevant information about the nearshore areas is readily available to assess progress and to inform enlightened decision making.

State of the Lakes Conference Highlights (2009)	Great Lakes Restoration Initiative Action Plan (2010)
Invasive Species Status: All lakes except Lake Superior are increasingly vulnerable and rated "Poor". Lake Superior is "Fair" and "unchanging" in vulnerability. Management Challenges: • Develop integrated invasive Species prevention and control strategies for the entire basin • Establish and enforce regulations to inhibit the introduction and spread of aquatic invasive species • Gain a better understanding of the links between vectors and donor regions, the reactivity of the Great Lakes ecosystem and the biology of potential harmful invaders	Invasive Species Goals • The introduction of new invasive species to the Great Lakes basin ecosystem is eliminated, reflecting a "zero tolerance policy" toward invasives. • The risk of introduction of species, which are imported for various uses, into the Great Lakes is minimized. • The spread of invasive species, by means of recreational activities, connecting waterways, and other vectors, beyond their current range is prevented. • A comprehensive program for detection and tracking newly identified invasive species in the Great Lakes is developed and provides up-to-date critical information needed by decision makers for evaluating potential rapid response actions. • An effective, efficient and environmentally sound program of integrated pest management for invasive species is developed and implemented, including program functions of containment, eradication, control and mitigation.
Contamination Status: All Great Lakes have "Mixed" status. Concentrations of contaminants are increasing in the nearshore and sources from wastewater, air pollution, contaminated sediment, runoff and groundwater are continuing. Improvements include declines in contaminants in herring gull eggs, concentrations in PCBs, DDT, mercury and some instances of chlordane and toxaphene. Increases in loadings of phosphorus, substances of emerging concern chemicals and atmospheric deposition. Management Challenge: • Eliminate nuisance algae growth through efforts to control excessive phosphorus. • Research human and ecosystem health implications of detected bioaccumulative toxic substances and newly monitored contaminants • Reduce atmospheric deposition of contaminants • Remove existing sources of PCBs in the basin • Systematically measure toxic chemicals from all vectors to improve source identification and local management actions	Toxic Substances and Areas of Concern Goals • Areas of Concern are cleaned up, restoring the areas and removing the beneficial use impairments. • The release of toxic substances in toxic amounts is prevented and the release of any or all persistent toxic substances (PTS) to the Great Lakes basin ecosystem is virtually eliminated. • Exposure to toxic substances from historically contaminated sources is significantly reduced through source reduction and other exposure reduction methods. • Environmental levels of toxic chemicals are reduced to the point that all restrictions on the consumption of Great Lakes fish can be lifted. • The health and integrity of wildlife populations and habitat are protected from adverse chemical and biological effects associated with the presence of toxic substances in the Great Lake Basin.
Human Health Status: Mixed and Undetermined: Drinking water is generally good but there are concerns about some contaminants. Beach advisories are higher for Lakes Erie and Ontario. Bioaccumulating contaminants in sport fish are declining. Air quality is improving regionally but there are localized problems. Management Challenges: • Protect Great Lakes drinking water sources from potential threats from contaminants, pathogens, salts and chemicals of emerging concern. • Review and standardize U. S. state guidelines for contaminants in sport fish. • Monitor chemicals of emerging concern, such as PBDEs and PFOS. • Identify human and ecosystem effects from exposure to multiple contaminants, including endocrine disruptors.	

State of the Lakes Conference Highlights (2009)	Great Lakes Restoration Initiative Action Plan (2010)
Biotic Communities Status: Mixed and Undetermined. Indicators of lower food web components (benthic organisms, *Diporeia*, native mussels, preyfish) show negative trends. Some higher food web components (lake trout, lake sturgeon, walleye, bald eagle) are positive in many places. Management Challenges: • Enhance native preyfish populations • Establish appropriate fish stocking levels in relation to the health of the preyfish population base • Improve biomonitoring programs and maintain trend data, including those for bald eagles • Protect existing high-quality nearshore areas • Plan and implement restoration projects that maximize benefits to all biotic communities, for example by incorporating native mussel refugia into coastal wetland restoration plans • Monitor fish communities to understand the relationship between *Diporeia* and zebra and quagga mussels	Habitat and Wildlife Protection and Restoration Goals • Protection and restoration of Great Lakes aquatic and terrestrial habitats, including physical, chemical, and biological processes and ecosystem functions, maintain or improve the conditions of native fish and wildlife. • Critical management activities (such as stocking native fish and other aquatic species, restoring access of migratory fish species at fish passage barriers, and identifying and addressing diseases) protect and conserve important fish and wildlife populations. • Sound decision making is facilitated by accessible, site specific and landscape-scale baseline status and trend information about fish and wildlife resources and their habitats. • High priority actions identified in strategic plans (such as state and federal species management, restoration and recovery plans, Lakewide Management Plans, Remedial Action Plans, and others) are implemented, lead to the achievement of plan goals, and reduce the loss of fish and wildlife and their habitats. • Development activities are planned and implemented in ways that are sensitive to environmental considerations and compatible with fish and wildlife and their habitats.
Land Use – Land Cover Status: Mixed and Undetermined. Land use is changing from forest and agriculture to development, transportation, and upland grass and brush (early succession) and conversion rates exceed predictions from population growth. Management Challenge: • Develop a uniform land use / land cover classification system across the basin • Update land use / land cover datasets • Manage forest lands to protect continuity of forest cover to allow for habitat protection and wildlife species mobility to maintain natural biodiversity • Develop and promote Green Cities concepts	
Resource Utilization (Water and Energy Supply) Status: Mixed and Undetermined. Water withdrawals have declined; electrical energy use is high, fuel consumption is increasing. Management Challenges • Research the ecological impact of water withdrawals. • Manage energy production and conservation to meet current and future demands • Meet the challenges of population growth and urban sprawl by improving current and future transportation systems and infrastructures.	No comparable Objectives
Climate Change Status: Shorter winters, warmer average temperatures, more frequent heavy rain, snow and extreme heat events; increasing air and water temperatures and decreasing lake ice Management Challenge: • Extend global climate change models to Great Lakes regional and local scales and link to weather models to assist in planning and designing effective stormwater management facilities	No comparable Objectives

Great Lakes Binational Toxics Strategy (1997) provides the basis for many of the goals and actions in the Toxics and Areas of Concern focus area in the GLRI Action Plan

The Canada-United States Strategy for the Virtual Elimination of Persistent Toxic Substances in the Great Lakes Basin, known as the Great Lakes Binational Toxics Strategy (GLBTS or Toxics Strategy) provides a framework for actions to reduce or eliminate persistent toxic substances, especially those which

bioaccumulate, from the Great Lakes Basin. The Toxics Strategy[8] was developed jointly by Canada and the United States in 1996 and 1997 and was signed April 7, 1997. The Toxics Strategy establishes reduction challenges for an initial list of persistent toxic substances targeted for virtual elimination: aldrin/dieldrin, benzo(a)pyrene, chlordane, DDT, hexachlorobenzene, alkyl-lead, mercury and compounds, mirex, octachlorostyrene, PCBs, dioxins and furans, and toxaphene. These substances have been associated with widespread, long-term adverse effects on wildlife in the Great Lakes, and, through their bioaccumulation, are of concern for human health. This was the first time specific reduction targets have been set jointly by the two countries. Recognizing the long-term nature of virtual elimination, the Strategy provides the framework for actions to achieve quantifiable reduction "challenges" in the timeframe 1997 to 2006 for specific toxic substances. The development of baseline measurements for tracking and measuring progress toward reductions is also a key element of the Strategy. In recent years, the efforts under the Strategy have focused on identifying and addressing emerging chemical threats to the Great Lakes.

From the beginning, USEPA and Environment Canada have involved state, provincial, tribal, industrial, environmental, academia and other stakeholders, recognizing that the governments alone cannot achieve the goal of virtual elimination -- all parts of society must cooperate to ensure success. In implementing the Strategy, the two countries continue to build this vital partnership. The goal of virtual elimination will be achieved through a variety of programs and actions, but the primary emphasis will be on pollution prevention.

The substances selected for focus under the Toxics Strategy were based on their previous nomination to lists relevant to pollution of the Great Lakes and as a measure of further corroboration for their environmental impact, reference was made to the persistent organic pollutants (POPs) of concern identified in the United Nations Environment Programme Governing Council Decision 18/32 of May 1995, and incorporated into the Council of the Commission for Environmental Cooperation's *Sound Management of Chemicals* Agreement between the U.S., Canada, and Mexico (Resolution #95-5), October 1995.

The Toxics Strategy also recognizes the importance of out-of-basin sources and contaminated sediment and established joint challenge goals for these important contributors to Great Lakes pollution.

Table 3. Cross-walk between the goals of the GLBTS (1997) and the GLRI Action Plan (2010)

Great Lakes Binational Toxics Strategy (1997)	**Great Lakes Restoration Initiative Action Plan (2010)**
To accomplish the objective of restoring and maintaining the integrity of the Great Lakes, the Strategy seeks reiterates the principles identified in the Great Lakes Water Quality Agreement to reduce and virtually eliminate the input of persistent toxic substances to the Great Lakes. Virtual elimination will be sought within the most expedient time frame through the most appropriate, common sense, practical and cost-effective blend of voluntary, regulatory or incentive-based actions. All feasible options will be considered, including pollution prevention, phase-outs and bans.	Toxic Substances and Areas of Concern Goals • Areas of Concern are cleaned up, restoring the areas and removing the beneficial use impairments. • The release of toxic substances in toxic amounts is prevented and the release of any or all persistent toxic substances (PTS) to the Great Lakes basin ecosystem is virtually eliminated. • Exposure to toxic substances from historically contaminated sources is significantly reduced through source reduction and other exposure reduction methods. • Environmental levels of toxic chemicals are reduced to the point that all restrictions on the consumption of Great Lakes fish can be lifted. • The health and integrity of wildlife populations and habitat are protected from adverse chemical and biological effects associated with the presence of toxic substances in the Great Lake Basin.

[8] http://www.epa.gov/bns

The Aquatic Nuisance Species (ANS) Task Force and the Great Lakes Panel on Aquatic Nuisance Species provide the basis for many of the goals and actions in the Invasive Species focus area in the GLRI Action Plan

The Aquatic Nuisance Species (ANS) Task Force[9] is an intergovernmental organization dedicated to preventing and controlling aquatic nuisance species, and implementing the Nonindigenous Aquatic Nuisance Prevention and Control Act (NANPCA) of 1990. The various NANPCA mandates were expanded later with the passage of the National Invasive Species Act (NISA) in 1996. The Task Force consists of 13 Federal agency representatives and 12 Ex-officio members, and is co-chaired by the U.S. Fish and Wildlife Service and National Oceanic and Atmospheric Administration. The Task force coordinates governmental efforts dealing with ANS in the U.S. with those of the private sector and other North American interests via regional panels and issue specific committees and work group.

The Great Lakes Panel[10] was established in 1991 and focuses its efforts in three broad areas – Information/Education, Research Coordination, and Policy Coordination. Each focus area is supported through a committee comprised of Great Lakes Panel members with relevant interests and expertise. The Information/Education Committee facilitates the coordination of aquatic nuisance species (ANS) information/education (I/E) activities conducted in the Great Lakes region; builds partnerships between the various stakeholders involved in ANS I/E efforts; and promotes the development and delivery of consistent messages regarding ANS prevention and control. The Research Coordination Committee provides a forum for ongoing dialogue and action among the parties who conduct, manage, sponsor or apply Great Lakes-related ANS research; enhances inter-regional communication and coordination of ANS research; and develops, maintains and disseminates an ANS research inventory database and associated policy recommendations regarding ANS research priorities. The Policy Coordination Committee coordinates development and dissemination of Great Lakes Panel policy positions on key ANS issues; exchanges information on critical ANS policy issues; promotes development and implementation of state ANS management plans; and coordinates the Great Lakes Panel's involvement in regional policy-related initiatives addressing ANS prevention and control.

The Panel has a diverse membership representing state, provincial and federal government agencies from the U.S. and Canada, local communities, tribal authorities, commercial and recreational groups, NGOs, and academia. The Panel operates on a consensus basis in coordinating ANS prevention and control activities in areas of information/education, research coordination and policy.

Table 4. Cross-walk between the recommendations of the Great Lakes Panel on Aquatic Nuisance Species and the goals of the GLRI Action Plan

Great Lakes Panel on Aquatic Nuisance Species	Great Lakes Restoration Initiative Action Plan (2010)
The Great Lakes Panel focuses its efforts in three broad areas – Information/Education, Research Coordination, and Policy Coordination. The Panel has provided specific recommendations or position statements to **the national ANS Task Force including;** • Renegotiation of the Great Lakes Water Quality Agreement • Professional Responsibility for Reporting of Aquatic Invasive Species	Invasive Species Goals • The introduction of new invasive species to the Great Lakes basin ecosystem is eliminated, reflecting a "zero tolerance policy" toward invasives. • The risk of introduction of species, which are imported for various uses, into the Great Lakes is minimized. • The spread of invasive species, by means of recreational activities, connecting waterways, and other vectors, beyond their current range is prevented.

[9] http://www.anstaskforce.gov
[10] http://www.glc.org/ans/panel.html

• National Ballast Water Discharge Standard • Ballast Water Regulation • Screening Tools for Aquatic Invasive Species • State Aquatic Nuisance Species Management Plans • Population of the ANS Task Force Experts Database • Chicago Sanitary & Ship Canal Aquatic Nuisance Dispersal Barrier • Information and Education priorities	• A comprehensive program for detection and tracking newly identified invasive species in the Great Lakes is developed and provides up-to-date critical information needed by decision makers for evaluating potential rapid response actions. • An effective, efficient and environmentally sound program of integrated pest management for invasive species is developed and implemented, including program functions of containment, eradication, control and mitigation.

The Joint Strategic Plan for Management of Great Lakes Fisheries provides the basis for many of the goals and actions in the Invasive Species and Habitat and Wildlife Protection and Restoration focus areas in the GLRI Action Plan

The Great Lakes Fishery Commission was established by the Convention on Great Lakes Fisheries between Canada and the United States in 1955. The Commission has two major responsibilities:

- To develop coordinated programs of research on the Great Lakes, and, on the basis of the findings, to recommend measures which will permit the maximum sustained productivity of stocks of fish of common concern; and
- To formulate and implement a program to eradicate or minimize sea lamprey populations in the Great Lakes.

The Great Lakes Fishery Commission is made up of eight Commissioners (four appointed from each the United States and Canada) and one U.S. Alternate Commissioner. Commissioners of the United States are appointed by the President for six-year terms. Commissioners of Canada are appointed by the Privy Council and serve at the Council's pleasure.

