

## INDICATORS AND INFORMATION

### I. Problem Statement

The Great Lakes ecosystem, the largest freshwater system in the world, is a dynamic and complex interaction of biological, chemical and physical components that are not yet fully understood. The sensitivity of this system to human influence has been demonstrated in recent decades through problems of invasive species, pollution, troubled fisheries and others have pointed to an urgent need for protection and restoration. Protection and restoration of the Great Lakes ecosystem require a well documented strategy, access to the best scientific information available, and coordinated action. A successful restoration strategy for the Great Lakes must 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 individual restoration projects either at local scales or basin-wide. 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, including the human communities.

Unfortunately, ecosystem monitoring, observation, research, indicator development and modeling efforts in the Great Lakes region are currently under-funded, lack comprehensive ecosystem approaches and where they exist, do so only as piecemeal programs. 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 lack of accessible integrated information 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. Also, 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.

Observing systems, including sensors, stations, networks and field data collection are the primary means for gathering information on the chemical, biological and physical characteristics of the Great Lakes ecosystem. These observations are used in a host of monitoring programs to take the pulse of the Great Lakes, assess natural variability, drive ecosystem forecasting models, and assess the progress of restorations efforts. Current challenges facing observing and monitoring include: incomplete inventories of federal, state/provincial and municipal observation and monitoring activities; insufficient spatial density of basic observations across the system; incomplete coverage over varying time scales (real-time to historic) and over space (site-specific, watershed, and region-wide); a lack of reliable and comparable monitoring protocols; and a lack of long-term financial commitments. Additional observation and monitoring are needed across the Great Lakes basin, including the open waters, coastal areas, tributaries and watersheds. Needed data collection efforts reach beyond measurement of the Great Lakes components and include such things as socio-economic data, inventories of pollutant releases or hazard potential and satellite remote sensing.

Some of the observations required are essential indicators that provide information on the state of the Great Lakes and progress toward achieving goals. Continued efforts are needed to ensure the viability of an informative and scientifically-based set of indicators (e.g., the State of the Lakes Ecosystem Conference (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 and yet practical to minimize complexity. 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. Indicators also need to be flexible enough to account for the unique conditions of each Great Lake, differences in temperature, trophic status, native biota, etc. In addition, indicators should be used in relation to realistic “end points” or desired results which are accepted by a clear majority of stakeholders. When creating end points, stakeholders also need to recognize that variability is the norm in natural systems; therefore, end points and target goals should not be expressed solely as discrete numbers but rather as a range of desired levels.

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. The Commission urged Congress to double the federal research budget over the next five years and to fund and adopt an integrated observing system on a regional basis.

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. The current funding level for Great Lakes research does not sufficiently support the level of research and development needed to address the host of ecological issues currently affecting the system to meet present-day demands. Any new restoration efforts will require coupled research and observations programs. Research has traditionally been focused on single issues. This focus must transition to an ecosystem approach with greater emphasis on predictive forecasting and adaptive management. 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. Data quality is also often not documented or communicated to data users. Coordination needs to be improved to ensure that critical decisions are made using the best available data. Standards for metadata (information about data) are required. Many institutions do not have the technological tools to implement data sharing protocols and applications such as Geographic Information Systems (GIS) and remote sensing techniques. Legal and institutional constraints, such as proprietary data and security provisions, can also adversely affect information sharing. A lack of strong, formal data exchange partnerships among Great Lakes organizations underlies many of these constraints.

Various methods are used to communicate information to those that require it, but coordination needs strengthening for the sheer breadth of information collected over the region. The lack of a coordinated message can make it difficult for audience groups to interpret and understand information. The audiences that require information are also diverse, requiring that complex information needs to be sufficiently repackaged to meet their needs. Some information, such as lake conditions and beach closings, requires rapid delivery. In addition, two-way communication needs to be promoted so that user needs are conveyed back to those producing the information. A comprehensive, two-way communication strategy has not been developed to address these needs.

