The Great Lakes Nearshore Framework

Acknowledgements

This document represents the collective effort of many individuals working together to draft the Great Lakes Nearshore Framework. This document is a product of the Lakewide Management Annex Nearshore Framework Task Team under leadership of Janette Anderson of Environment and Climate Change Canada and Elizabeth Hinchey Malloy of the U.S. Environmental Protection Agency. Task Team members included: Eric Anderson, Deborah Brooker, Tim Bruno, Jan Ciborowski, Paris Collingsworth, Lisa Fogarty, Bonnie Fox, Amy Klei, Julia Koh Hatcher Ayyoub, Gail Krantzberg, Fred Luckey, Wendy Leger, Jim Lehnen, John Masterson, Greg Mayne, Jody McKenna, Gary Muller, Catherine Riseng, Rachel Melzer, Julie Simard, Dawn Walsh, Peder Yurista and Pete Zuzek. Nearshore Framework Writing Team members included: Janette Anderson, John Dettmers, Elizabeth Hinchey Malloy, Jim Lehnen, Jody McKenna, Scott Parker, Paul Seelbach and Pete Zuzek.

Many thanks go to the participants who attended numerous workshops and meetings and to the reviewers who provided input, feedback and overall advice on Nearshore Framework development.

Cover photo credits: Brenda Jones and Anna McCartney.

Contents

Purpose and Scope of the Nearshore Framework

The Great Lakes are the world's largest freshwater resource, providing a source of drinking water for over 40 million people in Canada and the United States. The waters of the Great Lakes, together with their 16,000 kilometres (10,000 miles) of coastline, connecting river systems and watersheds are globally significant ecosystems. Substantial progress has been made towards protecting the Great Lakes since the Canada – United States Great Lakes Water Quality Agreement was first signed in 1972; however, ecological degradation of nearshore waters threatens the health and sustained productivity of this valuable ecosystem. A "Nearshore Framework", *i.e*., a systematic, integrated and collective approach for assessing nearshore health and identifying and communicating cumulative impacts and stresses, is needed to inform and promote action at all levels to restore and protect the ecological health of Great Lakes nearshore areas. To address this need, the 2012 update of the Great Lakes Water Quality Agreement (GLWQA) requires that Canada and the United States (the "Parties") develop a Nearshore Framework for the Great Lakes to be implemented through the GLWQA's Lakewide Management process. Specifically, through the GLWQA the Parties committed to: provide a comprehensive assessment of nearshore waters; share the information from the assessment; identify areas requiring protection, restoration or prevention activities; and identify causes of impairment and threats. Responsible agencies at federal, state, provincial and local levels, community groups and others can then factor these findings into their priority setting processes, create collaborative approaches, and take action.

The purpose of the Nearshore Framework is to address ongoing and emerging challenges to the nearshore waters of the Great Lakes, where restoration, protection and prevention activities are critical to improving and sustaining the ecological health of Great Lakes coastal areas and enhancing attendant social, cultural, recreational and economic benefits. The Nearshore Framework is envisioned to be a new impetus for aligning the efforts of federal, provincial, state, tribal governments, First Nations, Métis, municipal governments, watershed management agencies, local public agencies and the public to protect the Great Lakes nearshore. Continued and strengthened coordination and collaboration are needed to manage and protect our nearshore waters and to prevent and minimize lakewide water quality and ecosystem impacts which may result from chemical, physical, or biological stresses within the Great Lakes Basin. The Nearshore Framework will support action for nearshore areas under stress and protection for nearshore areas of high quality.

The Nearshore Framework represents the culmination of discussion, inspiration and input from a wide range of people and organizations throughout the Great Lakes basin. The Nearshore Framework was developed for use by the governmental agencies that comprise the Lake Partnerships charged with developing and implementing Lakewide Action and Management Plans (LAMPs) for each Great Lake[1] and also for use by local communities and individual agencies.

[1] This framework does not recommend changes to existing federal/state/provincial/tribal/First Nation legal or statutory definitions or standards affecting the Great Lakes nearshore.

The Nearshore Framework's scope addresses the nearshore waters and embayments along the coast of the Great Lakes, the lakes' connecting river systems and the international section of the St. Lawrence River. The GLWQA recognizes the interconnectedness within the basin watersheds where material and water flow from problem areas and deliver degrading influences to the lakes and connecting channels. The Nearshore Framework acknowledges the relationship between the zone of impact in the lakes and the zone of influence (the location where a problem originates, which can occur up in the watersheds far-removed from the lakes themselves).

For the purposes of assessment, the nearshore is defined as the area of the Great Lakes and connecting rivers where waters are subject to direct influences from shorelands, watersheds and off-shore influences. The nearshore will not be rigidly defined by depth or distance from shore but by a zone of impact where these influences are observed.

Under the Great Lakes Executive Committee's oversight and coordination, the Nearshore Framework will be integrated with other GLWQA activities. Development of a Great Lakes Nearshore Framework is consistent with other large ecosystem management initiatives underway in North America and beyond including: UN Strategic Plan for Biodiversity 2011-2020; U.S. National Ocean Policy Implementation Plan; U.S. Coastal Zone Management Act of 1972; The Strategic Vision of the Great Lakes Fishery Commission 2011-2020; Canada's National Framework for Canada's Network of Marine Protected Areas; UN Transforming our World: The 2030 Agenda for Sustainable Development; The Upper Midwest/Great Lakes Landscape Conservation Cooperative; 2014 Canada-Ontario Agreement on Great Lakes Water Quality and Ecosystem Health; and Ontario's Great Lakes Protection Act, 2015.

Call to Action

As the world's largest freshwater ecosystem, the Great Lakes are socially, economically, and environmentally significant to the region, the nation and the planet. The Great Lakes are ecologically and culturally rich and they provide ecological goods and services that are important to the region's societal health and well-being. Nearshore areas are a key priority for restoration and protection because they are the source of drinking water for most communities within the basin, are the areas of the lakes where most human recreation (e.g., swimming, boating, fishing, wildlife viewing) occurs, and are the critical ecological link between watersheds and the open waters of the Great Lakes. A sustainable and prosperous Great Lakes economy is dependent upon a healthy nearshore ecosystem and clean freshwater (Vaccaro and Read, 2011; Seelbach *et al*., 2014).