Recommendations on needed actions and research to serve the Commission's major responsibilities are presented in the 1981 (revised in 1997) Joint Strategic Plan for Management of Great Lakes Fisheries[11]. It was signed by each of the state, provincial, federal, and tribal natural resource agencies in the Great Lakes basin. In this document, the Commission's individual lake committees were identified as the "major action arms for implementing the strategic plan and developing operational procedures." Since that time, the lake committees and the Council of Lake Committees have addressed a wide variety of issues critical to a healthy Great Lakes ecosystem. Their decisions have become part of the guiding frame-work for future fishery and environmental management in the basin. Decisions of the council are made by consensus. When consensus cannot be achieved, the concerns of all agencies are described in the council report to the commission.

[11] http://www.glfc.org/fishmgmt/jsp97.pdf

Table 5. Cross-walk between recommendations by the Great Lakes Fisheries Commissions Joint Strategic Plan (1997) and the goals of the GLRI Action Plan (2010)

Joint Strategic Plan for Management of Great Lakes Fisheries (1997)	Great Lakes Restoration Initiative Action Plan (2010)
Prevent invasion of non-native fishes • No non-native fishes will be unintentionally introduced in the Great Lakes.	Invasive Species Goals • The introduction of new invasive species to the Great Lakes basin ecosystem is eliminated, reflecting a "zero tolerance policy" toward invasives. • The risk of introduction of species, which are imported for various uses, into the Great Lakes is minimized. • The spread of invasive species, by means of recreational activities, connecting waterways, and other vectors, beyond their current range is prevented. • A comprehensive program for detection and tracking newly identified invasive species in the Great Lakes is developed and provides up-to-date critical information needed by decision makers for evaluating potential rapid response actions. • An effective, efficient and environmentally sound program of integrated pest management for invasive species is developed and implemented, including program functions of containment, eradication, control and mitigation.
The Commission shall encourage the rehabilitation and conservation of healthy aquatic ecosystems in the Great Lakes that provide sustainable benefits to society, contain predominately self-regulating fish communities, and support fisheries with increasing contributions of naturally reproducing fish. Conserving biological diversity through rehabilitation of native fish populations, species, communities, and their habitats has a high priority. 1. Conserve native biodiversity • Native fish species will not be lost from any Great Lake. • Rehabilitation plans will be formulated for extirpated deepwater fishes by 2004. • Rehabilitation of lake trout will be achieved throughout Lake Superior and in Lake Huron's Georgian Bay, and naturally reproduced juvenile lake trout will increase in abundance elsewhere in the Great Lakes. 2. Increase natural recruitment • Natural reproduction will contribute a minimum of 50% of adult trout and salmon available for harvest from each lake. 3. Improve habitat • Promote the development and use of complementary approaches for assessing gains and losses of Great Lakes habitat. • Assess potential for "aquatic protected areas" to contribute to rehabilitation of native deep-water species and identify potential information needs that must be met prior to their effective implementation. 4. Gain new information • assesses causes of change in Great Lakes fish communities, • identifies the degree to which diseases have influenced fish populations, and • establishes a forum for intercontinental exchange of information on issues affecting large lakes. Lake specific fish community objectives are available at http://www.glfc.org/lakecom/	Habitat and Wildlife Protection and Restoration Goals • Protection and restoration of Great Lakes aquatic and terrestrial habitats, including physical, chemical, and biological processes and ecosystem functions, maintain or improve the conditions of native fish and wildlife. • Critical management activities (such as stocking native fish and other aquatic species, restoring access of migratory fish species at fish passage barriers, and identifying and addressing diseases) protect and conserve important fish and wildlife populations. • Sound decision making is facilitated by accessible, site specific and landscape-scale baseline status and trend information about fish and wildlife resources and their habitats. • High priority actions identified in strategic plans (such as state and federal species management, restoration and recovery plans, Lakewide Management Plans, Remedial Action Plans, and others) are implemented, lead to the achievement of plan goals, and reduce the loss of fish and wildlife and their habitats. • Development activities are planned and implemented in ways that are sensitive to environmental considerations and compatible with fish and wildlife and their habitats.

IV. Review and Oversight of the Great Lakes Restoration Initiative

The Great Lakes Restoration Initiative (GLRI) provides an unprecedented opportunity to restore and protect the Great Lakes. Along with this opportunity comes a responsibility to ensure that the best available science is used to prioritize and implement actions, as well as track progress. The Action Plan identifies the primary components that EPA and its federal partners will use to provide review and oversight of the GLRI-efforts including competitive funding programs, reporting mechanisms, the Great Lakes Accountability System (GLAS), and an independent scientific panel's review of the scientifically credibility of the Plan itself. The Action Plan is an adaptive management document. Based on overall progress toward attaining the goals and objectives, EPA and its Federal partners will adapt and modify activities in future years. The Action Plan can also be revised based on the input of this SAB panel.

Competitive Funding and Review Panels

The Action Plan outlines general guidance for funding and grant cycles (see pages 14-16 of the Action Plan).

In FY2010, EPA managed a $120 million Request for Proposals (RFP) covering 35 programs. The Request for Proposals was discussed with some 1200 participants during webinars on December 9 and December 16, 2009. By the due date of January 29, 2010, applicants had submitted approximately 1,050 proposals totaling over $942 million. Each proposal was assigned three or more reviewers who received access to their proposals via the Great Lakes Restoration Initiative proposal review database, which is a secure, password protected website. Each reviewer also received the RFP and review instructions. Conflict of interest statements were included with each proposal file and required the assurance of each reviewer. Each panelist was found to be impartial and could perform an independent assessment of the qualifications of the organizations that submitted proposals. EPA funded 286 assistance agreements for about $163 million in FY2010 to support the goals of the GLRI Action Plan.

In FY2010, EPA also provided our federal partners about $255 million through Interagency Agreements to direct the work of the agencies to supplement and enhance their Great Lakes restoration activities. Much of these resources were competitively funded through grants to non-federal organizations.

Reporting Mechanisms

All recipients of GLRI funds are required to provide routine progress reports on their individual projects as well as progress toward the goals, objectives, and measures of the Action Plan. Routine reporting occurs through both semi-annual progress reports submitted directly to EPA and quarterly reports entered into the Great Lakes Accountability System (GLAS) database. All recipients are also required to submit a final project report that incorporates the project's outputs and summarizes the nature and extent of the project, methodologies employed, significant event and experiences, conclusions, recommendations, and a compilation of the data collected.

These reporting tools will be used by EPA and the other federal agencies to report on the overall progress toward attaining the ecosystem goals and objectives of the Action Plan. EPA, in coordination with the IATF, is required by the 2010 Appropriation Conference Report[12] to submit an annual report to

[12] From 2010 Appropriations Conference Report, 111-316: "Beginning in 2011 and each year thereafter, the Agency is directed to provide detailed yearly program accomplishments and compare specific funding levels allocated for participating agencies from fiscal year to fiscal year.

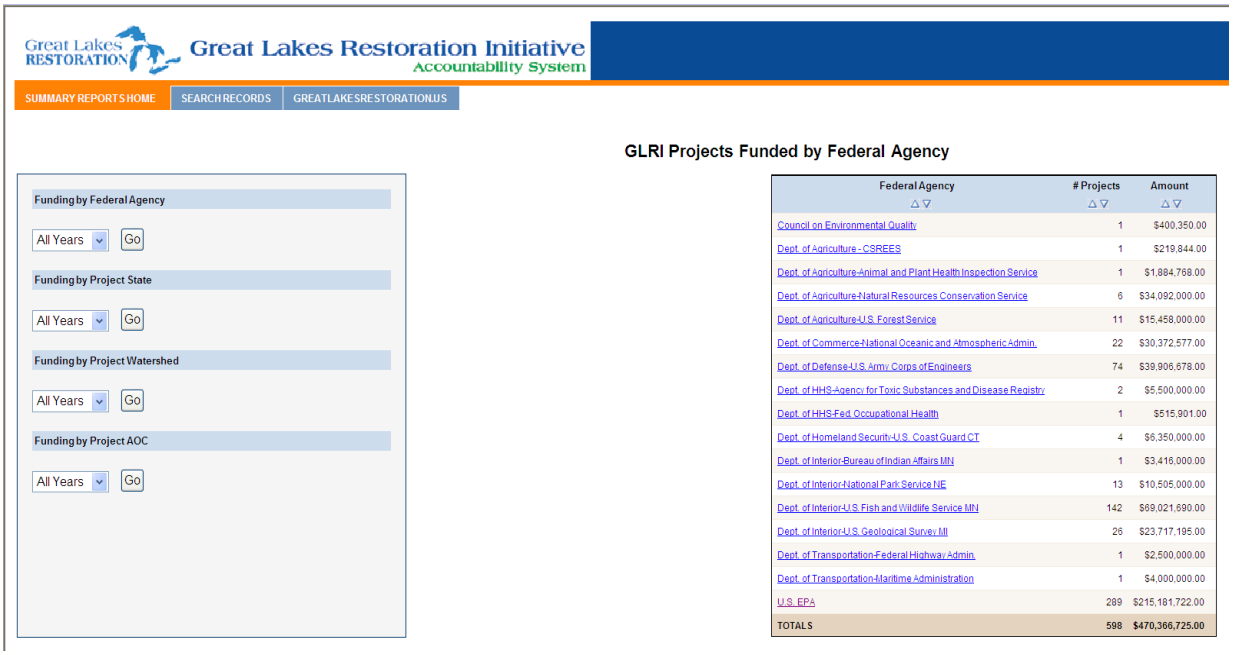
Congress detailing the yearly program accomplishments and funding levels allocate to participating agencies. The GLRI Action Plan also directs EPA and the rest of the IATF to provide an Annual Report to the President on accomplishments in achieving the Action Plan's objectives and measures.

EPA will work with the IATF to adapt and modify restoration efforts in future years based on reported accomplishments, progress in achieving the measures in the Action Plan, and newly identified needs. The Science Advisory Board (SAB) review is a critical component of this adaptive management process.

Great Lakes Accountability System (GLAS)

EPA developed and operates the Great Lakes Accountability System (GLAS) as the primary mechanism for collecting information to monitor and report on the progress of restoration efforts under the GLRI. The GLAS is a web-based reporting system transparently providing accountability to the public and to Congress for how GLRI funds are being used to restore the Great Lakes. All recipients of GLRI funding are required to provide information into GLAS to meet their quarterly reporting obligations. The GLAS system currently includes program and project information including project location, environmental progress and results, and additional project data. As GLAS evolves, it will be able to show the link between each project and the Goals, Objectives, Actions and Measures of Progress, outlined in the GLRI Action Plan, and document progress. The following picture is a screenshot of the searchable GLAS database[13].

Figure 1. Screen shot of the Great Lakes Accountability System database.



Federal Agency	# Projects	Amount
Council on Environmental Quality	1	$400,350.00
Dept. of Agriculture - CSREES	1	$219,844.00
Dept. of Agriculture-Animal and Plant Health Inspection Service	1	$1,884,768.00
Dept. of Agriculture-Natural Resources Conservation Service	6	$34,092,000.00
Dept. of Agriculture-U.S. Forest Service	11	$15,458,000.00
Dept. of Commerce-National Oceanic and Atmospheric Admin.	22	$30,372,577.00
Dept. of Defense-U.S. Army Corps of Engineers	74	$39,906,678.00
Dept. of HHS-Agency for Toxic Substances and Disease Registry	2	$5,500,000.00
Dept. of HHS-Fed. Occupational Health	1	$515,901.00
Dept. of Homeland Security-U.S. Coast Guard CT	4	$6,350,000.00
Dept. of Interior-Bureau of Indian Affairs MN	1	$3,416,000.00
Dept. of Interior-National Park Service NE	13	$10,505,000.00
Dept. of Interior-U.S. Fish and Wildlife Service MN	142	$69,021,690.00
Dept. of Interior-U.S. Geological Survey MI	26	$23,717,195.00
Dept. of Transportation-Federal Highway Admin.	1	$2,500,000.00
Dept. of Transportation-Maritime Administration	1	$4,000,000.00
U.S. EPA	289	$215,181,722.00
TOTALS	598	$470,366,725.00

Tracking Measures of Progress

To ensure that the progress of the GLRI is effectively monitored and reported, the GLRI Action Plan contains a set of 28 measures of progress to ensure efforts are on track for implementing long-term

[13] http://greatlakesrestoration.us/projects.html

goals. Some of the measures are existing measures under the Government Performance Results Act (GPRA)[14] for EPA and the other Federal Agencies. The other measures were developed for the GLRI Action Plan. EPA is using 15 of the GLRI Action Plan measures in its FY2012 National Water Program Guidance[15].

V. Science Advisory Board Review of the GLRI Action Plan

Science is the foundation that supports EPA activities, and consistent, Agency-wide implementation of independent peer review has been a priority for many years. The GLRI is no exception to this. Science will guide the Great Lakes Restoration Initiative (GLRI) efforts at multiple scales – Great Lakes basin-wide, Lake-specific, and locally at Areas of Concern. While the Action Plan draws upon many of the ecological goals and objectives of pre-existing plans and programs described above, the GLRI will use the best available science to prioritize and implement actions, as well as to track progress.

Directive for Review of the GLRI Action Plan

The Congressional Conference Report accompanying H.R. 2996[16] further specifies the need for EPA to "engage an independent, scientific panel to review the scientific credibility of the plan to optimize the likelihood of successful restoration at appropriate scales."

The following sections provide an overview of the scientific analyses of the environmental problems in the Great Lakes ecosystem that are being addressed by the Great Lakes Restoration Initiative.

Problem Overview: Toxic Substances and Areas of Concern

The priority goals and objectives for toxic substances and areas of concern within the GLRI Action Plan originated from a number of efforts within the Great Lakes scientific and ecosystem management community to identify and diagnose the ongoing problems associated with toxic substances. Over the years, these efforts have focused on “legacy contamination” – pollution left over from past practices, but that continues to re-circulate and remain a public health threat. In recent years, the Great Lakes scientific community has been active in attempting to better understand the significance of chemicals of emerging concern in the Great Lakes.

The Great Lakes Binational Toxics Strategy (GLBTS) and the State of the Lakes Ecosystem Conference (SOLEC) are the primary fora for reporting on the status and trends of toxics substances the health and integrity of the Great Lakes. The most recent SOLEC report[17] on the 2008 assessment included a summary of the condition of contamination and human health. All lakes were rated as mixed (both good and degraded features) and noted that not all data were available to assess the ecosystem over

---

[14] The 1993 Government Performance and Results Act (GPRA) holds federal agencies accountable for using resources wisely and achieving program results. GPRA requires agencies to develop plans for what they intend to accomplish, measure how well they are doing, make appropriate decisions based on the information they have gathered, and communicate information about their performance to Congress and to the public.

[15] The *National Water Program Guidance (Guidance)* for fiscal year (FY) 2012 describes how the Environmental Protection Agency (EPA), states, territories, and tribal governments will work together to protect and improve the quality of the nation’s waters, including wetlands, and ensuring safe drinking water. Within EPA, the Office of Water oversees the delivery of the national water programs, while the regional offices work with states, tribes, territories, and others to implement these programs and other supporting efforts. http://www.epa.gov/planandbudget/annualplan/FY12_OW_NPM_Gdnce.pdf

[16] Public Law 111-88, the Department of the Interior, Environment, and Related Agencies Appropriations Act, 2010.