## II. Goals and Milestones

### Goals:

- Stakeholders and decision makers 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 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. This network must be continually improved to adapt to technological advances and emerging informational needs of Great Lakes managers and stakeholders.
- Robust information gathering and integration tools be made available to support scientifically informed decisions. Decision-support tools must be flexible, not constrain the user's viewpoint, and offer enhanced abilities for multi-participant decision making. Predictive modeling tools should be applied to priority restoration issues and be spatially integrated to provide lake-wide assessments.
- Great Lakes research programs are conducted in a comprehensive, strategically coordinated manner and designed to meet user needs. Research should also be targeted at ecosystem level predictions.
- Progress achieved in the design of the scientifically-verified set of indicators for the Great Lakes ecosystem will be exploited. Indicators need to be implemented to meet the distinct needs of all user groups. A formalized approach for refinement of existing and development of new indicators should be followed to respond to evolving science, user needs, and ecosystem conditions.
- Standardized information management systems will be implemented by organizations within the region and connected through an integrated network of information systems. This should include application of appropriate information technology infrastructure and development of policies to share information across institutional and jurisdictional boundaries.
- Communication efforts in the Great Lakes will deliver accurate scientific and technical Great Lakes information to fulfill the needs of the decision makers, stakeholder groups, and the general public. Communication avenues must also be two-way, conveying user needs to information providers.

## III. Recommended Actions

All recommended actions call for greater coordination within the Great Lakes region, including participation of numerous partners at the federal, state, local/municipal, Native American, and binational levels and partners from industry, academia, public interest groups and the public to be effective.

**Recommendation 1: 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. The Great Lakes Interagency Task Force and other stakeholders need to implement the U.S. contribution to the Integrated Earth Observation System (IEOS) and the Integrated Ocean Observing System (IOOS as part of the Global Earth Observing System of Systems (GEOSS). Monitoring must be better coordinated through the existing Great Lakes management entities, both at a lake-wide and region-wide basis.**

Rationale: Observing systems and monitoring programs are the primary means for gathering information on the chemical, biological and physical characteristics of the Great Lakes ecosystem. These programs are needed to take the pulse of the Great Lakes, assess natural variability, drive ecosystem forecasting models, and assess the progress of restoration efforts. Monitoring and observing systems require continued improvements to adapt to changing technologies and informational needs of Great Lakes resource management. Initial activities should be focused on implementing the Great Lakes Observing System (GLOS) as the regional component of IOOS.

Concerted action to address lake-wide and basin-wide problems requires consistent and coordinated information collection across municipal, state and national boundaries. U.S. agencies must lead the way in expanding and coordinating ecosystem-based and issue-focused monitoring programs including protocols, scientific rationale, and integration of indicators. Such coordination should be done on a binational basis for each lake through the Lakewide Management Plans (LaMPs).

Cost: \$28 million for 5 years

**Recommendation 2: The Great Lakes Interagency Task Force should promote the continued development and implementation of science-based indicators to meet the information and management needs identified by the regional collaboration, including implementation of indicators developed through the SOLEC process.**

Rationale: Restoration of the Great Lakes ecosystem must begin with setting of clear and quantifiable goals and desired endpoints for critical Great Lakes attributes. A set of measurable and meaningful indicators is essential for determining progress in meeting these goals and in helping decision-makers adapt their management actions in accordance with the ecosystems response. High-priority, management-relevant indicators must be identified, scientifically developed and tested for each critical restoration issue. Current indicators need to be broadened beyond water quality issues and enhanced to draw in more stakeholder and scientific involvement. As an established and successful binational effort, the SOLEC process needs to receive increased financial support and participation to accomplish the goals of comprehensive regional assessments.