At numerous places along the Great Lakes nearshore, conditions have become degraded due to a variety of human-induced, climate-induced and invasive species-induced stressors. Human activities in the landscape have a more direct influence on nearshore water quality than on offshore water quality (Yurista *et al.,* 2015). Nearshore water quality may serve as a sentinel for the longer-term trajectory of offshore water quality and lake-wide condition (Yurista *et al*., 2015, Yurista *et al.,* 2016). Management of the nearshore is challenging because the nearshore is a complex, highly variable environment in which tributary inflows and open water processes vary spatially and across daily, seasonal and annual temporal scales.

Government agencies, academics and non-government organizations have made significant investments in nearshore monitoring, assessment and protection and/or restoration; however, there is no comprehensive assessment of overall nearshore condition and the key stresses affecting that condition. Consequently there is no accepted means to identify areas most in need of remediation and/or protection from cumulative stresses. The Framework recognizes that preventing degradation in currently healthy areas is much less costly than remediating areas that have been allowed to degrade.

The "Nearshore Waters of the Great Lakes" (Edsall and Charlton 1997) and the "Nearshore Areas of the Great Lakes" (EC and U.S. EPA 2009)[2] provide rationale for a binational focus on the Great Lakes nearshore aquatic system. The concept of a Great Lakes Nearshore Framework was introduced at an International Joint Commission (IJC) Nearshore Priority Expert Consultation Workshop in 2007 (IJC 2009). The 2009-2011 IJC Priority Cycle "Work Group Report on A Nearshore Framework" (IJC 2011) recommended an adaptive management approach for the Nearshore Framework and focused heavily on the need for better agency collaboration and integration of watersheds in nearshore management.

The 2012 GLWQA presents both a commitment and a unique opportunity to establish a nearshore assessment and management framework that adapts to changing ecological conditions and embraces innovative solutions to maximize ecological function, sustain desirable ecosystem services, and increase resilience to current and anticipated stressors.

Guiding Principles

Principles are a powerful guide for uniting and engaging partners, including governmental and non-governmental agencies and local communities and organizations, to collectively develop solutions and promote action. The following five key principles reflect expert input and lessons learned from other international examples of collaborative approaches for ecosystem management and will be used to guide collective efforts to assess condition and to take action to protect and restore the nearshore under the Nearshore Framework.

Key Principle 1: Healthy Great Lakes Support Healthy People:

- Recognize that the Great Lakes and their watersheds are the foundation of the region's prosperity and collective well-being and sustain a rich variety of plants, animals, and habitats;
- Recognize that the Lakes also provide a source of drinking water for over 40 million people, foster subsistence that is integral to the heritage of many traditional and aboriginal cultures, and create recreational opportunities vital to our economy and well-being; and
- Recognize that the Great Lakes are a vast shared resource containing a significant portion of the world's freshwater, and that they provide the foundation for trillions of dollars in economic activity.

[2] These background papers were developed for the 1996 and 2008 State of the Lakes Ecosystem Conferences.

Key Principle 2: Collaborative Governance:

- Base decisions on listening and seeking emergent wisdom among parties representing the spectrum of societal interests.
- Respect the roles of governments, the private sector, and society in decision making, and the need for highly cooperative and integrated interventions to address coastal management issues and opportunities.
- Foster and maintain working relationships with First Nations, Métis and tribal governments in the context of their traditional territories, cultural beliefs and traditional ecological knowledge.
- Acknowledge aboriginal rights and title and perspectives.

Key Principle 3: Ecosystem-based Management:

- Apply a holistic, science-based approach to understand and manage landscapes and resources in a healthy and sustainable manner.
- Recognize zones of influence and zones of impact using a place-based approach.
- Work across geographies, jurisdictions, and disciplines.
- Focus on underlying processes that drive systems at multiple scales.
- Recognize that humans are a part of the ecosystem and that our activities affect the ecosystem and that we depend on the services that the ecosystem provides.
- Maintain resilient ecological systems such that desired ecosystem structures and functions are maintained following disturbances.

Key Principle 4: Iterative Learning and Action:

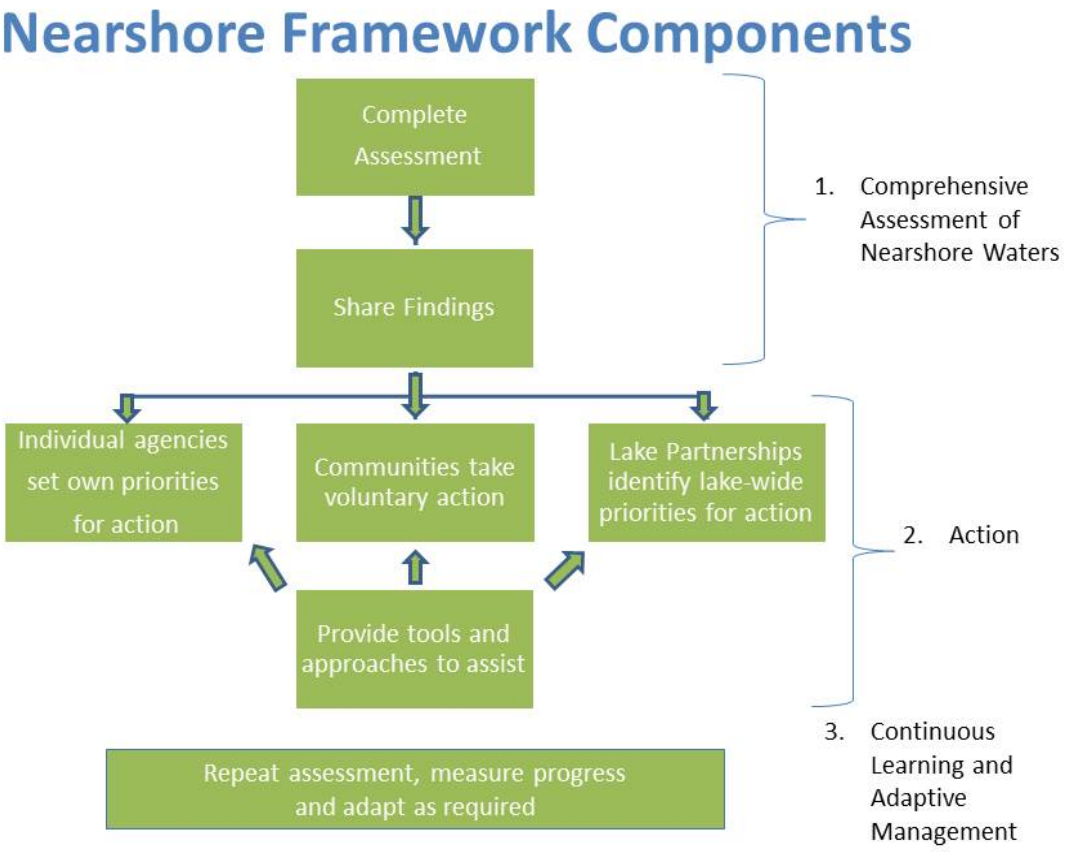
- Agree to be a "learning community", regularly adjusting actions to address changing conditions and new knowledge through adaptive management.