[17] State of the Great Lakes 2009, http://www.epa.gov/solec/sogl2009/sogl2009complete.pdf

time, so overall trends could not be identified. The report noted that since the 1970s, concentrations of historically-regulated contaminants such as polychlorinated biphenyls (PCBs), dichloro-diphenyl-trichloroethane (DDT) and mercury have generally declined in most Great Lakes media including fish, herring gull eggs, and air. However, the rate of decline is slowing. In some cases, concentrations are beginning to increase again (e.g. some fish species). The assessment for contamination is based on a number of individual indicator reports for contamination in biota and contamination in different media. The indicators for contamination in biota including "contamination in whole fish[18]", "contamination in colonial nesting waterbirds[19]", and "contamination in young-of-the-year spottail shiners[20]" rely on long-standing monitoring programs in the Great Lakes. Although these metrics generally show an "improving" trend, they were rated "mixed" for presence of some contaminants above health criteria or guidelines. Similarly, the indicators for contamination in media including "atmospheric deposition of toxic chemicals"[21], "toxic chemical concentrations in offshore waters", and "concentrations of contaminants in sediment cores" also rely on long-standing monitoring programs. These metrics also generally show an "improving" trend, but were rated "mixed" due to the hot spots and the presence of chemicals of emerging concern. The 2009 SOLEC report also indicated that human health was rated "mixed" with an undetermined trend. Concentrations of "legacy" contaminants continue to decrease in sport fish in most lakes; although Lakes Erie and Superior show an unchanging trend. The other metrics including "Biological Markers of Human Exposure to Persistent Chemicals" and "Drinking Water Quality" were not assessed.

Over the past 12 years, the Great Lakes Binational Toxics Strategy (GLBTS) has proven to be a valuable forum, not only for bringing stakeholders together to achieve the Strategy's goals, but also for providing opportunities for the governments of Canada and the US to openly share ideas with a diverse group of stakeholders. The forum has fostered new approaches to toxics prevention, such as green chemistry, and has led to collaborative efforts to restore and protect the Great Lakes from persistent toxic substances. Fourteen of the original 17 challenge goals have been met, and significant progress has been made on the remaining three. Over the past few years, the GLBTS focused attention on chemicals of emerging concern in the Great Lakes environment. These include human and veterinary pharmaceuticals, personal care products, flame retardants, endocrine disrupting chemicals, and other industrial chemicals. The Integration Workgroup has kept apprised of actions being taken to address emerging chemicals by Canadian and US Chemical Management Programs. Great Lakes monitoring programs indicate that chemicals of emerging concern are present in the Great Lakes aquatic ecosystem. However, a lack of effects data on the ecological impact of these chemicals represents an obstacle to fully assessing threats to human health and the environment. In response, the GLBTS has begun to develop a comprehensive strategy for evaluating the biological impact of toxic substances.

The GLBTS 2008-2009 Progress Report[22] also provides another forum for Great Lakes researchers to report the results of monitoring and surveillance efforts in the Great Lakes region. Every 2-3 years the GLBTS presents monitoring data for environmental indicators in the air over the Great Lakes and in Great Lakes fish, herring gull eggs, bivalves (mussels), sediment, and surface waters. Trends in atmospheric concentrations are described by ambient air monitoring data collected by the Integrated Atmospheric Deposition Network and the National Air Pollution Surveillance (NAPS) network. Levels in fish tissue are illustrated by data collected from Canada's Great Lakes Fish Contaminant Surveillance

[18] Great Lakes Fish Monitoring and Surveillance Program, http://epa.gov/greatlakes/monitoring/fish/index.html
[19] Great Lakes Herring Gull Monitoring Program
[20] Environment Canada Great Lakes Fish Surveillance Programs, http://www.ec.gc.ca/grandslacs-greatlakes/default.asp?lang=En&n=386031A0-1
[21] Integrated Atmospheric Deposition Network, http://epa.gov/greatlakes/monitoring/air2/index.html
[22] http://epa.gov/greatlakes/bns/reports/2009/2009GLBTSrpt.pdf

Program and US EPA's Great Lakes Fish Monitoring Program. The status of toxic substances in Great Lakes herring gull eggs is described by data collected and analyzed by the Canadian Wildlife Service. The NOAA Mussel Watch Program provides monitoring data with which to track trends of legacy substances and emerging contaminants of concern. Spatial and temporal trends in Great Lakes sediment are described by data collected from various water and sediment contaminant monitoring programs operating in the Great Lakes. Similar to the State of the Lakes Report 2009, the GLBTS 2008-2009 Progress Report found that concentrations of "legacy" contaminants are generally declining in all media albeit slowly and chemicals of emerging concern are being found in all media.

The Great Lakes Regional Collaboration Strategy, developed by scientific experts and endorsed by the Great Lakes Governors, the Great Lakes Mayors, the Tribal Caucus, and the Great Lakes Congressional Delegation in 2005, included priority environmental concerns about toxic pollutants and Areas of Concern/sediments. The Strategy goals and milestones are grounded in the environmental findings presented in SOLEC and the GLBTS. The Strategy concluded that "while certain persistent toxic substances (PTS) have been significantly reduced in the Great Lakes Basin Ecosystem over the past 30 years, they continue to be present at levels that pose threats to human and wildlife health, warrant fish consumption advisories in all five lakes, and disrupt a way of life for many in the basin, particularly the life ways and culture of tribal communities. PTS releases from contaminated bottom sediments, various industrial processes, and non-point sources, loadings from atmospheric deposition, contaminated groundwater, and continuous cycling of PTS within the Great Lakes themselves, all contribute to this ongoing problem. More recently, researchers have documented the presence of additional chemicals of emerging concern that may also pose threats to the Great Lakes. Characteristics of these substances, such as sources, releases, fate, transport, persistence, bioaccumulation, and toxicity, must be better understood."

The Strategy similarly concluded that much remains to be done about the remediation of contaminated sediments in the U.S. Areas of Concern (AOCs)[23]. Great Lakes Areas of Concern (AOCs) are severely degraded geographic areas within the Great Lakes Basin. They are defined by the U.S.-Canada Great Lakes Water Quality Agreement[24] (Annex 2 of the 1987 Protocol) as "geographic areas that fail to meet the general or specific objectives of the agreement where such failure has caused or is likely to cause impairment of beneficial use of the area's ability to support aquatic life." The U.S. and Canadian governments originally identified 43 such areas; 26 in U.S. waters, 17 in Canadian water (five are shared between U.S. and Canada on connecting river systems). Four AOCs (three in Canada and one in the U.S.) have been formally delisted. The U.S. Policy Committee developed delisting principles and guidelines[25] that defined delisting as the implementation of all recommended actions for restoring beneficial uses are completed, and as the uses are restored and maintained. The critical test for any such process and associated criteria is to insure that it is rigorous, scientifically defensible, and allows for full review and comment from interested and affected stakeholders. The guidelines were drafted by a workgroup comprised of representatives from the eight Great Lakes states and other U.S. federal agencies, with observers from the Canadian federal and provincial agencies and the International Joint Commission (IJC).

Remedial Action Plans (RAPs)[26] for Great Lakes Areas of Concern (AOCs) are developed and implemented through an ecosystem-based, multi-media approach for assessing and remediating

[23] http://epa.gov/greatlakes/aoc/index.html
[24] http://epa.gov/greatlakes/glwqa/index.html
[25] Restoring United States Areas of Concern: Delisting Principles and Guidelines, http://www.epa.gov/glnpo/aoc/rapdelistingfinal02.PDF
[26] http://epa.gov/greatlakes/aoc/rap.html

impaired uses. RAPs are perhaps the best example of community-based environmental protection in existence. Through a blend of public and private agencies and organizations, the RAPs continue to be a catalyst to advance the watershed approach for ecosystem remediation and restoration, and they continue to make progress towards the restoration and protection of the all of the remaining Great Lakes AOCs. A RAP is developed in three stages: Stage I identifies and assesses use impairments, and identifies the sources of the stresses from all media in the AOC; Stage II identifies proposed remedial actions and their method of implementation; and Stage III documents evidence that uses have been restored. It is important to note that, in practice, these stages often overlap, and that the RAPs often become iterative documents, representing the current state of knowledge, planning and remedial activity in the AOC.

Contaminated sediments are linked to impairments in all U.S. AOCs. In January 2005, the U.S. Policy Committee for the Great Lakes identified 75 remaining sites in the AOCs with a total estimated volume of nearly 75 million cubic yards of contaminated sediments. The Strategy identified three primary barriers to achieving further progress in restoring the AOCs: 1) optimizing program administration and effectiveness; 2) addressing contaminated sediments (including disposal and destruction technology issues); and, 3) establishing final restoration targets to facilitate "delisting" of AOCs – formally removing them from the list of designated Areas of Concern in the Great Lakes. To address these barriers, the Strategy recommends that Federal and State agencies better coordinate efforts and build and maintain capacity among partners involved in AOC restoration.

The Great Lakes Legacy Act[27] of 2002 is part of a larger strategy to provide a healthy, natural Great Lakes environment for swimming and fishing as well as a source of clean water for drinking and industrial uses. Although discharges of toxic chemicals to the Great Lakes have been reduced in the last 30 years, high concentrations of contaminants persist in the sediment of some rivers, harbors and bays as a "legacy" of North America's industrialization. The Act provides funding to take the necessary steps to clean up contaminated sediment in "Areas of Concern located wholly or partially in the United States," including specific funding designated for public outreach and research components. The Great Lakes Legacy Act was reauthorized by Congress and signed into law on October 8, 2008. The Act reauthorizes the U.S. EPA GLNPO for two more years at level funding. The new legislation allows GLNPO to continue to move forward with sediment cleanups in the Great Lakes Areas of Concern.

As of 2010, 17 cleanup projects have been largely completed or are underway. More than 1,220,000 cubic yards of sediment have been remediated. The key to the success of these projects has been the strong partnerships that have developed between EPA and other federal, state, local and private entities. The seven completed GLLA projects have been the springboard for Great Lakes communities to turn areas that were once a detriment to economic growth and a healthy environment into a new asset for their cities and watersheds. These cleanups are turning contaminated waterways into rejuvenated fish and native plant habitats, and neighboring properties are becoming sites of economic growth, including marina construction. Biking and hiking trails along with fishing piers are planned for areas that used to be marked with contamination warning signs.

The scientific community has been active in prioritizing and identifying chemicals of emerging concern in the Great Lakes ecosystem. In 2006, Muir and Howard published the seminal paper "Are There Other Persistent Organic Pollutants? A Challenge to Environmental Chemists". Muir and Howard postulated that there are "widely used substances that are predicted to meet screening criteria as P&B and LRAT

[27] http://www.epa.gov/grtlakes/sediment/legacy/index.html

chemicals but that are not currently analyzed in environmental matrices." Muir and Howard further stated that recent advancements in analytical approaches should allow for measurements of these chemicals in environmental matrices. The publication of this list spurned a large number of efforts to identify the presence of chemicals of emerging concern in the Great Lakes and across the world (Gauthier et al. 2009, Venier and Hites 2008, Gouteux et al. 2008, Stapleton et al. 2008, Tomy et al. 2008). In 2010, Howard and Muir published a follow-up paper refining and expanding their initial list of new persistent and bioaccumulative organics among chemicals in commerce. A total of 610 chemicals were identified as potential P&B chemicals out of the 22,263 chemicals in commerce. Out of the 610 potential P&B chemicals, Howard and Muir further prioritized the list into high priority chemicals for each chemical group (brominated, chlorinated, fluorinated, silicone and other). These high priority chemicals and other chemicals on the list of 610 are now being assessed by most of the Great Lakes monitoring programs.

In 2007, the International Joint Commission[28] (IJC) charged a multi-Board Work Group on the Priority of Chemicals of Emerging Concern with reviewing the scientific and policy aspects related to identification, impact, and management of chemicals of emerging concern in the Great Lakes (IJC 2009). The Work Group reviewed the body of current scientific knowledge on chemicals of emerging concern specific to the Great Lakes watershed and the policy and management regimes in Canada and the U.S. The consultation included scientists and other experts from governments, industry, and academia. The findings from this review included:

- There has been an increasing shift in focus from industrial point sources to dispersed, non-point releases of chemicals and substances, such as those in consumer products and pharmaceuticals that may require new analyses and approaches, including risk management approaches.
- Our ability to detect chemicals in environmental media surpasses our ability to understand the implications of such findings.
- There has been limited surveillance for many chemicals of emerging concern in the Great Lakes.
- There are significant scientific gaps in our ability to interpret environmental monitoring data, including a lack of understanding of mixtures and cumulative exposures, information on sources, information on uses and life cycles of products and a lack of regulatory criteria.
- There are voluntary stewardship initiatives in place on both sides of the border that address some of the chemicals of emerging concern.
- Chemical-by-chemical analyses of chemicals of emerging concern in Great Lakes biota does not by itself constitute a sufficient basis to assess toxicant stress in the Great Lakes ecosystem.

The recommendations from this review include:

- There should be enhanced binational communication, coordination, and cooperation on the design and implementation of monitoring programs for chemicals of emerging concern.
- Appropriate tools should be developed in order to adequately assess the exposures and impacts of chemicals of emerging concern.
- New policies need to be developed to manage chemicals of emerging concern in the Great Lakes with new and innovative approaches that continue to use sound scientific methods and principles.
- Consumer education should be conducted and incentives should be provided to encourage conservation and consumer choices that can help drive changes in consumer products and create marketplace incentives for manufacturers.

[28] http://www.ijc.org/

- Further emphasis should be placed on gaining knowledge and understanding of human health effects as they pertain to the major categories of chemicals of emerging concern.

Toxic Substances and Areas of Concern Goals, Objectives, Measures and Actions in the Great Lakes Restoration Initiative Action Plan

Building on the environmental problems that have been highlighted through state-of-the-lakes efforts, in the scientific literature and in the science-based strategies in recent years, authors of the GLRI Action Plan incorporated issues associated with toxic substances and Areas of Concern as a focus area. The goals and objectives are consistent with the issues that were raised by these efforts. Thus, the goals for toxic substances and Areas of Concern included:

- Areas of Concern are cleaned up, restoring the areas and removing the beneficial use impairments.
- The release of toxic substances in toxic amounts is prevented and the release of any or all persistent toxic substances (PTS) to the Great Lakes basin ecosystem is virtually eliminated.
- Exposure to toxic substances from historically contaminated sources is significantly reduced through source reduction and other exposure reduction methods.
- Environmental levels of toxic chemicals are reduced to the point that all restrictions on the consumption of Great Lakes fish can be lifted.
- The health and integrity of wildlife populations and habitat are protected from adverse chemical and biological effects associated with the presence of toxic substances in the Great Lakes Basin.

The GLRI Action Plan also incorporated specific objectives and actions for addressing the goals and measures to gage progress. Table 6 provides a summary.