Cost: \$4 million for five years

**Recommendation 3: The overall federal research budget to the Great Lakes should be doubled over the next 5 years. In addition, adequate funds should be made available to support a Great Lakes Research Office as authorized in the 1987 Clean Water Act Amendments (33 U.S.C. 1268) to coordinate these research efforts. Finally, for all new appropriations in support of Great Lake's restoration activities, at least 10% of these funds should be dedicated toward research to aid planning and assessment.**

Rationale: Additional research is required to: a) set management goals and expectations; b) assess risks in management alternatives; c) identify the most cost-effective restoration strategies; d) evaluate connectedness to other components of the ecosystem; and e) evaluate progress in achieving management goals and expectations. Research needs to be focused on improving predictive capabilities regarding the lakes, particularly regarding the impacts of chemical, biological and physical changes on ecosystem structure and function. Per the U.S. Commission on Ocean Policy, overall research funding should be doubled over the next five years to fix the observation that "chronic under-investment has also left much of [the region's] infrastructure in woefully poor condition." The Great Lakes Research Office (GLRO) would work in conjunction with existing institutional entities to coordinate a comprehensive research strategy with an emphasis on predictive ecosystem-based research organized to address existing and emerging ecological issues. Great Lakes research programs need to be funded in accordance with an established research strategy, emphasizing research integration in the decision making process. The GLRO would closely coordinate all activities with the IJC's Council of Great Lakes Research Managers. Research should also be a fundamental and integral part of a comprehensive Great Lakes restoration program. At least ten percent of the restoration funding should be devoted to the effort. To support independent and localized investigations, increased support of university-based Great Lakes science is needed through increased competitive grants for Great Lakes research through the National Science Foundation and other federal and state programs.

Cost: Overall doubling of current research funding (an increase of approximately \$35 million over 5 years), plus 10% of any additional restoration efforts and \$600,000 annually (or \$3 million over 5 years) would be used to support the research office.

**Recommendation 4: The Great Lakes Interagency Task Force should establish a regional information management infrastructure (i.e. network of networks) to facilitate easy and accessible information exchange among all regional partners, stakeholders and decision makers. Regional partners need to adopt standardized data management protocols and commit to open data availability to create a consistent and comprehensive repository of Great Lakes data.**

Rationale: The U.S. Commission on Ocean Policy recognized that: “The data generated from increased research, enhanced monitoring networks, and new observing systems will be essential in improving our management of ocean and coastal resources. However, two major challenges face today’s data managers: the sheer volume of incoming data, which strains storage and assimilation capabilities, and the demand for timely access to the data in a variety of formats by user communities. Meeting these challenges will require a concerted effort to modernize the current data management system and will require greatly improved interagency planning and coordination.” In the Great Lakes, infrastructure is required to help turn data into useful information. Integrated and coordinated scientific and technical information is needed to adequately share results of ecosystem investigations with stakeholders. Long-term funding of an information management infrastructure to acquire and exchange timely, objective and accurate information is needed. The infrastructure will facilitate two-way communication between scientists and stakeholders, also allowing stakeholder needs to inform the investigations. The information management infrastructure should mesh with and augment existing infrastructure, such as the Great Lakes Information Network (GLIN) and provide for sustainability of such a network as an independent regional asset. A workgroup of information management professionals is needed to implement the distributed network of servers and databases to support this infrastructure. The workgroup should include representatives from key stakeholders with recognized data stewardship expertise and would coordinate interagency and inter-jurisdictional partnerships and mitigate institutional and legal barriers. The workgroup would promulgate data standards, quality assurance protocols, metadata production and region-wide multi-server search and access capabilities.

Cost: \$2 million per year for five years

**Recommendation 5: 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 to coordinate and manage communication of scientific and technical information.**

Rationale: Communications professionals from federal and state governmental agencies, environmental groups, regional and local organizations, Native American interests, relevant industry associations and academia would participate in the workgroup and provide oversight for the development and implementation of a comprehensive regional communications plan. The communication plan would include periodic reviews of audience needs and assess optimal methods of information delivery to decision-makers and the public. By sharing experience, tools and workloads, the workgroup would facilitate efficient and consistent delivery of Great Lakes information to disparate audiences and oversee small grants to regional and local organizations to enhance communications efforts. The workgroup should rely upon the expertise of the Great Lakes Sea Grant Network and the Great Lake’s Information Network. Increased support for NOAA’s Centers for Ocean Science and Education Excellence (COSEE) program in the Great Lakes is needed.

Cost: \$1 million per year for five years