Key Principle 5: Responsibility and Accountability:

- Establish clear and unambiguous roles and responsibilities.
- Be publically accountable for making decisions and taking action to achieve mutually-desired outcomes for the Great Lakes nearshore.

Nearshore Framework Components:

The Nearshore Framework has three components: 1) Comprehensive Assessment of Nearshore Waters, 2) Action, and 3) Continuous Learning and Adaptive Management (Figure 1), described below.



1: Comprehensive Assessment of Nearshore Waters

The Parties, building upon existing monitoring, research and reporting and in collaboration with key governmental and non-governmental partner agencies and organizations, will assess the state of Great Lakes nearshore areas to produce information and maps showing areas of high quality and areas under stress. Knowledge of ecological thresholds, other Great Lakes assessments, stressor information, indicators and traditional ecological knowledge will be used to aid in: 1) the identification and mapping of high quality nearshore areas and areas that are or may become subject to high stress and; 2) the determination of factors and cumulative effects that are causing stress or threats.

The assessment will require the assembly and coordination of a range of data from multiple sources into a coordinated geospatial data framework[3]. The ability to use geospatial data to analyze effects of a combination of different impacts on coastal systems is valuable not only for measuring the health of

[3] Geospatial data has explicit geographic positioning information included within it allowing it to be depicted on maps and charts (National Research Council 2004).

coastal environments but also for coastal planning and management assistance (European Environment Agency, 2013). Maps produced with geospatial data can integrate information that has traditionally been analyzed separately, allowing for effective ecosystem-based management (European Environment Agency 2013). It is anticipated that the Nearshore Framework's reliance on data sharing amongst partners will be facilitated by the ongoing and future adoption of "open data" initiatives by Great Lake partner agencies, organizations and communities. The approach to completing the assessment involves three phases (for additional details, see Appendix 1 "Conducting a Baseline Survey of Great Lakes Habitat" draft May 2016) as follows:

- Phase 1 involves delineation of the nearshore into units which are then classified by ecosystem type (*e.g.,* shoals, high energy shores, coastal wetlands, river mouths, embayments, depositional areas). These ecosystem types have been created and are maintained by physical processes and lake characteristics that change at a relatively slow rate (*e.g.,* wave energy, bathymetry, substrate type, geomorphology and distance to rivers). Once ecosystem types are classified, human impacts can be assessed, individual units and/or ecosystem types can be prioritized for protection and/or restoration and the condition of these units and ecosystem types can be compared and monitored for change over time (Roff *et al.,* 2003).

- Phase 2 involves the assessment of each unit using dynamic parameters (*i.e*., characteristics of habitat that are likely to change at a more rapid rate than physical parameters). To determine the condition of each unit, data and information on water quality (pH, dissolved oxygen, conductivity), water clarity, aquatic vegetation composition, sediment condition, benthic community composition, chlorophyll *a* and other parameters as appropriate, will be compared to thresholds. The assessment will also take into account the impact of nearshore conditions on human uses by incorporating data related to designated uses for nearshore waters (*e.g.,* fishing, swimming, drinking water), and social and cultural impacts (*e.g*., local, traditional and aboriginal cultural heritage and Traditional Ecological Knowledge).

- Phase 3 involves the review of biological information, because biota (*e.g.,* fish, waterfowl, reptiles and amphibians, and benthic organisms) are the final interpreters of ecological condition. Whether native biota thrive or not indicates whether habitat is of adequate quality to support their life processes. The final phase of the assessment will use existing data on key attributes of biological assemblages, guilds and communities to confirm findings of the condition assessment of units.

Improvement in nearshore condition will be measured over time by reassessing nearshore conditions using the comprehensive assessment approach described above in each Great Lake and connecting river system and comparing assessments over time. It is proposed that the Nearshore Framework assessment align with the reporting year of the GLWQA Cooperative Science and Monitoring Initiative

(CSMI) rotational cycle for a given lake[4], to take advantage of opportunities to incorporate relevant nearshore data from the CSMI year of cooperative monitoring into the assessment and allow the Lake Partnerships to incorporate the assessment results into their respective LAMP. Results of the assessments will be shared with individual agencies, communities and the public.

As the data and information to support the Nearshore Framework are assembled and applied to complete the assessment, cumulative effects impacting the nearshore and future threats to areas of high ecological value will be better understood and the knowledge shared will assist in priority setting for science and management.

2: Action

Building upon the information provided by the assessment, locally-led collaborations of Federal, State and Provincial Governments, Tribal Governments, First Nations, Métis, Municipal Governments, watershed management agencies, local public agencies and the Public will be able to identify management priorities, take action to protect nearshore areas of high ecological value, protect water quality, and restore degraded areas. In keeping with the Nearshore Framework Guiding Principles, the Parties will share information, tools and approaches as follows below.

The Parties will:

- Provide the assessment results and maps;
- Provide access to all information upon which assessment is based;
- Assist in identifying causes of stress in areas found to be in poor condition;
- Assist in assessing risk and threats to areas found to be in high quality condition;
- Share tools and approaches to help communities engage and take action to improve nearshore water quality and ecosystem health and protect nearshore areas of high quality;
- Document and share success stories from communities that have successfully addressed nearshore issues.

3: Continuous Learning and Adaptive Management

The comprehensive assessment will be repeated on a five-year rotational cycle i.e., one lake and its associated connecting river system(s) will be assessed per year. The consistency of the assessment approach will allow trends to be identified and will enable the determination of improvement or degradation of water quality and ecosystem health across nearshore ecosystem types.