Table 6. GLRI Action Plan Goals, Objectives, Actions and Measures associated with Toxic Substances and Areas of Concern

Great Lakes Restoration Initiative Action Plan (2010) Goals	GLRI Action Plan Objectives	GLRI Action Plan Actions	GLRI Action Plan Measures (see Action Plan for details)
Toxic Substances and Areas of Concern Goals: • Areas of Concern are cleaned up, restoring the areas and removing the beneficial use impairments. • The release of toxic substances in toxic amounts is prevented and the release of any or all persistent toxic substances (PTS) to the Great Lakes basin ecosystem is virtually eliminated. • Exposure to toxic substances from historically contaminated sources is significantly reduced through source reduction and other exposure reduction methods. • Environmental levels of toxic chemicals are reduced to the point that all restrictions on the consumption of Great Lakes fish can be lifted. • The health and integrity of wildlife populations and habitat are protected from adverse chemical and biological effects associated with the presence of toxic substances in the Great Lake Basin.	Toxic Substances and Areas of Concern Objectives: • By 2014, delist five Areas of Concern. • By 2014, 46 Beneficial Use Impairments (BUIs) will be removed in Areas of Concern. • By 2011, 15 million pounds of electronic waste and 15 million pills of unwanted medicine will be collected or their release will have been prevented. • By 2014, 45 million pounds of e-waste, 45 million pills of unwanted medicines, and 4.5 million pounds of household hazardous waste in the Great Lakes basin will have been collected or their release will have been prevented. • By 2014, 9.4 million cubic yards of contaminated sediments will be remediated. • Through 2014, an annual average of up to 5% annual decline will be maintained or improved for the trend (year 2000 and on) in average concentrations of PCBs in whole lake trout and walleye samples.	Toxic Substances and Areas of Concern Actions: Restore Areas of Concern / Remediate Contaminated Sediments Strategic Pollution Prevention and Reduction Projects Protect Human Health through Safer Fish Consumption Measuring Progress and Assessing New Toxic Threats	Measures of Progress: Number of Areas of Concern in the Great Lakes where all management actions necessary for delisting have been implemented AOC BUIs removed BUI delisting project starts at Areas of Concern Cubin Yards (in millions) of contaminated sediment remediated in the Great Lakes Pollution (in pounds) collected through prevention and waste minimization projects in the Great Lakes basin Cumulative percentage decline for the long term trend in average concentrations of PCBs in Great Lakes fish

Citations

Environment Canada and U. S. Environmental Protection Agency. 2009. State of the Great Lakes 2009. http://www.epa.gov/glnpo/solec.

Great Lakes Regional Collaboration Strategy to Restore and Protect the Great Lakes. 2005. http://www.glrc.us/.

Muir, D.C.G. and Howard, P.H. 2006. Are there other persistent organic pollutants? A challenge to environmental chemists. *Environmental Science & Technology* 40(23): 7157-7166.

Howard, P.H. and Muir, D.C.G. 2010. Identifying new persistent and bioaccumulative organics among chemicals in commerce. *Environmental Science & Technology* 44(7): 2277-2285.

Venier, M.; Hites, R.A. 2008. Flame retardants in the atmosphere near the Great Lakes. *Environmental Science & Technology* 42, 4745-4751.

Stapleton, H. M.; Allen, J. G.; Kelly, S. M.; Konstantinov, A.; Klosterhaus, S.; Watkins, D.; McClean, M. D.; Webster, T. F. Alternate and new brominated flame retardants detected in U.S. house dust *Environ. Sci. Technol.* **2008**, 42, 6910– 6916

Tomy, G. T.; Pleskach, K.; Arsenault, G.; Potter, D.; McCrindle, R.; Marvin, C. H.; Sverko, E.; Tittlemier, S. Identification of the novel cycloaliphatic brominated flame retardant 1,2-dibromo-4-(1,2-dibromoethyl)cyclohexane in Canadian Arctic Beluga (*Delphinapterus leucas*) *Environ. Sci. Technol.* **2008**, 42, 543– 549

Gauthier, L. T.; Potter, D.; Hebert, C. E.; Letcher, R. J. Temporal trends and spatial distribution of non-polybrominated diphenyl ether flame retardants in the eggs of colonial populations of Great Lakes herring gulls *Environ. Sci. Technol.* **2009**, 43, 312– 317

Gouteux, B.; Alaee, M.; Mabury, S.; Pacepavicius, G.; Muir, D. Brominated flame retardant polymers: A possible source for emerging brominated aromatic compounds in the environment *Environ. Sci. Technol.* **2008**, 42, 9039– 9044

Great Lakes Chemicals of Emerging Concern Advisory Work Group to the International Joint Commission (IJC), 2009. Great Lakes Water Quality Agreement Priorities 2007-09 Series. Work Group Report on Great Lakes Chemicals of Emerging Concern, 2009. IJC, Special Publication 2009-01, Windsor, Ontario, Canada. http://www.ijc.org/en/priorities/2009/chemicals

Problem Overview: Invasive Species

The priority goals and objectives for invasive species within the GLRI Action Plan originated from a number of efforts within the Great Lakes scientific and ecosystem management community to identify and diagnose the ongoing problems associated with invasive species. In recent years, the Great Lakes scientific community has been active in attempting to understand better assess the importance vectors of invasive species, innovative control technology, and early warning signals to potential invasions.

SOLEC – the State of the Lakes Ecosystem Conference – is the primary forum for reporting on the status and trends of the health and integrity of the Great Lakes. The most recent SOLEC report[29], summarizing the 2008 assessment, included a summary of the condition of invasive species. The condition was "poor" with a "deteriorating" trend. New non-native species, now totaling 185 aquatic and at least 157 terrestrial species, continue to be discovered in the Great Lakes. Each new non-native species can interact with the ecosystem in unpredictable ways, with at least 10 percent of non-native species considered to be invasive, meaning that they negatively impact ecosystem health. The presence of invasive species can be linked to many current ecosystem challenges including the decline in the lower food web's *Diporeia* populations, fish and waterfowl diseases, and excessive algal growth. Shipping continues to be a major concern for introductions and spread of invasive species. However, the roles of canals, online purchase of aquatic plants, and the aquarium and fish-bait industries are receiving increasing attention. SOLEC's invasive species assessment relies on 3 detailed indicator assessments: non-native species – aquatic; non-native species terrestrial; and sea lamprey.

The non-native species - aquatic indicator is rated as "poor" with a deteriorating trend. Nonindigenous species (NIS) continue to be discovered in the Great Lakes. Negative impacts of established invaders persist and new negative impacts, including synergistic disruptions, are becoming evident. *Diporeia*, the dominant benthic macroinvertebrate in offshore waters of the Great Lakes, populations continue to decline dramatically with the expansion of dreissenid mussles. An introduced virus, Viral Hemorrhagic Septicemia (VHS) has caused mass die-offs of fish. Researchers are seeking to better understand links between vectors and donor regions, the receptivity of the Great Lakes ecosystem, and the biology of new invaders in order to make recommendations to reduce the risk of future invasion. To protect the biological integrity of the Great Lakes, it is essential to closely monitor routes of entry for NIS, to introduce effective safeguards, and to quickly adjust safeguards as needed. The rate of invasion may increase if positive interactions involving established NIS or native species facilitate the establishment of new NIS. Ricciardi (2001) suggested that such a scenario of "invasional meltdown" is occurring in the Great Lakes, although Simberloff (2006) cautioned that most of these cases have not been proven. Moreover, each new invader can interact in unpredictable ways with previously established invaders, potentially creating synergistic impacts (Ricciardi 2001, 2005). For example, recurring outbreaks of avian botulism in the lower Great Lakes are thought to result from the effects of dreissenid mussels and round gobies, in which the mussels create environmental conditions that promote the pathogenic bacterium and the gobies transfer bacterial toxin from the mussels to higher levels of the food web.

The non-native species – terrestrial indicator is rated as "Not Assessed" with an undetermined trend. Terrestrial non-indigenous species (NIS) are pervasive in the Great Lakes basin. Although not all introductions have an adverse effect on native habitats, those that do, pose a considerable ecological, social, and economic burden. Historically, the Great Lakes basin has proven to be particularly vulnerable to NIS, mainly due to population, industrialization, and the high volume of transboundary movement of

[29] State of the Great Lakes 2009, http://www.epa.gov/solec/sogl2009/sogl2009complete.pdf

goods and people. Data are disorganized, inhibiting an adequate assessment of the status, trends, and impacts of NIS in the region. In the United States, many organizations and activities have emerged in recent years to address invasive species issues. Their activities are numerous, but focus on four major areas: prevention (according to the National Invasive Species Council Management Plan (NISC 2001), the first line of defense against invasive species is to prevent them from becoming established); early detection and rapid response programs (which work in coordination with state and local efforts "to eradicate or contain invasive species before they became too widespread and control becomes technically and/or financially impossible"); ranking systems (which are designed to assess the relative threat posed by each invasive species in order to prioritize policy, management and education efforts); and regional or state plant councils (which include the NISC, Midwest Invasive Plant Network, Indiana Invasive Plant Species Assessment Working Group, Michigan Invasive Plant Council, Minnesota Invasive Species Advisory Council, Ohio Invasive Plants Council, Wisconsin Council on Invasive Species, and the Invasive Plants Association of Wisconsin).

The sea lamprey indicator is rated as "fair" with a mixed trend. The sea lamprey is a non-native species and a lethal parasite of the larger fishes in the Great Lakes (Bergstedt and Schneider 1988, Kitchell 1990), and has caused ecological and economic tragedy in terms of their impact on the Great Lakes fish communities (Smith and Tibbles 1980). The first complete round of stream treatments with the lampricide TFM (as early as 1960 in Lake Superior) successfully suppressed sea lamprey populations to less than 10% of pre-control abundance in all of the Great Lakes. Never-the-less, the sea lamprey continues to be a significant source of mortality for larger fish (Bergstedt and Schneider 1988, Kitchell 1990) and a road block to achieving critical fishery objectives. Sea lamprey abundances are above target ranges in all lakes except Lake Ontario. The trends are improving in Lake Superior, unchanging in Lakes Huron, Erie, and Ontario, and deteriorating in Lake Michigan. As fish communities recover from the effects of sea lamprey predation, there is evidence that sea lamprey populations will benefit from the increase in prey availability. Facilitated through what are called compensatory mechanisms, more sea lampreys may survive due to the increase in prey availability, thus precipitating an increase in reproductive potential and recruitment (i.e. more sea lampreys may be available to prey on fish). Continuing the search for new or unidentified sources of sea lampreys is critical for sea lamprey control, especially as fish communities recover, water quality improves and dams are removed as part of ecosystem restoration. The Great Lakes Fisheries Commission[30] has a goal of reducing reliance on lampricides and increasing efforts to integrate other control techniques, such as the sterile-male-release technique or the installation of barriers to stop the upstream migration of adults. Pheromones that affect migration and mating have been discovered and offer exciting potential as new alternative controls. The use of alternative controls is consistent with sound practices of integrated pest management, but can put additional pressures on the ecosystem such as limiting the passage of fish upstream of barriers. Care must be taken in applying new alternatives or in reducing lampricide use to not allow sea lamprey abundances to increase.

The Research Coordination Committee of the Great Lakes Panel on Aquatic Nuisance Species compiled a document of aquatic invasive species research priorities[31] to serve as a resource for, and provide guidance to, private foundations and local, state/provincial, and federal agencies that provide funding on AIS prevention and control in the Great Lakes as well as those involved in the conduct of AIS research, management, and control initiatives. The research priorities include:

- Prevention – Maritime shipping (ballast water, hull fouling, anchor lockers, etc.)

[30] http://www.glfc.org/
[31] http://www.glc.org/ans/pdf/2010-01-04-GLP%20RCC%20Priorities_for%20distribution.pdf

    - *This topic is being addressed by a separate SAB panel and will not be addressed as part of the review of the GLRI Action Plan.*
- Prevention – Canals and artificial waterways connecting Great Lakes to other watersheds
    - *This topic is being through a separate Asian Carp Control Strategy Framework that will eventually shift out of the GLRI, and will not be addressed as part of the review of the GLRI Action Plan.*
- Prevention – Commerce in live organisms
- Prevention – Trailer craft including recreational boaters
- Preventing and managing new invasions (general cross-cutting themes)
- Detection, Monitoring and Rapid Response
- Control and Management
- Coordination and Information Management
- Threats and Impacts to ecosystems, human health and economic values

Purposeful or accidental releases of species arising from the trade of live organisms (aquarium, water garden, live food, aquaculture and live bait) make up the second most important pathway of introduction into the Great Lakes (Ricciardi 2006). Growing concern in the Great Lakes region over introduction and spread of aquatic invasive species through these trades has prompted the development of species-specific regulations in the Great Lakes states and provinces. In 2008, the Great Lakes Panel on Aquatic Nuisance Species compiled a comprehensive list[32] of all aquatic species for which certain activities related to commercial trade are restricted or prohibited, at either state, provincial or federal levels to facilitate greater consistency and policy effectiveness on a regional basis among these Great Lakes jurisdictions. In addition, this list should also serve as a useful resource for user groups, commercial interests, and others stakeholders within the region by increasing awareness of these regulations.

In 2003, the Great Lakes Panel identified the need to establish research priorities. As part of this process, panel members agreed to develop a separate list of priority species[33]. This list is intended to highlight a few of those organisms with known and significant adverse impacts on the Great Lakes ecosystem, its users and uses. The list is intended to be dynamic, shifting and changing as the research develops, populations fluctuate, new impacts are found and new organisms of concern appear on the horizon.

There is global recognition of the need for regional nonindigenous species databases that can be cross-referenced and linked. The Great Lakes Aquatic Nonindigenous Species Information System (GLANSIS)[34] is designed to be a "one-stop" information source for established nonindigenous aquatic species in the Great Lakes. GLANSIS is operated by NOAA as a Great Lakes node of the USGS national NAS database[35] – allowing access to enhanced features and search capacity for Great Lakes-specific invasive species information while seamlessly linking to the national database. GLANSIS currently contains full profiles and distribution maps for over 180 species. Detailed fact sheets are available for each species. The two most recent ANS reported and verified established in the Great Lakes basin were viral hemorrhagic septicemia (VHS), and *Hemimysis anomala*.

[32] http://www.glc.org/ans/pdf/08-11-26-Great%20Lakes%20Reg%20Species%20List-complete.pdf
[33] http://www.glc.org/ans/pdf/priority-species.pdf
[34] http://www.glerl.noaa.gov/res/Programs/glansis/glansis.html
[35] National Nonindigenous Aquatic Species (NAS) Database, http://nas.er.usgs.gov/

GLANSIS received funding under the Great Lakes Restoration Initiative for several improvements in support of early detection and rapid response including the following:

- Addition of 'range expansion' species – those native to one portion of the Great Lakes but which are considered invasive to other portions of the basin.
- Addition of high priority 'watchlist' species – those which have been identified in the literature as high risk for invading and becoming established in the Great Lakes.
- Updated and consistent 'impact' information, especially potential impacts, better able to risk assessment
- Addition of management information — regulations, best management practices and control methodologies – – for all the species in the database.
- Enhanced bibliographic information.
- Addition of non-technical fact sheets for priority species of public interest.

As a result of international commerce, travel and local practices, ANS have been introduced throughout the Mississippi River and Great Lakes basins. These two basins are connected by man-made channels that, in the past, exhibited poor water quality, which was an impediment to the transfer of organisms between the basins. Now that water quality has improved, these canals allow the transfer of both indigenous and nonindigenous invasive species. The United States Army Corps of Engineers (USACE), in consultation with other federal agencies, Native American tribes, state agencies, local governments and non-governmental organizations, is conducting the Great Lakes and Mississippi River Interbasin Study (GLMRIS)[36]. In accordance with the study authorization, USACE will evaluate a range of options and technologies (collectively known as "ANS controls") to prevent the spread of aquatic nuisance species between the Great Lakes and Mississippi River by aquatic pathways. In this context, the term "prevent" includes the reduction of risk to the maximum extent possible, because it may not be technologically feasible to achieve an absolute solution. As part of this study, USACE will conduct a detailed analysis of various ANS controls, including hydrologic separation.

Following the *Economic and Environmental Principles and Guidelines for Water and Related Land Resource Implementation Studies*, Water Resource Council, March 10, 1983, USACE will:

- Inventory current and forecast future conditions within the study area;
- Identify aquatic pathways that may exist between the Great Lakes and Mississippi River basins;
- Inventory current and future potential aquatic nuisance species;
- Analyze possible ANS controls to prevent ANS transfer, to include hydrologic separation of the basins;
- Analyze the impacts each ANS control may have on significant natural resources and existing and forecasted uses of the lakes and waterways within the study area; and
- Recommend a plan to prevent ANS transfer between the basins. If necessary, the plan will include mitigation measures for impacted waterway uses and significant natural resources.

The Great Lakes Regional Collaboration Strategy, developed by scientific experts and endorsed by the Great Lakes Governors, the Great Lakes Mayors, the Tribal Caucus, and the Great Lakes Congressional Delegation in 2005, included priority environmental concerns about aquatic invasive species. The Strategy addresses species invasion through five vectors: (1) maritime commerce (e.g. ship ballast); (2) aquaculture; (3) canals and waterways; (4) recreational activities; and (5) trade and use of live organisms. The corresponding recommendations to each vector are as follows:

[36] http://glmris.anl.gov/

- Ship and barge-mediated introductions and spread of AIS in the Great Lakes should be eliminated, through the immediate promulgation of environmentally protective standards for ballast water, and the implementation of effective ship-board treatments and management measures.
    - *This topic is being addressed by a separate SAB panel and will not be addressed as part of the review of the GLRI Action Plan.*
- Federal, state, and/or local governments must enact measures that ensure the region's canals and waterways are not a vector for AIS
    - *This topic is being through a separate Asian Carp Control Strategy Framework that will eventually shift out of the GLRI, and will not be addressed as part of the review of the GLRI Action Plan.*
- Federal and state governments must take immediate steps to prevent the introduction and spread of AIS through the trade and potential release of live organisms, including developiong a list of species of concern for the Great Lakes basin.
- Establish a Great Lakes Aquatic Invasives Species Integrated Management Program to implement rapid response, control, and management programs and assess the effectiveness of those programs. This includes implementing a system of enhanced monitoring and ecological surveys, research to develop and implement new control methods for uncontrolled species of concern, and establishing a coordinated data management system.
- Federal, state, and tribal agencies, academic institutions and other organizations should receive adequate support to conduct and evaluate cost-effective AIS vector-specific outreach and education programs. These programs should focus on behavior change and responsibility of resource users.

Invasive Species Goals, Objectives, Measures and Actions in the Great Lakes Restoration Initiative Action Plan

Building on the environmental problems that have been highlighted through state-of-the-lakes efforts, in the scientific literature and in the science-based strategies in recent years, authors of the GLRI Action Plan incorporated issues associated with invasive species as a focus area. The goals and objectives are consistent with the issues that were raised by these efforts. Thus, the goals for invasive species included:

- The introduction of new species to the Great Lakes basin ecosystem is eliminated, reflecting a "zero tolerance policy" toward invasives.
- The risk of introduction of species, which are imported for various uses, into the Great Lakes is minimized.
- The spread of invasive species, by means of recreational activities, connecting waterways, and other vectors, beyond their current range is prevented.
- A comprehensive program for detection and tracking newly identified invasive species in the Great Lakes is developed and provides up-to-date critical information needed by decision makers for evaluating potential rapid response actions.
- An effective, efficient and environmentally sound program of integrated pest management for invasive species is developed and implemented, including program functions of containment, eradication, control and migration.

The GLRI Action Plan also incorporated specific objectives and actions for addressing the goals and metrics to gage progress. Table 7 provides a summary.

Table 7. GLRI Action Plan Goals, Objectives, Actions and Measures associated with Invasive Species

Great Lakes Restoration Initiative Action Plan (2010) Goals	GLRI Action Plan Objectives	GLRI Action Plan Actions	GLRI Action Plan Measures (see Action Plan for details)
Invasive Species Goals: • The introduction of new invasive species to the Great Lakes basin ecosystem is eliminated, reflecting a "zero tolerance policy" toward invasives. • The risk of introduction of species, which are imported for various uses, into the Great Lakes is minimized. • The spread of invasive species, by means of recreational activities, connecting waterways, and other vectors, beyond their current range is prevented. • A comprehensive program for detection and tracking newly identified invasive species in the Great Lakes is developed and provides up-to-date critical information needed by decision makers for evaluating potential rapid response actions. • An effective, efficient and environmentally sound program of integrated pest management for invasive species is developed and implemented, including program functions of containment, eradication, control and mitigation.	Invasive Species Objectives: • By 2011, eight state ANS management plans will be established or revised to include rapid response capabilities. By 2014, eight state-based, multi-agency rapid response plans will be implemented and 22 mock exercises to practice responses carried out under those plans and/or actual response actions will be completed. • Six technologies that prevent the introduction of invasive species and four technologies that either contain or control invasive species will be developed or refined and piloted by 2011. Ten technologies that prevent the introduction of invasive species and five technologies that either contain or control invasive species will be developed or refined and piloted by 2014. • By 2011, methodology and protocols will be piloted for the coordinated monitoring methodology and shared protocols for basinwide invasive species surveillance. By 2014, a basinwide surveillance program with shared sampling protocols and methodologies to provide early detection of non-native species will be operational. • By 2014, a 40 percent reduction in the yearly average rate of invasive species newly detected in the Great Lakes ecosystem will be achieved, compared to the period 2000-2009. • By 2014, invasice species populations within the Great Lakes Ecosystem will have been controlled and reduced, as measured in populations controlled to a target level in 6,500 acreas of managed area and by removing 5,000 pounds of invasive species from the Great Lakes ecosystem. • By 2014, approximately 10 million recreation and resource users will be educated on best practices that prevent the introduction and spread of invasive species.	Invasive Species Actions: Develop Ballast Water Treatment that Protects Freshwater Ecosystems Implement Early Actions to Address Water Pathway Vectors Prevention by Broad Stakeholder Outreach and Education Develop and Demonstrate Innovative Control Technology Support States' Role in Invasive Species Prevention and Control Control Key Invasive Species and Investigate Causal Mechanisms by which ANS impact Native Species Establish Early Detection and Rapid Response Capability	Measures of Progress: Rate of nonnative species newly detected in the Great lakes ecosystem Acres managed for populations of invasive species controlled to a target level Number of multi-agency plans established, mock exercises to practice rapid responses carried out under those plans, and/or actual rapid response actions Number of recreation and resource users contacted on best practices that prevent the introduction and spread of invasive species

Citations

Environment Canada and U. S. Environmental Protection Agency. 2009. State of the Great Lakes 2009. http://www.epa.gov/glnpo/solec.

Great Lakes Regional Collaboration Strategy to Restore and Protect the Great Lakes. 2005. http://www.glrc.us/.

Ricciardi, A. 2001. Facilitative interactions among aquatic invaders: is an "invasional meltdown" occurring in the Great Lakes? *Can. J. Fish. Aquat. Sci*. 58:2513-2525.

Ricciardi, A. 2005. Facilitation and synergistic interactions among introduced aquatic species. In *Invasive Alien Species: A New Synthesis*. H.A. Mooney, R.N. Mack, J. McNeely, L.E. Neville, P.J. Schei, and J.K. Waage, eds., pp. 162–178. Washington, DC: Island Press.

Ricciardi, A. 2006. Patterns of invasions in the Laurentian Great Lakes in relation to changes in vector activity. *Diversity and Distributions* 12:425-433.

Simberloff, D. 2006. Invasional meltdown 6 years later: important phenomenon, unfortunate metaphor, or both? *Ecol. Letters* 9:912-919.

National Invasive Species Council (NISC). 2001. *National Management Plan: Meeting the Invasive Species Challenge*. Website available at: http://www.invasivespeciesinfo.gov/council/nmptoc.shtml.

Bergstedt, R.A., and Schneider, C.P. 1988. Assessment of sea lamprey (*Petromyzon marinus*) predation by recovery of dead lake trout (*Salvelinus namaycush*) from Lake Ontario, 1982-85. *Can. J. Fish. Aquat. Sci.* 45:1406-1410.

Kitchell, J.F. 1990. The scope for mortality caused by sea lamprey. *Trans. Amer. Fish. Soc.* 119:642-648.

Smith, B.R., and Tibbles, J.J. 1980. Sea lamprey (*Petromyzon marinus*) in lakes Huron, Michigan and Superior: history of invasion and control, 1936-78. *Can. J. Fish. Aquat. Sci.* 37:1780-1801.

Problem Overview: Nearshore Health and Nonpoint Source Pollution

The priority goals and objectives for nearshore health and nonpoint source pollution within the GLRI Action Plan originated from a number of efforts within the Great Lakes scientific and ecosystem management communities to identify and diagnose the ongoing problems associated with coastal ecosystems. In recent years, the Great Lakes scientific community has been active in attempting to understand better the relationships between watershed sources of stressors and the condition of coastal waters, and to highlight ongoing and evolving environmental problems and causes.

SOLEC – the State of the Lakes Ecosystem Conference – is the primary forum for reporting on the status and trends of the health and integrity of the Great Lakes. The most recent SOLEC report[37], summarizing the 2008 assessment, included a summary of the condition of coastal zones and aquatic habitats. All lakes were rated as mixed (both good and degraded features), but the report noted that data were not available to assess the ecosystem over time, so trends could not be identified. The report noted some types of coastal features, such as "coastal wetlands, islands, alvars, cobble beaches, sand dunes, and aquatic habitats, are being adversely impacted by alteration of natural water level fluctuations, shoreline hardening, development and elevated phosphorus concentrations and loadings." In many nearshore regions, previously declining levels of phosphorus are beginning to increase again; nuisance populations of *Cladophora* are increasing; populations of planktonic algae, including harmful algal blooms, are increasing in some places; and populations of the amphipod, *Diporeia*, the once-dominant native benthic invertebrate, have been decimated in Lakes Michigan, Huron, Ontario and Erie. The nearshore zone assessment was rated as "poor" for phosphorus concentrations and loadings, with undetermined trends indicating insufficient data. Some metrics, such as "nearshore species diversity and stability", "nearshore fish habitat", "sediment available for coastal nourishment", "extent and quality of nearshore natural land cover", and "protected nearshore areas" were not reported because there is no lakewide assessment information. The 2009 SOLEC report also indicated that beach advisories, postings and closures had not improved. Nine percent of beaches in the U. S. and 42 percent of beaches in Canada were posted with health advisories more than 10 percent of the 2006-2007 beach seasons.

The scientific community has been active in identifying ecosystem conditions and problems, as well as needs for technical information for coastal areas of the Great Lakes. Niemi et al. (2007) identified needs for environmental indicators specific to Great Lakes coastal waters. They point to the ongoing insults from non-point sources of sediment, nutrients and contaminants, invasions by exotic species, climate change, and human-dominated land use. They argued the need for diagnostic indicators to inform management decisions on restoration and protection of coastal ecosystems. The linkages between ecological conditions in coastal habitats and various stressors was demonstrated by Peterson et al. (2007) in a special issue of the Journal of Great Lakes Research (v. 33 (3) 2007). Watershed conditions associated with agriculture, atmospheric deposition, land cover, human population, point sources, and soils were shown to be related to the environmental condition of coastal wetlands and nearshore waters. The authors proposed a "cumulative stress index" to describe the relationship.

The Lake Erie Millenium Network (LEMN)[38] is a consortium of research organizations within the U. S. and Canada, with a purpose for defining and understanding Lake Erie environmental problems and offering scientific analyses to inform solutions and track changes in ecosystems of the lake. In 2007, LEMN

[37] State of the Great Lakes 2009, http://www.epa.gov/solec/sogl2009/sogl2009complete.pdf
[38] http://www.lemn.org

began a series of workshops on watershed-based nutrients and nearshore ecosystem behavior. The workshops, from 2007 and 2008, brought together experts from across the Great Lakes to synthesize their research results from various Great Lakes studies. These workshops highlighted the importance of the nearshore zone waters. Runoff from watersheds and non-point sources of pollution are primary drivers for nearshore impairments.

In 2004, the USEPA outlined the Clean Beaches Plan to initiate actions under the Beaches, Environmental Assessment and Coastal Health (BEACH) Act of 2000. The Plan provided for grants to states for beach monitoring and reporting on closures for health reasons. EPA proposed to update standards for pathogens and to provide technical guidance for monitoring. Many Great Lakes states began the process of adopting criteria (see water.epa.gov/lawsregs/lawsguidance/beachrules/bacteria-rule-final-fx.cfm). The intensity of beach monitoring increased, resulting in a greater number of sites that posted advisories or closures. These activities increased concern about human health risk associated with water-contact activities in coastal areas of the Great Lakes, and they provided the rationale for inclusion of goals for pathogens and other nuisance growth in the nearshore areas in the GLRI Action Plan.

Experts were convened by the International Joint Commission in 2008 and early 2009 from academic and other research organizations from across the Great Lakes basin. The report (Eutrophication Advisory Workgroup to the IJC (2009)) stated:

> "The eutrophication abatement success story of the late 1970s and early 1980s continues to be often cited as the principal achievement under the auspices of the Great Lakes Water Quality Agreement and as a model for cooperation on transboundary waters. The U.S. and Canada spent over $8 billion on phosphorus control programs, and eutrophication for a time was reversed in the Great Lakes. Now the most visible signs of eutrophication—nuisance Cyanobacteria (blue-green algae) blooms and rotting shoreline piles of the green macro-alga *Cladophora*—have returned to all of the Great Lakes except Lake Superior. The objectives in Annex 3 (control of phosphorus) of the Agreement on elimination of nuisance algal growths and dissolved oxygen depletion in the bottom waters of the central basin of Lake Erie are no longer being met. Current observations on parts of all of the lakes except perhaps Lake Superior include:
>
> - the return of *Microcystis* blooms (a HAB-harmful algal bloom species);
> - *Cladophora* blooms (nearshore nuisance algal growths);
> - dissolved oxygen depletion in the bottom waters of the central basin of Lake Erie;
> - increases in the frequencies of beach postings or closings;
> - botulism toxicity events re-emerging in the late 1990s and early 2000s for the first time in the Great Lakes since 1963-64;
> - total phosphorus concentrations in offshore waters are well below what the old models said they should be given phosphorus loading estimations;
> - "desertification" (loss of productivity) in offshore waters."