[4] CSMI implementation timeline: Year 1: Report communicating results from previous monitoring year & identification of science/monitoring needs; Year 2: Planning; Year 3: Year of cooperative science and monitoring; Year 4: Laboratory analysis; Year 5: Data analysis and report writing (and repeat cycle)

The Nearshore Framework approach will evolve over time based on experience gained in applying the framework and through advancements in science. In the same manner, tools and approaches for community action should be regularly reviewed and updated to reflect lessons learned from implementation. Successful models from outside the Great Lakes ecosystem should be regularly reviewed and considered for applicability to the Nearshore Framework.

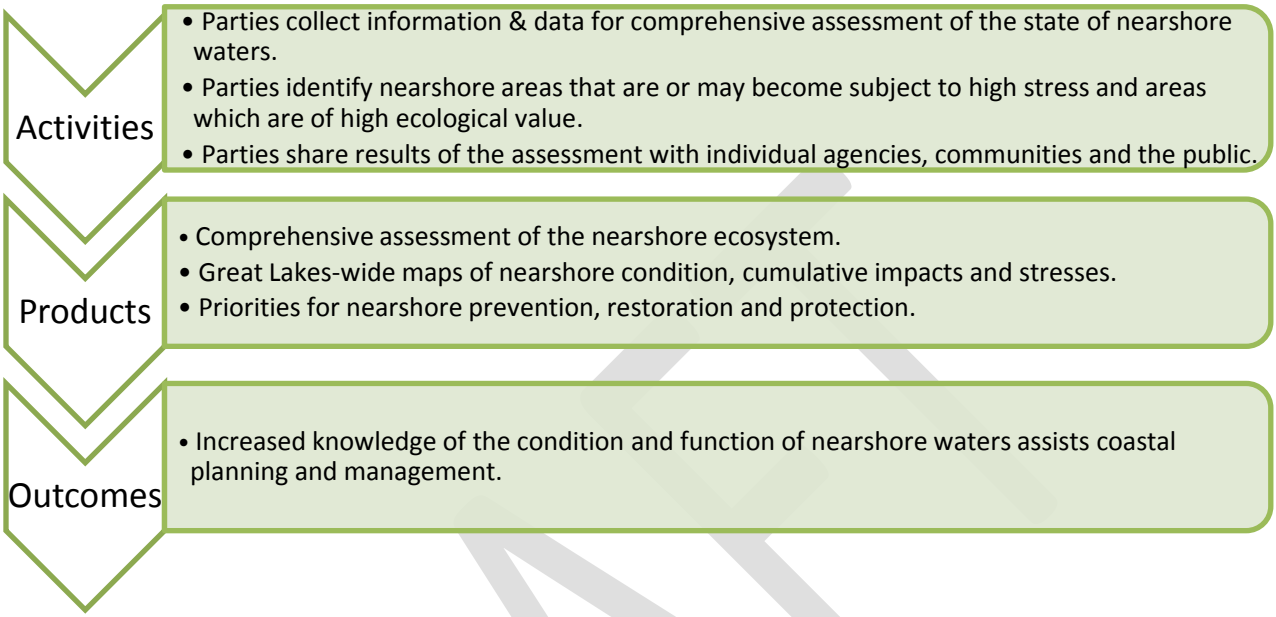
It is in the spirit of continuous learning and adaptive management that the Parties propose implementation of the Nearshore Framework begins with pilot testing of the approach, beginning in 2016-17. Following pilot testing the Nearshore Framework will be modified based on lessons learned prior to being applied on a lakewide scale.

The implementation of this Nearshore Framework will result in an increased understanding of the state of nearshore waters and an increase in our collective understanding of the importance and need to prevent degradation, restore and protect nearshore areas. Seeking ways to enhance the transfer of knowledge, expertise, and approaches across both sides of the border will maximize our binational successes under the Nearshore Framework. This will lead to the following long-term outcomes:

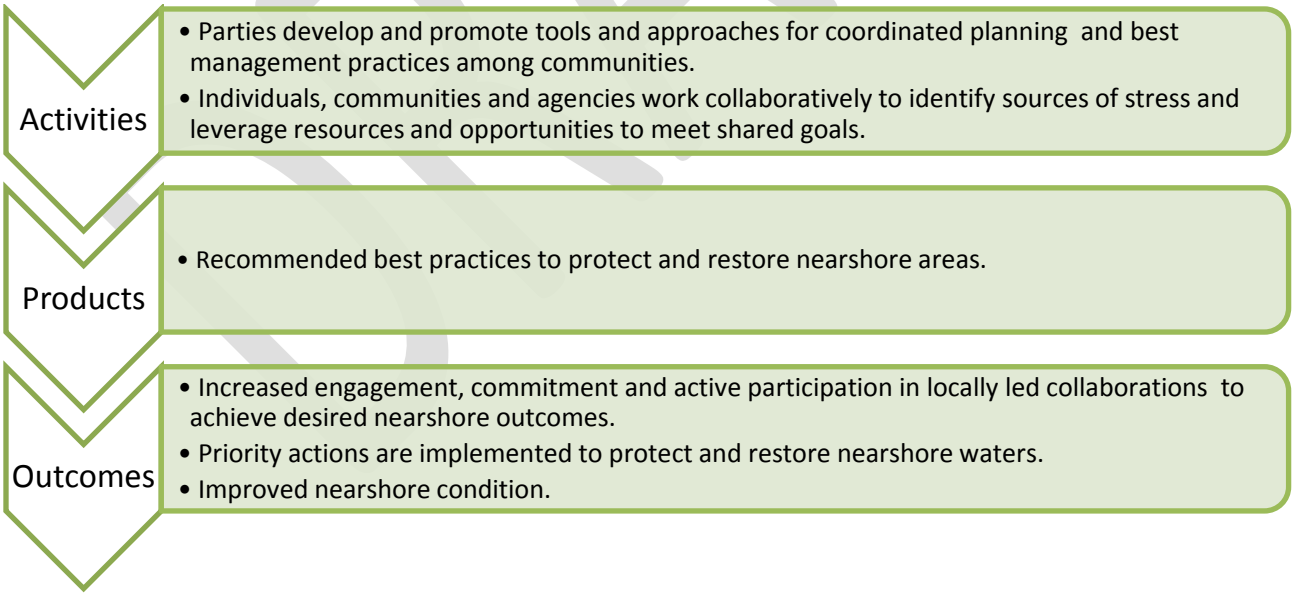
- Improved water quality and ecosystem health at both local and lake-wide scale;
- improved and more resilient structure and function of nearshore ecosystems;
- reduced cumulative impacts of human activities in nearshore areas;
- a decrease in unsustainable uses of nearshore waters; and
- increased public and partner awareness of the value of and, stewardship of, and investment in, the Great Lakes.

For each Nearshore Framework component, the following activities, products and outcomes are identified:

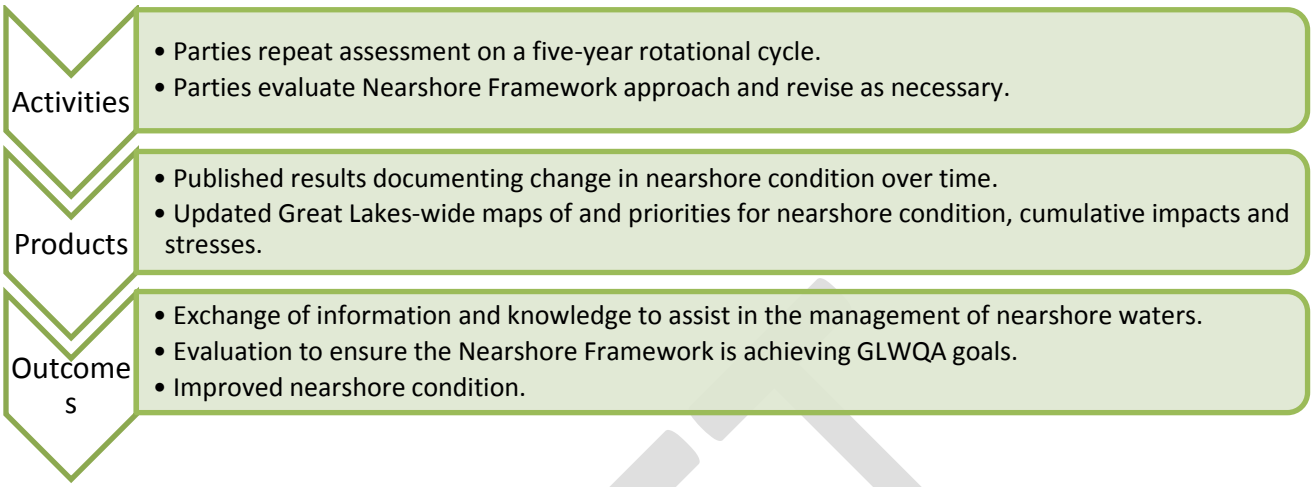
Component 1: Comprehensive Assessment of Nearshore Waters



Component 2: Action



Component 3: Continuous Learning and Adaptive Management



The Path Forward: Initial Steps along the Great Lakes Coast

The Great Lakes Water Quality Agreement commits the Parties to conduct a baseline assessment of existing habitat in the Great Lakes. This assessment will be used to establish a target of net habitat gain and to measure future progress. The assessment approach (see Appendix 1, "Conducting a Baseline Survey of Great Lakes Habitat," currently under review) has been developed to meet the specific needs of both the Nearshore Framework's comprehensive assessment of nearshore waters and the baseline survey of Great Lakes habitat, given that the two commitments require similar information and overlap geographically in the nearshore area. The Nearshore Framework assessment will be limited to the nearshore waters and will have additional components such as the consideration of water quality impacts on human uses while the baseline survey of Great Lakes habitat will encompass the Waters of the Great Lakes (*i.e.,* nearshore and open waters and connecting river systems) and will be limited to impacts on native species and their habitats. An implementation task team led by the Parties will define the approach for the initial assessment and pilot it in one or more areas of the Great Lakes nearshore. Ideally, the pilot would include an area of high ecological value and an area that is or may become subject to high stress. A final product of the task team will be a manual detailing the analysis procedures and quality control measures required.

As recognized in the GLWQA, no single government or agency has the ability to achieve the Agreement objectives alone; involvement and participation of State and Provincial Governments, Tribal Governments, First Nations, Métis, Municipal governments, watershed management agencies, local public agencies, and the Public is essential. Successful implementation of the Nearshore Framework will require partner support at all levels and the accompanying shared sense of responsibility. Active participation along with ecosystem based management, multi-jurisdictional collaboration and a shared sense of responsibility for stewardship by the people and their leaders are needed for sustainable governance of the Great Lakes (Manno and Krantzberg, 2008).

References

Great Lakes Water Quality Agreement Protocol, 2012.

EC and U.S. EPA. 2009. Nearshore Areas of the Great Lakes 2009. ISBN 978-100-13562-5.

Edsall, T.A. and Charlton, M.N. 1997. Nearshore Waters of the Great Lakes. State of the Lakes Ecosystem Conference 1996 Background paper.

European Environment Agency. 2013. Balancing the future of Europe's coasts - knowledge base for integrated management. ISSN 1725-9177.

IJC (International Joint Commission). 2011. Work Group Report on a Nearshore Framework. IJC 2009-2011 Priority Cycle.

IJC (International Joint Commission). 2009. Workgroup Report on Nearshore Framework. Priorities 2007-2009 Series.

Manno, J. and Krantzberg, G. 2008. Rediscovering and revitalizing the Great Lakes governance. In Governance for Sustainability—Issues, Challenges, Successes; Bosselmann, K., Engel, R.,Taylor, P., Eds.; IUCN: Gland, Switzerland, pp. 159–170.

National Research Council. 2004. A Geospatial Framework for the Coastal Zone. The National Academies Press, Washington, D.C. ISBN: 0-309-53110-1.

Roff, J.C., Taylor, M.E. and Laughren, J. 2003, Geophysical approaches to the classification, delineation and monitoring of marine habitats and their communities. Aquatic Conservation: Marine and Freshwater Ecosystems, 13:77-90.

Seelbach, P.W, J.G. Read, K.A. Buckner, T. Eder and C. Manninen. 2014. Great Lakes Blue Accounting: Empowering Decisions to Realize Regional Water Values. A Report to the Council of Great Lakes Governors, in response to the governor's 2013 resolution on water monitoring, March 28, 2014.