This report concluded that nearshore soluble reactive phosphorus, *Cladophora* biomass, and Dreissenid biomass are key elements in eutrophication in the Great Lakes.

The Great Lakes Regional Collaboration Strategy, developed by scientific experts and endorsed by the Great Lakes Governors, the Great Lakes Mayors, the Tribal Caucus, and the Great Lakes Congressional Delegation in 2005, included priority environmental concerns about non-point sources of pollutants. Strategy goals for coastal health included protection of drinking water from coastal and tributary

sources; reduction of sediment, phosphorus, and nitrogen loadings; and reduction of agricultural nutrient inputs.

Nearshore Health and Nonpoint Source Pollution Goals, Objectives, Measures and Actions in the Great Lakes Restoration Initiative Action Plan

Building on the environmental problems that have been highlighted in SOLEC reports, in the scientific literature, and in the science-based strategies in recent years, authors of the GLRI Action Plan incorporated issues associated with nearshore health and non-point source pollution as a focus area. The goals and objectives are consistent with the issues that were raised by these previous efforts. Thus, the goals for nearshore health and nonpoint source pollution included:

- Nearshore aquatic communities consist of healthy, self-sustaining plant and animal populations dominated by native and naturalized species.
- Land use, recreation and economic activities are managed to ensure that nearshore aquatic, wetland and upland habitats will sustain the health and function of natural communities.
- The presence of bacteria, viruses, pathogens, nuisance growths of plants or animals, objectionable taste or odors, or other risks to human health are reduced to levels in which water quality standards are met and beneficial uses attained to protect human use and enjoyment of the nearshore areas.
- High quality bathing beach opportunities are maintained by eliminating impairments from bacterial, algal and chemical contamination; effective monitoring for pathogens; effective modeling of environmental conditions, where appropriate; and timely communications to the public about beach health and daily swimming conditions.
- A significant reduction in soil erosion and the loading of sediments, nutrients and pollutants into tributaries is achieved through greater implementation of practices that conserve soil and slow overland flow in agriculture, forestry and urban areas.
- High quality, timely and relevant information about the nearshore areas is readily available to assess progress and to inform enlightened decision making.

The GLRI Action Plan also incorporated specific objectives and actions for addressing the goals and metrics to gage progress. Table 8 provides a summary.

Table 8. GLRI Action Plan Goals, Objectives, Actions and Measures associated with nearshore health and nonpoint source pollution

Great Lakes Restoration Initiative Action Plan (2010) Goals	GLRI Action Plan Objectives	GLRI Action Plan Actions	GLRI Action Plan Metrics (see Action Plan for details)
Nearshore Health and Nonpoint Source Pollution Goals: • Nearshore aquatic communities consist of healthy, self-sustaining plant and animal populations dominated by native and naturalized species. • Land use, recreation and economic activities are managed to ensure that nearshore aquatic, wetland and	Nearshore Health and Nonpoint Source Pollution Objectives: • By 2010, EPA will compile and map the highest priority watersheds for implementation of targeted nonpoint source pollution control measures • By 2014, remediation, restoration and conservation actions in at least one targeted watershed in each Great Lake basin will control	Nearshore Health and Nonpoint Source Pollution Actions: Targeting Watershed Plan Implementation Identify Sources and Reduce Loadings of Nutrients and Soil	Measures of Progress: Five-year average annual loadings of soluble reactive phosphorus from tributaries draining targeted watersheds Percentage of beaches meeting bacteria standards 95% or more of beach days Extent (sq. miles) of Great Lakes harmful algal blooms

Great Lakes Restoration Initiative Action Plan (2010) Goals	GLRI Action Plan Objectives	GLRI Action Plan Actions	GLRI Action Plan Metrics (see Action Plan for details)
upland habitats will sustain the health and function of natural communities. • The presence of bacteria, viruses, pathogens, nuisance growths of plants or animals, objectionable taste or odors, or other risks to human health are reduced to levels in which water quality standards are met and beneficial uses attained to protect human use and enjoyment of the nearshore areas. • High quality bathing beach opportunities are maintained by eliminating impairments from bacterial, algal and chemical contamination; effective monitoring for pathogens; effective modeling of environmental conditions, where appropriate; and timely communications to the public about beach health and daily swimming conditions. • A significant reduction in soil erosion and the loading of sediments, nutrients and pollutants into tributaries is achieved through greater implementation of practices that conserve soil and slow overland flow in agriculture, forestry and urban areas. • High quality, timely and relevant information about the nearshore areas is readily available to assess progress and to inform enlightened decision making.	erosion, reduce nutrient runoff from urban and agricultural sources, and improve habitat to protect nearshore aquatic resources. • By 2014, a baseline will be established for total sustpended solids loadings from targeted tributaries • By 2014, a measurable decrease will be achieved in soluble phosphorus loading from 2008 levels in targeted tributaries • By 2014, the causes of nutrient-related nearshore biological impairments will be better understood, and following local or watershed remedial actions, the number and severity of incidences of harmful algal blooms (HABs), avian botulism, and/or excessive *Cladophora* growth will be significantly reducted from 2008 levels • By 2014, a comprehensive nearshore monitoring program will have been established and implemented, including a publicly accessible reporting system, based on a suite of environmental indicators • By 2014, 50 percent of high priority Great Lakes beaches will have been assessed using a standardized sanitary tool to identify sources of contamination • By 2014, 20 percent of high priority Great Lakes beaches will have begun to implement measures to control, manage or remediate pollution sources identified through the use of sanitary surveys • By 2014, rapid testing or predictive modeling methods (to improve the accuracy of decisions on beach postings to better protect public health) will be employed at 33 % of high priority beaches • By 2014, the area of agricultural lands in conservation and/or utilizing conservation tillage practices will increase by 50% over 2008 levels	Erosion Improve Public Health Protection at Beaches Generate Critical Information for Protecting Nearshore Health	Annual number of days US Great Lakes beaches are closed or posted due to nuisance algae Annual volume of sediment deposition in defined harbor areas in targeted watersheds (cu. yards) Acres in Great Lakes watershed with USDA conservation practices implemented to reduce erosion, nutrient and/or pesticide loading under Farm Bill Programs

Citations

Environment Canada and U. S. Environmental Protection Agency. 2009. State of the Great Lakes 2009. http://www.epa.gov/glnpo/solec.

Great Lakes Regional Collaboration Strategy to Restore and Protect the Great Lakes. 2005. http://www.glrc.us/.

Niemi, G. J., J. R. Kelly, and N. P. Danz. 2007. Environmental indicators for the coastal region of the North American Great Lakes: Introduction and prospectus. Journal of Great Lakes Research 33 (3): 1-12.

Peterson, G. S., M. E. Sierszen, P. M. Yurista, and J. R. Kelly. 2007. Stable nitrogen isotopes of plankton and benthos reflect a landscape-level influence on Great Lakes coastal ecosystems. Journal of Great Lakes Research 33(3): 27-41.

Eutrophication Advisory Work Group to the International Joint Commission (IJC), 2009. Great Lakes Water Quality Agreement Priorities 2007-09 Series. Work Group Report on Eutrophication, 2009. IJC, Special Publication 2009-02, Windsor, Ontario, Canada.

Problem Overview: Habitat and Wildlife Protection and Restoration

The priority goals and objectives for habitat and wildlife protection and restoration within the GLRI Action Plan originated from a number of efforts within the Great Lakes scientific and ecosystem management community to identify and diagnose the ongoing problems associated with habitat degradation and destruction, alteration of natural lake level fluctuations, poor land management practices, and habitat fragmentation. Great Lakes habitat losses have led to an altered food web, compromised biodiversity, and poorly functioning ecosystems. In recent years, the Great Lakes scientific community has been active in attempting to better understand the condition of Great Lakes ecosystems. Over the years, numerous efforts through a variety of organizations have led to the habitat and wildlife protection and restoration section of the GLRI Action Plan.

In 1994, The Nature Conservancy's Great Lakes Program published the seminal paper "The Conservation of Biological Diversity in the Great Lakes Ecosystem: Issues and Opportunities"[39]. The paper described Great Lakes systems, rare species and community types, threats, and protection and restoration solutions to biodiversity problems.

SOLEC 1996 produced background papers the Great Lakes nearshore. The idea of Biodiversity Investment Areas was introduced in the paper, "Land by the Lakes. " Additional Biodiversity Investment Area papers were produced for SOLEC 1998. These papers[40] pointed out the need for aquatic and terrestrial habitat and species research, monitoring, and indicators.

One outcome of the SOLEC indicator process is the implementation of a Great Lakes coastal wetland monitoring. A binational group of scientists has determined priority indicators for coastal wetland quality, in particular birds, amphibians, fish, invertebrates, plants, wetland extent and type, and water chemistry. A five-year monitoring plan[41] is establishing baseline data and providing information to decision makers in order to set priorities for protection and restoration.

The Great Lakes Coastal Wetlands Consortium (Consortium) was also instrumental in informing the newly implemented coastal wetland monitoring program. The Consortium was formed in 2000 with the goal of producing a cohesive, long-term plan to monitor Great Lakes coastal wetlands. In March 2008, the Coastal Wetlands Consortium completed the *Great Lakes Coastal Wetlands Monitoring Plan*[42] to monitor Great Lakes coastal wetlands using a scientifically validated sampling design and suite of indicators and metrics developed by many project partners. Since inception of the Consortium, more than 50 organizations have contributed to this plan from initial pilot studies, to development of a Great Lakes coastal wetlands inventory and classification system, drafting of final coastal wetlands monitoring protocols, to the design of a publicly accessible international database. The partners included scientific and policy experts drawn from key U.S. and Canadian federal, state and provincial agencies, nongovernmental organizations, academia, and members of other interest groups with responsibility for coastal wetlands monitoring. The *Great Lakes Coastal Wetlands Monitoring Plan* recommends multiple biological protocols and metrics for monitoring the condition of Great Lakes coastal wetlands – including those for plants, invertebrates, fish, amphibians, birds, and landscape. Also recommended is a design for sampling Great Lakes coastal wetlands that allows users to monitor condition of these wetlands on an annual basis. With a combination of repeated site visits and random sampling of other wetlands on

[39] http://epa.gov/greatlakes/ecopage/glbd/issues/index.html
[40] http://www.epa.gov/glnpo/solec/archive/index.html
[41] http://www.lakescientist.com/2010/glri-funds-10-million-great-lakes-coastal-wetlands-study
[42] http://www.glc.org/wetlands/final-report.html

an annual basis, users can establish status and trends (positive, negative, no change) of wetland condition for a given site, region, or for all Great Lakes coastal wetlands.

The most recent SOLEC report[43], summarizing the 2008 assessment, included a summary of the condition of biotic communities and land use - land cover. The land use – land cover assessment was rated "mixed" with an undetermined trend. Changes on the landscape, due in part to pressures associated with urban population growth, affect the Great Lakes, especially in the nearshore zone where the land meets the water. Changes in land use and land cover affect how water moves across the landscape, and they alter tributary and nearshore flow regimes. Altered flow regimes affect seasonal timing of water inputs and may result in increased erosion, sediment transport, and reduced water quality in tributaries and nearshore areas of the Great Lakes. These changes may modify nearshore aquatic habitat structure and alter ecological functions.

Biotic communities were rated "mixed" with an undetermined trend. Overall, the status of biotic communities varies from one lake to another, with Lake Superior generally having a more positive status than the other lakes. Indicators that measure lower food web components generally show more negative status and trends, and most of these can be related back to the impacts of invasive zebra and quagga mussels. Some indicators that focus on higher food web components are more positive and highlight the successes that can be achieved as a result of long-term restoration and protection efforts.

The biotic communities assessment is based on over 20 detailed indicator reports including assessments of fish populations (e.g. salmon, lake trout, and lake sturgeon), birds, mammals, amphibians, invertebrates, and plants. The number of stocked salmonids per year is decreasing due to improvements in suppressing the abundance of alewife, as well as the increased health and reproduction of the salmonine population. Lake Superior is the only lake where natural reproduction of lake trout has been re-established. Natural reproduction of lake trout in the other lakes is low and localized. Lake sturgeon populations are increasing in all the lakes, yet remain a small fraction of historic populations. In many areas, habitat restoration is needed because critical spawning and rearing habitat for lake sturgeon has been destroyed or altered. Preyfish populations are at historic lows (in all lakes except for Erie) and continue to shift away from their natural state. Food webs are becoming more benthic as a result of the expansion of dreissenid mussels. However, the benthification of the food web has not benefited *diporeia*, once the most abundant amphipod in the cold, offshore regions of the lakes. *Diporeia* populations have declined significantly and are having profound impacts on fish species (e.g. lake whitefish) that used to prey exclusively on them. Similarly, changes in zooplankton community structure and overall declines in summer biomass are occurring in Lakes Michigan, Huron, and Ontario. Coastal wetland plant communities are degraded in urban and industrial areas, although some communites (mostly in the northern part of the basin) are of high quality and in good status. Water level control in Lake Ontario has degraded many of its coastal wetlands.

The land use – land cover assessment is also based on nearly 20 detailed indicator reports including assessments of land cover, ground surface hardening, forest lands, agricultural lands, urban /suburban lands, and protected areas. From 1992 to 2001, approximately 2 million acres or 2.5 percent of the Great Lakes basin experienced a change in land use. These changes were dominated by a conversion of forested and agricultural lands to either high or low intensity development, transportation (roads), or upland grasses and brush (early successional vegetation). More than half of these changes are considered to be irreversible and permanent. Conversion rates exceeded predictions based on

[43] State of the Great Lakes 2009, http://www.epa.gov/solec/sogl2009/sogl2009complete.pdf

population growth alone. As coastal areas are developed, shorelines are armored to protect property and infrastructure. Physical alterations to the land/water interface disrupt natural coastal processes which, over time, can have significant regional impacts on nearshore and coastal margin substrates, habitat, hydraulic connectivity, and nearshore water quality. In Ohio, more than 75 percent of the coastline was armored by 2000, and recent recession-line mapping showed a significant increase in the number of shore protection structures installed between 1990 and 2004. Impervious surfaces cover 8.5 percent of the Great Lakes watershed within U.S. borders. Lake Michigan and U.S. Lake Erie watersheds have the highest proportion of impervious surfaces. The Lake Superior watershed contains the lowest proportion of impervious surfaces within the United States portion of the Great Lakes basin. Sprawl is increasing in rural and urban fringe areas of the Great Lakes basin, placing a strain on infrastructure and consuming habitat in areas that previously tended to have healthier environments than those in urban areas. This trend is expected to continue. SOLEC also reports on the preservation of the area and quality of Great Lakes cobble beaches, alvars (naturally open habitats on flat limestone bedrock), islands, and sand dunes for the maintenance of biodiversity and the protection of rare species. Baseline conditions are now available for islands.