Vaccaro L, and Read J. 2011. Vital to Our Nation's Economy: Great Lakes Jobs Report (Michigan Sea Grant), Available at http://www.miseagrant.umich.edu/downloads/economy/11-203-Great-Lakes-Jobs-report.pdf. Accessed March 2016.

Yurista, P.M., Kelly, J.R., Cotter, A.M., Miller, S.E., and Van Alstine, J.D. 2015. Lake Michigan: Nearshore variability and a nearshore–offshore distinction in water quality. Journal of Great Lakes Research. 41:111-122.

Yurista, P.M. Kelly, J.R., and Scharold, J.V. 2016. Great Lakes nearshore-offshore: distinct water quality regions. Journal of Great Lakes Research. 42: 375–385.

Appendix 1: Conducting a Baseline Survey of Great Lakes Habitat (draft May 2016)

Contents

Introduction:

The Great Lakes ecosystem is the world's largest freshwater system. It supports globally rare habitats and species and many spectacular natural features. However, there has yet to be a comprehensive, coordinated basin-wide assessment of the fish and wildlife habitats of the Great Lakes that will establish a baseline against which to measure progress in improving quantity and quality of habitat.

In 1978, the need for restoration and enhancement of water quality in the Great Lakes ecosystem was recognized in the binational Great Lakes Water Quality Agreement (GLWQA). While the original agreement was proactive and bold for its time, the revised 2012 agreement was significantly expanded to include 10 Annexes, including one featuring Habitat and Species. The purpose of the Habitat and Species Annex (Annex 7) is to contribute to achievement of the General and Specific Objectives of this Agreement by conserving, protecting, maintaining, restoring, and enhancing the resilience of native species and their habitat, as well as by supporting essential ecosystem services. In addition to working towards this purpose, the Parties are committed to:

"…conduct a baseline survey of the existing habitat against which to establish a Great Lakes Basin Ecosystem target of net habitat gain and measure future progress".

To meet this commitment the Habitat and Species Subcommittee formed the Baseline Assessment Task Team and directed the members (Appendix) to:

1. Inventory existing surveys of habitats and species.

2. Develop recommendations for assessing net habitat gain based on information in the Biodiversity Conservation Strategies, existing programs, and supporting science.

3. Identify, evaluate, and recommend new approaches for spatial monitoring of habitat extent and condition, including remote-sensing, to conduct baseline surveys

The commitment to develop a Nearshore Framework under the Lakewide Management Annex (Annex 2) calls for a similar assessment of the Great Lakes:

"…provide an overall assessment of the state of the nearshore Waters of the Great Lakes… " and *"…to assess changes in the nearshore over time".*

The Task Team seized the opportunity to maximize efficiency by leveraging the expertise of both groups to develop a single overall assessment approach. The survey can be adapted to meet the specific needs of the Nearshore Framework as the two commitments require similar information and overlap geographically in the nearshore area. The Nearshore Framework assessment will be limited to nearshore waters and will have additional components such as consideration of human factors (*i.e.*, impacts on human health and uses), while the Baseline Survey will encompass both nearshore and offshore waters and will be limited to factors that impact native species as per the GLWQA. In consultation with many experts in the field of habitat assessment, the Task Team reviewed a number of Great Lakes initiatives:

- Great Lakes Aquatic Habitat Framework (GLAHF)
- Great Lakes Regional Aquatic Gap Analysis
- Great Lakes Environmental Assessment and Mapping Project (GLEAM)
- Great Lakes Environmental Indicators (GLEI)
- Great Lakes Coastal Wetland Consortium
- Great Lakes Basin Fish Habitat Strategic Plan, Great Lakes Basin Fish Habitat Partnership
- State of the Great Lakes Indicators (SOLEC)
- Great Lakes Biodiversity Conservation Strategies
- Cooperative Science and Monitoring Initiative (CSMI)
- U.S. National Coastal Condition Assessment (NCCA)

Approaches, tools and programs for assessing the Great Lakes basin habitat are extensive and while no existing survey or assessment program met the entire needs of the Baseline Survey, the existing programs did offer information or methods that can be used to develop a consistent basin-wide survey. As the baseline assessment is implemented, a more in depth review of existing monitoring programs will be conducted.

What follows is the recommended approach for defining habitat extent and condition resulting from the Task Team's deliberations over 2 years during conference calls, meetings and three binational workshops. Implementation of the approach will be led by the Parties but will be dependent on a

commitment and contributions from potential partner agencies to collaborate, share data and begin the tasks in an iterative process.

With the new assessment, comes an opportunity to strengthen collaborative actions to conserve, protect, maintain, restore and enhance the resilience of native species and their habitat, as well as supporting essential ecosystem services and to achieve a net gain in habitat. A net gain in habitat will require an understanding of not just the quantity of the habitats that comprise the Great Lakes, but also their functionality and condition. Taking a "place-based" approach is advised which will consider physical characteristics and natural processes that structure, organize and define aquatic ecosystems and regulate the biological and chemical elements of the system. This is a primary step in creating a holistic understanding of the Great Lakes ecosystem.

Defining Habitat and Functionality:

Sustainable aquatic life is the outcome of a healthy ecosystem; structured, organized, and defined by the natural physical and chemical processes of the lakes including hydrology, fluvial and nearshore hydraulic and sediment processes, connectivity, connections with groundwater and open lake processes. The diversity of habitats used by biota to meet their full life cycle requirements varies for each species and they are dynamic over time. For example, a walleye spawning in river rapids in the spring can be found in the depths of the lakes in the summer, and a migrating duck relies on wetlands as nesting and staging areas during their migration in the spring to the far north and their return south in the autumn.

The entire Great Lakes basin is a globally significant resource in terms of the habitat it provides for fish and wildlife. In recognition of these significant resources, many governmental and nongovernmental organizations continue to pursue high priority conservation activities that support these resources throughout the entire basin whether within the Great Lakes proper or in watersheds. The GLWQA recognizes the interconnectedness within the basin watersheds where material and water flow from problem areas and deliver degrading influences to the lakes and connecting channels. The Nearshore Framework and the individual lake "Biodiversity Conservation Strategies" acknowledge the relationship between the zone of impact in the lakes and the zone of influence (the location where a problem originates, which can occur up in the watersheds far-removed from the lakes themselves.