The Great Lakes Regional Collaboration (GLRC) Strategy, developed by scientific experts and endorsed by the Great Lakes Governors, the Great Lakes Mayors, the Tribal Caucus, and the Great Lakes Congressional Delegation in 2005, included priority environmental concerns about habitat conservation and species management (http://www.glrc.us/documents/strategy/Habitat-Species-Appendix.pdf). The landscape and aquatic ecosystems in the Great Lakes basin have been altered due to human settlement and activities, resulting in the loss or degradation of many habitats, and threatening the species they support. Invasive species, non-piont source run-off, and aquatic food web disruption are some of the key threats to the health and sustainability of Great Lakes habitats and species they support; additional key threats include the loss of fish spawning substrate and nursery areas, disruption of sediment transport, contaminants, altered lake levels, loss of floodplains and riparian buffers, hydrological changes, and landscape fragmentation and alterations. The Great Lakes have lost more than half of the region's original wetlands and 60 percent of forested lands. These changes in habitat type and extent have contributed to numerous plants and animal extirpations. The Strategy identified the following systems as initial priorities for which restoration and protection efforts should be focused: (1) Fish and wildlife populations in Open and Nearshore Waters; (2) Wetlands; (3) Riverine Habitats; (4) Coastal Shore and Upland Habitats. For each of these priorities, the Strategy recommended the following short-term actions:

- Fish and wildlife in open and nearshore waters
    - Develop and evaluate lake trout restoration efforts using guidance from existing fishery management plans
    - Develop an initiative to re-establish native lake sturgeon and coregonines
    - Refine or develop techniques or models to improve assessment and exploitation strategies and management protocols for important fish species (e.g. yellow perch, lake whitefish, walleye).
    - Develop an understanding of factors involved in recruitment of lake trout and other important native species, and remove or mitigate major impediments to recruitment.
- Wetlands
    - Restore or protect 550,000 acres of wetlands and associated uplands (1.1 M acres).
    - Achieve at least 1.54 million breeding pairs of waterfowl (annual breeding population under average environmental conditions)
    - Update inventory and mapping of wetland habitat types

    - Acknowledge, develop, and enhance federal and state regulations and enforcement for coastal and inland wetland protection that also facilitate and accelerate wetland restoration
- Riverine habitat and related riparian areas
    - Restore ten Great Lakes tributaries (five barrier and five riparian habitat projects)
    - Restore coaster brook trout and lake sturgeon to Great Lakes tributaries
    - Adopt a method to characterize or classify watersheds based on degree of altered hydrology
- Coastal and upland habitats
    - Inventory and assess all Great Lakes coastal habitats and prioritize them for protection and restoration
    - Protect or restore 10,000 acres of high priority coastal and upland habitats per year
    - Conduct detailed monitoring of AOCs in coastal shore areas
    - Protect and restore 1,100,000 acres of uplands associated with wetlands

In 2006, a Great Lakes federal interagency Wetlands Subcommittee[44] was formed and charged improving coordination of federal wetlands management programs, protecting and restoring 200,000 acres of wetlands, streamlining the wetlands restoration permitting process, and updating the national wetlands inventory. Although the subcommittee was comprised of federal agency representation, the Executive Committee of the GLRC, with representation from states, local government, tribal and non-governmental interests, served in an advisory capacity to the Wetlands Subcommittee. In June 2008, the Great Lakes Regional Collaboration released a progress report and a call to action[45] on habitats, and wetlands in particular. One of the principle recommendations in this report was the need for a single, centralized system to collect and qualify information on wetlands protection and restoration activities across the Great Lakes in a way that measures progress and demonstrates the need for achieving the wetlands commitment.

In their report, Prescription for Great Lakes Ecosystem Protection and Restoration: Avoiding the Tipping Point of Irreversible Changes, Bails et al. stated that there is "compelling evidence that in many parts of the Great Lakes we are at or beyond this tipping point (the point at which ecosystem-level changes occur rapidly and unexpectedly, confounding the traditional relationships between sources of stress and the expected ecosystem response). Certain areas of the Great Lakes are increasingly experiencing ecosystem breakdown, where intensifying levels of stress from a combination of sources have overwhelmed the natural processes that normally stabilize and buffer the system from permanent change." In the Great Lakes, nonlinear changes are no longer a future threat – these types of changes are taking place now. While in some areas some indicators of ecosystem health have continued to improve over the past decade, other large areas in the lakes are undergoing rapid changes where combinations of effects of old and new stresses are interacting synergistically to trigger a chain reaction process of ecosystem degradation. The rapidness of this chain reaction process, seen over the past five to fifteen years and involving sudden and unpredictable changes, is unique in the Great Lakes' recorded history. Some of the most significant changes observed include the radical food web disruptions occurring in Lakes Michigan, Huron, Erie, and Ontario; the reoccurrence of the anoxic/hypoxic zone in the central basin and other impairments (such as blooms of *Microcystis* cyanobacteria in the western basin) in Lake Erie; and ongoing problems related to invasive species and other impairments in Lake Ontario.

[44] http://www.glrc.us/initiatives/wetlands/index.html
[45] http://www.glrc.us/documents/CallToAction06-19-2008.pdf

At a lakewide scale, the Lakewide Management Plan (LaMP) process has undertaken the development of a biodiversity conservation strategy for each Great Lake. *The Beautiful Lake: A Binational Biodiversity Conservation Strategy for Lake Ontario*[46]*, for example,* describes key threats to biodiversity, potential strategies to abate the threats, recommends priority action sites, and recommends indicators to assess the health of the Lake's biodiversity. The Lake Huron biodiversity strategy[47] has also been completed. The Lakes Erie, Michigan and Superior biodiversity plans are currently under development.

At a local scale, binational conservation efforts are included in the Remedial Action Plans through the Area of Concern program[48]. Habitat-related beneficial use impairments require federal, state and local cooperation to solve habitats and species stressor problems. Other local partnerships, while not necessarily binational and much less formal, do initiate and carry out conservation programs that have influenced the GLRI Action Plan. The Stewardship Network[49], Chicago Wilderness[50], Lake Erie Alleghany Partnership[51], and Ontario's Conservation Authorities[52], among others, contribute to overall basinwide conservation of habitats and species.

Many other agencies and organizations are protecting and restoring Great Lakes coastal resources as part of the Great Lakes Restoration Initiative. Through the Joint Strategic Plan for Management of Great Lakes Fisheries[53], the Great Lakes Fisheries Commission[54] sets goals and objectives for fisheries research, invasive sea lamprey control, and cooperative fishery management among the state, provincial, tribal, and federal management agencies. Federal agencies such as the U.S. Fish and Wildlife Service (USFWS), National Oceanic and Atmospheric Administration (NOAA), and U.S. Army Corps of Engineers (ACE) administer and implement complementary programs that improve fish passage and aquatic habitat in the Great Lakes. The USFWS National Fish Passage Program[55], USFWS Great Lakes Fish and Wildlife Restoration Act[56], Great Lakes Basin Fish Habitat Partnership[57], NOAA Open Rivers Initiative[58], and the USACE Great Lakes Fishery and Ecosystem Restoration Program[59], all leverage funding to research and implement activities that directly improve the ability of fish or other aquatic species to move by reconnecting habitat that has been fragmented by barriers.

The 2007 *U.S. Fish and Wildlife Service Joint Venture Implementation Plan*[60] and separate bird-group conservation strategies developed for waterfowl, waterbirds, shorebirds, and landbirds provide estimates of what, where, when, and how much habitat is needed in the region. Funding is targeted to actions that will increase and sustain populations of priority bird species at target levels. Since the inception of the regional Upper Mississippi/Great Lakes Joint Venture, partners have protected, restored, and enhanced more than 522,500 acres of habitat.

---

[46] http://www.epa.gov/glnpo/lakeont/reports/lo_biodiversity.pdf
[47] http://www.miseagrant.umich.edu/downloads/biodiversity/10-732-Lake-Huron_Biodiversity-screen.pdf
[48] http://epa.gov/glnpo/aoc/index.html
[49] http://www.stewardshipnetwork.org/site/c.hrLOKWPILuF/b.1361967/k.755C/The_Stewardship_Network.htm
[50] http://www.chicagowilderness.org/
[51] http://www.leapbio.org/
[52] http://www.conservation-ontario.on.ca/
[53] http://www.glfc.org/fishmgmt/jsp97.pdf
[54] http://www.glfc.org/
[55] http://www.fws.gov/fisheries/fwco/fishpassage/
[56] http://www.fws.gov/midwest/fisheries/glfwra-grants.html
[57] http://www.fws.gov/midwest/GLBFHP/
[58] http://www.habitat.noaa.gov/pdf/ori_fact_sheet.pdf
[59] http://www.glfc.int/glfer/
[60] http://www.fws.gov/midwest/NAWMP/documents/WaterfowlManagementPlan.pdf

USFWS and NOAA also administer dedicated coastal programs in the Great Lakes Basin. The USFWS Coastal Program[61] develops innovative partnerships with local and statewide land trusts and other conservation partners to identify and protect some of the most valuable fish and wildlife habitat and species in the Great Lakes basin. The program features non-regulatory, partnership-based efforts to conserve healthy coastal ecosystems for the benefit of fish, wildlife and people.

NOAA's Coastal Zone Management Program[62] supports state programs in their quest to balance the complex demands of coastal resource use, economic development, and conservation. The program supports local smart growth planning and watershed management leading to long-term sustainability; promotes habitat conservation through wetland mapping and management; and reduces nonpoint sources of pollution through storm water management, designing and operating clean marinas, and public education and outreach efforts.

Finally, several other non-governmental programs have contributed to the GLRI Action Plan. The Healing Our Waters Coalition[63] goal is to protect and restore the Great Lakes and to secure a sustainable restoration plan and the billions of dollars of state and federal funding needed to implement it. The Nature Conservancy and the Nature Conservancy of Canada's *Binational Conservation Blueprint for the Great Lakes*[64] guides work to preserve the range of natural coastal systems that support a tremendous variety of plants and animals, such as the Pitcher's thistle and the piping plover, many of which occur nowhere else on Earth. Sustain Our Great Lakes[65] is a binational public–private partnership among ArcelorMittal, U.S. Environmental Protection Agency, U.S. Fish and Wildlife Service, U.S. Forest Service, National Fish and Wildlife Foundation, and National Oceanic and Atmospheric Administration. Its mission is to sustain, restore and protect fish, wildlife and habitat in the Great Lakes basin by leveraging funding, building conservation capacity, and focusing partners and resources toward key ecological issues.

Habitat and Wildlife Protection and Restoration Goals, Objectives, Measures and Actions in the Great Lakes Restoration Initiative Action Plan

Building on the environmental problems that have been highlighted through state-of-the –lakes efforts, in the scientific literature and in the science-based strategies in recent years, authors of the GLRI Action Plan incorporated issues associated with habitat and wildlife protection and restoration as a focus area. The goals and objectives are consistent with the issues that were raised by these efforts. Thus, the goals for habitat and wildlife protection and restoration included:

- Protection and restoration of Great Lakes aquatic and terrestrial habitats, including physical, chemical, and biological processes and ecosystem functions, maintain or improve the conditions of native fish and wildlife.
- Critical management activities (such as stocking native fish and other aquatic species, restoring access of migratory fish species at fish passage barriers, and identifying and addressing diseases) protect and conserve important fish and wildlife populations.
- Sound decision making is facilitated by accessible, site specific and landscape-scale baseline status and trend information about fish and wildlife resources and their habitats.

[61] http://www.fws.gov/midwest/greatlakes/glcoastal.htm
[62] http://coastalmanagement.noaa.gov/programs/czm.html
[63] http://www.healthylakes.org/
[64] http://nhic.mnr.gov.on.ca/projects/conservation_blueprint/blueprint_main.cfm
[65] http://www.sustainourgreatlakes.org/Home.aspx

- High priority actions identified in strategic plans (such as state and federal species management, restoration and recovery plans, Lakewide Management Plans, Remedial Action Plans, and others) are implemented, lead to achievement of plan goals, and reduce the loss of fish and wildlife and their habitats.
- Development activities and planned and implemented in ways that are sensitive to environmental considerations and compatible with fish and wildlife and their habitats.

The GLRI Action Plan also incorporated specific objectives and actions for addressing the goals and metrics to gage progress. Table 9 provides a summary.

Table 9. GLRI Action Plan Goals, Objectives, Actions and Measures associated with habitat and wildlife protection and restoration

Great Lakes Restoration Initiative Action Plan (2010) Goals	GLRI Action Plan Objectives	GLRI Action Plan Actions	GLRI Action Plan Measures (see Action Plan for details)
Habitat and Wildlife Protection and Restoration Goals: • Protection and restoration of Great Lakes aquatic and terrestrial habitats, including physical, chemical, and biological processes and ecosystem functions, maintain or improve the conditions of native fish and wildlife. • Critical management activities (such as stocking native fish and other aquatic species, restoring access of migratory fish species at fish passage barriers, and identifying and addressing diseases) protect and conserve important fish and wildlife populations. • Sound decision making is facilitated by accessible, site specific and landscape-scale baseline status and trend information about fish and wildlife resources and their habitats. • High priority actions identified in strategic plans (such as state and federal species management, restoration and recovery plans, Lakewide Management Plans, Remedial Action Plans, and others) are implemented, lead to the achievement of plan goals, and reduce the loss of fish and wildlife and their habitats. • Development activities are planned and implemented in ways that are sensitive to environmental considerations and compatible with fish and wildlife and their habitats.	Habitat and Wildlife Protection and Restoration Objectives: • By 2014, 4,500 miles of Great Lakes river and tributaries will be reopened and 450 barriers to fish passage will be removed or bypassed. • By 2014, 82% of recovery actions for federally listed priority species will be implemented. • By 2014, 53 percent of populations of native aquatic non-threatened and endangered species are self sustaining. • By 2014, 97,500 acres of wetlands, wetland-associated uplands, and high priority coastal, upland, urban, and island habitats will be protected, restored, or enhanced. • By 2014, 100 percent of U.S. coastal wetlands in the Great Lakes basin will be assessed. • By 2014, 30 habitat-related beneficial use impairments will be delisted across the Areas of Concern.	Habitat and Wildlife Protection and Restoration Actions: Improve Aquatic Ecosystem Resiliency Maintain, Improve or Enhance the Populations of Native Species Enhance Wetlands, Wetland-Associated Uplands, and High Priority Coastal, Upland, and Island Habitats Identify, Inventory, and Track Progress on Great Lakes Habitats, Including Coastal Wetland Restoration Restore Habitat Functioning in Areas of Concern	Measures of Progress: Miles of rivers reopened for fish passage Number of fish passage barriers removed or bypassed Number of species delisted due to recovery Percent of recovery actions implemented for priority listed species % of populations of native aquatic non-threatened and endangered species self-sustaining in the wild Number of acres of wetlands and wetland-associated uplands protected, restored, and enhanced % of US coastal Great Lakes wetlands assessed Number of habitat-related BUIs removed from the 27 US AOCs so impaired

Citations

Environment Canada and U. S. Environmental Protection Agency. 2009. State of the Great Lakes 2009. http://www.epa.gov/glnpo/solec.

Great Lakes Regional Collaboration Strategy to Restore and Protect the Great Lakes. 2005. http://www.glrc.us/.

Great Lakes Regional Collaboration Habitat/Wetlands Initiative: A Progress Report and Call to Action. June 2008. http://www.glrc.us/.

Great Lakes Coastal Wetlands Consortium. 2008. Great Lakes Coastal Wetlands Monitoring Plan. http://www.glc.org/wetlands/final-report.html

Prescription for Great Lakes Ecosystem Protection and Restoration: Avoiding the Tipping Point of Irreversible Changes, December 2005, Jack Bails, Alfred Beeton, Jonathan Bulkley, Ph.D., Michele DePhilip, John Gannon, Ph.D., Michael Murray, Ph.D., Henry Regier, Ph.D., Donald Scavia, Ph.D., http://www.snre.umich.edu/scavia/wp-content/uploads/2009/11/prescription_for_great_lakes_08_30_2006.pdf

Problem Overview: Accountability, Education, Monitoring, Evaluation, Outreach, and Partnerships

The priority goals and objectives for accountability, education, monitoring, evaluation, outreach, and partnerships within the GLRI Action Plan originated from a number of efforts within the Great Lakes scientific and ecosystem management community to provide additional oversight, monitoring, assessment, and coordination. In recent years, the Great Lakes scientific community has been active in attempting to better assess key indicators of overall ecosystem function to evaluate restoration progress and provide information that decision makers need.

This focus area is intended to be the "necessary backbone" of the entire GLRI through oversight, monitoring and assessment, education and outreach, and partnerships. Section III detailed the numerous collaborative and strategic partnerships that are addressing the complex issues faced by the Great Lakes. Section IV summarized the primary management and reporting mechanisms in place to implement the Initiative. In this section, we will focus on the actions associated with monitoring and communication in the GLRI Action Plan.

The Great Lakes Regional Collaboration Strategy, developed by scientific experts and endorsed by the Great Lakes Governors, the Great Lakes Mayors, the Tribal Caucus, and the Great Lakes Congressional Delegation in 2005, highlighted the priority environmental concerns facing the Great Lakes and the need for greater coordination to provide information to decision makers in a timely and effective manner.

The Great Lakes ecosystem, the largest freshwater system in the world, is a dynamic and complex interaction of biological, chemical and physical components that is not yet fully understood. The sensitivity of this system to human influence, however, has been repeatedly demonstrated in recent decades. Environmental degradation, caused by problems such as the introduction of invasive species, point source and non-point source pollution, and declining fisheries, has pointed to an urgent need for protection and restoration. Protection and restoration of the Great Lakes ecosystem require a well-documented, collaborative strategy, access to the best scientific information available, and coordinated action. A successful restoration strategy for the Great Lakes must also include an informed decision making process based on consistent methods to measure and monitor key indicators of the ecosystem's function. Such measurements need to occur before and after the initiation of restoration efforts at local and basin-wide scales. Once collected, information needs to be compiled and communicated consistently to inform the restoration process, decision makers and the public. These activities will provide resource managers, elected officials, and other stakeholders with the timely, accurate and cost-effective information necessary for making decisions concerning the protection and restoration of the Great Lakes ecosystem so as to sustain healthy societies, economic activities and natural systems. Unfortunately, ecosystem monitoring, observation, research, indicator development and modeling efforts in the Great Lakes region are currently under-funded, lack comprehensive ecosystem approaches and exist only as piecemeal programs.

Despite these drawbacks, the volume of data collected for the Great Lakes and their tributary watersheds has expanded considerably in recent years, coinciding with an increase in the complexity of issues that need to be addressed. The current lack of accessible, integrated information management systems limits decision-making abilities and application of adaptive management principles for the protection and restoration of ecological resources. Adaptive management requires one to identify priority issues, gather information, establish metrics, evaluate options, implement actions, track progress, reevaluate actions based on observed responses, communicate results and adjust both management approaches and monitoring activities. Although such capabilities are advancing within the

Great Lakes basin, they exist only in piecemeal fashion and are have not been fully integrated for the comprehensive management of the Lakes. To further complicate matters, decisions made on one issue often affect other issues. Observing systems, monitoring programs, indicators, research, modeling and analysis, information management and communication must therefore be integrated into a holistic decision-making process.

Continued efforts are needed to ensure the viability of an informative and scientifically-based set of indicators (e.g., SOLEC indicator suite) that are useful for management decisions and to inform the public. The SOLEC indicator suite has been refined over the last decade to be comprehensive yet practical and actionable. Several of the Great Lakes Regional Collaboration strategy teams have, however, identified that other indicators are needed to track progress on specific restoration areas both locally and across the Great Lakes – St. Lawrence River basin. These will require additional research to develop realistic endpoints, cause-effect relationships, appropriate metrics and monitoring protocols.

The U.S. Commission on Ocean Policy highlighted the need for "unbiased, credible and up-to-date scientific information" to properly manage the human activities that effect the nation's oceans coasts and Great Lakes. The Commission found that new scientific findings demonstrate the complexity and interconnectedness of natural systems and that management approaches have not been updated to reflect this complexity with responsibilities remaining dispersed among a confusing array of agencies at the federal, state, and local levels. Managers, decision makers, and the public require timely access to reliable data and solid scientific information that have been translated into meaningful products.

Research on the Great Lakes specifically provides the understanding necessary to make informed, scientifically-supportable decisions and actions, to assess the associated risks, expectations and timelines of management actions, to plan for effective observation and monitoring programs and to identify sensitive and meaningful indicators of ecosystem status. Restoration requires research to develop innovative approaches and monitoring to determine if restoration is successful in meeting targets and goals. Research should be directed towards improving the understanding of natural fluctuations and interactions of ecosystem components. Improvements in predictive capabilities are needed, particularly regarding the impacts of chemical, biological and physical changes on ecosystem structure and function. Development of such capabilities requires a comprehensive research coordination strategy across partnering institutions.

Information produced by research and observations must be made readily available to managers, decision-makers and the public. This will require information integration, management and communication. Integration and management of information are hampered by institutional management approaches restricting access by outside entities and policy constraints that restrict a user's ability to discover the existence, location and characteristics of Great Lakes data.

The GLRC Strategy recommendations for the indicators and information strategy team include:

- To provide accurate, complete and consistent information, the Great Lakes region must increase and better coordinate the collection of critical information regarding the Great Lakes ecosystem. Monitoring must be better coordinated through the existing Great Lakes management entities, both at a lake-wide and region-wide basis.
- To meet the information and management needs of Great Lakes restoration activities, the Great Lakes Interagency Task Force should promote the continued development and implementation of science-based indicators, including implementation of indicators developed through the SOLEC process.

- To facilitate easy and accessible information exchange among all regional partners, stakeholders and decision makers and to create a consistent and comprehensive repository of Great Lakes data, the Great Lakes Interagency Task Force and all regional partners should augment the regional information management infrastructure (i.e. establish a network or networks), adopt standardized data management protocols and commit to open data availability.
- To coordinate and manage communication of scientific and technical information, the Great Lakes Interagency Task Force should establish a communications workgroup composed of public affairs specialists from Federal, State, and regional entities and key industries.

In their report, Prescription for Great Lakes Ecosystem Protection and Restoration: Avoiding the Tipping Point of Irreversible Changes, Bails et al. identified four primary management objectives, one of which is to better monitor ecosystem health and the progress of restoration and protection efforts. Monitoring the ecosystem response through an agreed-upon set of integrative indicators will be an extremely important part of any Great Lakes restoration effort. This effort should build on ongoing efforts such as the development and application of SOLEC indicators. Major changes in the ecosystem are occurring while many of the indicators that governments have traditionally used to measure Great Lakes health (water clarity, ambient water pollution levels, and certain contaminant levels in wildlife) are actually improving. Because nonlinear changes, such as those the Great Lakes are currently experiencing, may confound expected relationships between sources of stress and the lakes' response, traditional indicators may not be adequate descriptors of the health of the ecosystem and may not be useful in predicting future conditions. While some type of consensus on indicators is desirable, given the dynamic nature of the system and our understanding of it, flexibility must also be included in the development and use of indicators.

Certain features of the ecosystem appear to be particularly responsive to overfishing, nutrient loading, the release of toxic chemicals, land use practices, invasive plant and animal species, hydrologic alterations, and climate change. There have been varying degrees of research on integrative indicators of ecosystem integrity with most effort focused on emblematic species and wetland complexes. Some evidence suggests smaller organisms at the bottom of the food chain respond more quickly to change, and thus monitoring micro- and macroinvertebrates might well reveal the earliest signs of ecosystem disruption and/or recovery (Odum, 1985).

Accountability, Education, Monitoring, Evaluation, Outreach, and Partnerships Goals, Objectives, Measures and Actions in the Great Lakes Restoration Initiative Action Plan

Building on the environmental problems that have been highlighted through state-of-the-lakes efforts, in the scientific literature and in the science-based strategies in recent years, authors of the GLRI Action Plan incorporated issues associated with Accountability, Education, Monitoring, Evaluation, Outreach, and Partnerships as a focus area. The goals and objectives are consistent with the issues that were raised by these efforts. Thus, the goals for Accountability, Education, Monitoring, Evaluation, Outreach, and Partnerships included:

- A cooperative monitoring and observing system provides a comprehensive assessment of the Great Lakes ecosystem.
- The necessary technology and programmatic infrastructure supports monitoring and reporting, including Great Lakes

- Restoration Initiative project deliverables by all agencies and participating stakeholders. Data and information are provided in reports that are public friendly, timely and available on the Internet. Reports present integrated and scaled data from watersheds to lakes to Great Lakes basinwide.
- Increase outreach and education for the Great Lakes, and provide ongoing K-12 education for students to understand the benefits and ecosystem functions of the Great Lakes so they are able to make decisions to ensure that restoration investments are enhanced over time.
- Expand the range of opportunities for Great Lakes stakeholders and citizens to provide input to the governments and participate in Great Lakes issues and concerns.
- Work under the goals and objectives of the Great Lakes Water Quality Agreement is coordinated between the U.S. and Canada through Lakewide Management Plans (LaMP) and other binational processes, programs, and plans.

The GLRI Action Plan also incorporated specific objectives and actions for addressing the goals and metrics to gage progress. Table 10 provides a summary.

Table 10. GLRI Action Plan Goals, Objectives, Actions and Measures associated with accountability, education, monitoring, evaluation, communication, and partnerships

Great Lakes Restoration Initiative Action Plan (2010) Goals	GLRI Action Plan Objectives (see Action Plan for details)	GLRI Action Plan Actions	GLRI Action Plan Metrics (see Action Plan for details)
Accountability, Education, Monitoring, Evaluation, Communication and Partnerships Goals: • A cooperative monitoring and observing system provides a comprehensive assessment of the Great Lakes ecosystem. • The necessary technology and programmatic infrastructure supports monitoring and reporting, including Great Lakes • Restoration Initiative project deliverables by all agencies and participating stakeholders. Data and information are provided in reports that are public friendly, timely and available on the Internet. Reports present integrated and scaled data from watersheds to lakes to Great Lakes basinwide. • Increase outreach and education for the Great Lakes, and provide ongoing K-12 education for students to understand the benefits and ecosystem functions of the Great Lakes so they are able to make decisions to ensure that restoration investments are enhanced over time. • Expand the range of opportunities for Great Lakes stakeholders and citizens to provide input to the governments and participate in Great Lakes issues and concerns.	Accountability, Education, Monitoring, Evaluation, Communication and Partnerships Objectives: • By 2011, opportunities for collaboration, planning, data accessibility and accountability will be increased through the expanded use of internet-based technology. • By 2011, an Accountability System will be developed and implemented for the Initiative. • By 2011, a satellite remote sensing program will be implemented to assess Great Lakes productivity and biological events. • By 2011, outreach and education efforts are increased, including identifying and revising existing curricula to incorporate sustainable education needs for the Great Lakes that meet state and other relevant learning standards. • By 2011, a refined suite of science-based indicators for development of a comprehensive assessment of Great Lakes ecosystem health will be identified, monitoring programs for those indicators will begin to be implemented, and restoration and protection actions tied to those	Accountability, Education, Monitoring, Evaluation, Communication and Parternships Actions: Develop the Great Lakes Restoration Accountability System Measure and Evaluate the Health of the Great Lakes Ecosystem using the Best Available Science Support Great Lakes Restoration Education Enhance Partnerships	Measures of Progress: Improvement in the overall aquatic ecosystem health of the Great Lakes using the Great Lakes 40-point scale Number of priority LaMP (Lakewide Management Plan) projects that are completed Number of educational institutions incorporating new or existing Great Lakes protection and stewardship criteria into their broader environment education curricula

Great Lakes Restoration Initiative Action Plan (2010) Goals	GLRI Action Plan Objectives (see Action Plan for details)	GLRI Action Plan Actions	GLRI Action Plan Metrics (see Action Plan for details)
• Work under the goals and objectives of the Great Lakes Water Quality Agreement is coordinated between the U.S. and Canada through Lakewide Management Plans (LaMP) and other binational processes, programs, and plans.	assessments and programs assured. • By 2011, social media access opportunities for basinwide public involvement in the Initiative will be in place. • By 2012, education efforts under existing curricula that meet state and other relevant learning standards will be coordinated across states, and a system for tracking student and teacher outreach for their use. • By 2012, improved coordination with Canada will take place for programs under the Great Lakes Water Quality Agreement. • By 2014, a statistically valid and comprehensive assessment, using a probability-based design, of Great Lakes water resources, will be established. • By 2014, timely data and information will be provided to decision makers at multiple scales within a framework of established baselines, targets, indicators of progress, and monitoring.		

Citations

Great Lakes Regional Collaboration Strategy to Restore and Protect the Great Lakes. 2005. http://www.glrc.us/.

Prescription for Great Lakes Ecosystem Protection and Restoration: Avoiding the Tipping Point of Irreversible Changes, December 2005, Jack Bails, Alfred Beeton, Jonathan Bulkley, Ph.D., Michele DePhilip, John Gannon, Ph.D., Michael Murray, Ph.D., Henry Regier, Ph.D., Donald Scavia, Ph.D., http://www.snre.umich.edu/scavia/wp-content/uploads/2009/11/prescription_for_great_lakes_08_30_2006.pdf

Odum, E. P. 1985. Trends to be expected in stressed ecosystems. *Bioscience* 35:419–422.