The Baseline Survey is restricted to aquatic ecosystems in the *Waters of the Great Lakes*[5], based on two considerations:

1. The General Objectives of the GLWQA state that the *Waters of the Great Lakes* should support healthy and productive wetlands and other habitats to sustain resilient populations of native species (Article 3 (a) (v));

Habitat:

For the purposes of the Baseline Survey, Great Lakes habitats are defined as the physical, chemical, and biological characteristics and interactions over space and time in the Great Lakes, which support the life requirements of aquatic-dependent species for their sustained production.

[5] The upper limit of the Survey will be set at a historical extreme high water level to be determined by the implementation team in consultation with the International Joint Commission.

2. *Waters of the Great Lakes* is defined in the GLWQA as Waters of Lakes Superior, Huron, Michigan, Erie, and Ontario and the connecting river systems of St. Mary's, St. Clair including Lake St. Clair, Detroit, Niagara, and St. Lawrence at the international boundary or upstream from the point at which this river becomes the international boundary between Canada and the United States, including all open and nearshore waters (Article 1 (j)).

Target habitats will therefore be restricted to:

- Connecting channels
- Coastal wetlands
- Shorelines
- River mouths
- Nearshore waters
- Open lake waters.

While streams, tributaries, inland lakes and wetlands, and upland terrestrial areas in the entire basin provide habitat for many species at various life stages, they are not included in the scope of this Baseline Survey. This practical decision does not diminish the enormous influence that conditions in watersheds have on the Great Lakes proper and that many of the factors that must be modified to achieve net habitat gain are located within watersheds. It also does not preclude or limit other Great Lakes agencies, organizations or academics from similar assessment efforts in the watersheds of the Great Lakes Basin, in fact it is encouraged. The Baseline Survey approach is to tackle the important and significant technical challenge of assessing the habitat of the Great Lakes proper while tracking this approach over time and making adjustments as needed.

A Great Lakes Basin Ecosystem Target of Net Habitat Gain

Establishing Targets:

The Baseline Survey approach will establish a baseline of quantity and condition of existing Great Lakes habitat and will allow for further assessments to determine whether future changes result in a net increase in quantity of certain habitats and improvement in habitat condition. A net gain in habitat for native fish and wildlife species is an overarching target. Numeric and narrative targets may be developed for specific habitats and species, at relevant geographic scales, to support local conservation and restoration strategies and action plans, as appropriate. They should be based on information gained from the Survey, the Biodiversity Conservation Strategies developed for each lake/connecting channel, existing programs and supporting science. Preliminary discussions have resulted in some initial concepts that will be explored further during the implementation phase. The target(s) for Net Habitat Gain may be set and described in terms of achieving one or more of the following:

1. **A spatial increase in "priority habitats"[6] for communities of native fish and wildlife species.**

Agencies such as the U.S. Fish and Wildlife Service, Environment and Climate Change Canada, Canada's Department of Fisheries and Oceans, National Park Service, Parks Canada and many state, provincial and local agencies as well as non-governmental organizations are dedicated to understanding population health of priority, aquatic dependent species, their habitat needs and the availability and extent of habitat to support them. Increases in spatial extent of specific habitat types over time will be one measure of net habitat gain.

2. **Improvement in habitat condition and functionality of habitat types from *severely degraded and not functional* to *degraded but functional* and then to *high quality and highly functional.***

The Baseline Survey will assess the condition of habitats by comparison to established thresholds[7] for variables which correspond with measures of ecosystem health. Changes in condition in future surveys will be determined as either deteriorating, maintaining or improving compared to baseline conditions. A determination of improvement over time could then be regarded as a net gain in habitat.

3. **Maintaining the Condition of High Quality Habitat**

Recognizing the high costs associated with remediation actions, efforts to maintain the quality of highly functional habitat may also be considered as a measure of net gain. While targets might be set to measure improvement of a degraded area they may also be set to maintain a unit that is in pristine condition.

The Baseline Survey Approach:

The recommended approach for conducting the Baseline Survey involves three phases:

1. Delineation and classification of habitat
2. Assessment of habitat condition and functionality
3. Biological confirmation of the Survey

The Survey will rely on remotely sensed data, existing information and information that are anticipated to be collected as part of ongoing agency/other programs wherever possible. Because of the high cost of collecting information, getting coverage in such a large system and sustaining monitoring programs, this approach is designed with a heavy reliance on existing and evolving data sharing practices across the Great Lakes. The ability to measure change over time is imperative, so a data management system will be used to spatially organize data.

Phase 1: Delineation and Classification of Habitat

Phase 1 involves delineating the Great Lakes and connecting rivers into units which are then classified by ecosystem type (*e.g.,* shoals, high energy shores, coastal wetlands, river mouths, embayments, depositional areas). These ecosystem types result from and are maintained by physical processes and

[6] To be defined during the implementation phase.
[7] To be defined during the implementation phase.

lake characteristics that form the basis of habitat structure and that often change at a relatively slow rate (*e.g.*, mean wave energy, bathymetry, substrate type, geomorphology, and distance to rivers). It is necessary to recognize and understand the structure of the aquatic ecosystem because fish and wildlife respond to the structural components of their habitat and the physical dynamics that shape their environment.

Table 1 contains the proposed variables identified by the Task Team that may be used to characterize the units. This approach acknowledges and builds upon the work undertaken by the Great Lakes research scientists involved in the Great Lakes Aquatic Habitat Framework (GLAHF) project (http://glahf.org/) who have developed a spatial framework, database and classification for Great Lakes ecological data. As these projects (GLAHF and the Baseline Survey) are further developed and refined, it will be critical to share experiences and knowledge gained along the way towards fulfilling the research objectives and those of the GLWQA and to strive for compatibility wherever possible.

Table 1: Proposed Physical Variables

Physical Variable:	Characterized by:	Rationale
Depth	Meters below surface.	Affects light attenuation, vegetation, energy, temperature.
Surficial Substrate	Bedrock, sand, clay, mud, etc.	Substrate defines types of habitat and potential for vegetation, fish spawning, etc.
Wave energy	Incident in-lake gradients – Joules/m2/yr	Wave energy drives geomorphic evolution in the coastal zone, which creates diversity in habitat.
Geology and Geomorphology	Geologic framework and geomorphic features.	Geologic framework (e.g., bedrock) and geomorphic features (e.g., embayments) create different types of habitat.
River mouths	Delta, river mouth and upstream extent of lake influences.	River mouths connect watersheds to the lake/connecting channel, deliver water, nutrients and create sheltered habitat.

Water surface temperature	Cumulative degree days, annual mean.	Gradients in annual water temperature provide different habitat for different types of fish.
Aquatic Vegetation	Presence/absence of emergent vegetation.	Indicates wetlands.

Refinement of the list of variables and ground-truthing using knowledge of habitat components and biota within the Great Lakes will be necessary during the implementation stage when the available data are compiled and the baseline assessment begins. Available datasets will be assessed for their ability to represent the physical variables of interest at the spatial scales necessary for the assessment. A pattern analysis using these variables will assist in mapping areas of relative ecological uniformity and classifying them. A nested approach which delineates smaller and larger scale units may be used as a reporting mechanism to accommodate the spatial resolution of the variables used for the condition assessment. Recognizing the three dimensional nature of the Great Lakes, three-dimensional water column information will be summarized and depicted in two-dimensional maps to start; however, in future it may be possible to incorporate the third dimension in more advanced mapping products as they are developed. Repeating the delineation and classification should be considered in five or ten year timeframes.

Proposed Delineation and Classification Method	The data characterizing physical processes will be divided into appropriate categories of ranges and assigned a code. For example; wave energy density could be divided into groups such as: high-2, medium-1, or low-0, and presence of aquatic vegetation-1 or absence of aquatic vegetation-0. The combination of different variables will produce a "zip code" for each unit describing its physical habitat. For example: an area with submerged vegetation and low energy results in a coding of "10"; and the corresponding classification is "wetland". The different combinations of variables translate into different abiotic units which will be confirmed by biotic information and nested into larger units at a spatial scale that will allow the Phase 2 assessment of condition and functionality.

Phase 2: Assessment of Condition and Functionality

Phase 2 involves the assessment of each unit using dynamic variables (*i.e.,* characteristics of habitat that are likely to change at a more rapid rate than physical parameters). This approach considers the physical characteristics and natural processes that structure, organize and define aquatic ecosystems and regulate the biological and chemical elements of the system. The physical habitat and the chemical and biological interactions in the Great Lakes as well as the functionality (connectivity, diversity, resilience to perturbations) support the life requirements of the aquatic dependent biota and the temporal nature of habitat use for many of the Great Lakes biota. The dynamic variables that define the condition of the habitat (*e.g.*, water quality, clarity, chlorophyll a, aquatic vegetation composition, sediment quality, benthic community composition etc.) provide a link to understanding condition and

function. Table 2 contains the preliminary dynamic variables proposed by the Task Team which may be used to assess habitat condition.

Table 2: Proposed dynamic variables

Dynamic Variables:	Characterized by:	Rationale
Water quality (pH, dissolved oxygen, conductivity)	Specific to variables.	Habitat is influenced by state of variables relative to thresholds.
Chlorophyll a	ug/L	Acts as a surrogate for nutrients, overall indicator of biological activity in the water column.
Benthic community	Abundance and community composition	Affected by water and sediment quality and substrate
Surficial sediment quality	Specific to environmental indicator	Changes in sediment quality influence aquatic habitat.
Submerged and emergent aquatic vegetation	Plant community quality	A measure of wetland quality.
Water clarity	Turbidity, suspended solids, algae blooms	Affects aquatic life and may indicate source areas.
Surficial substrate type	Particle size, soft vs. hard substrate	Determines types of vegetation/benthic and fish communities.

To determine the ecological condition of each unit, environmental data will be compared to developed ecological thresholds reflective of ecologically optimal conditions that have been determined for objective-based targets. In part, condition thresholds represent the limits of environmental variable levels within which key species or communities are expected to be able to survive and reproduce. Thresholds may be habitat dependent and may vary from lake/connecting channel to another. An area's ecological condition (nearness to an environmental threshold level/tipping point) will be the basis for determining if it is a candidate for protection (in danger of crossing the tipping point if environmental stress increases) or restoration (likely to be brought back from beyond a threshold if appropriate practices are implemented).

Mapping the distribution of these thresholds will permit one to relate the expected distribution of species or biological communities to values of dynamic variables. These maps will be developed during the implementation phase using existing knowledge. Temporal scales for each variable will be incorporated into the methodology. Integrating spatial information and tracking conditions and

thresholds through time is essential to determining resilience of the habitats, i.e., their ability to withstand changes such as shifts in temperature or hydrologic regime.

The National Coastal Condition Assessment, led by the EPA with involvement by U.S. states, collects water quality variables in coastal areas of the U.S. and includes the Great Lakes every five years. Similar data, with less extensive coverage, are collected through long term monitoring carried out by the Ontario Ministry of the Environment and Climate Change (MOECC). Some variables, such as temperature and chlorophyll a, can be monitored using aerial imagery and other forms of remote sensing that can be accessed through partners such as the National Oceanic and Atmospheric Administration (NOAA). Surficial substrate type can be determined using LIDAR, which is routinely collected for shorelines along the U.S. side of the lakes by the US Army Corps of Engineers and in a few limited locations on the Canadian side. Additional data are available for open waters through the Cooperative Science and Monitoring Initiative (CSMI) and the GLFC's lower trophic lake monitoring programs. Phase 2 will be repeated concurrently one lake at a time, every five years on a rotational basis consistent with the Cooperative Science and Monitoring Initiative[8].

Phase 3: Biological Confirmation of the Survey

Phase 3 involves the review of biological information to confirm the results of the Survey because biota (*e.g.*, fish, waterfowl, reptiles and amphibians, and benthic organisms) are the final interpreters of ecological condition. Whether native biota thrive or not indicates whether habitat is of adequate quality to support their life processes. The final phase of the Survey will use existing data on key attributes of biological assemblages, guilds and communities to confirm findings of the condition assessment of units. The biota to be used for this stage is yet to be determined and modeling of species distributions and/or abundances may be used.

Synoptic biotic data are not available for the Great Lakes however extensive data are available for selected areas from existing species monitoring programs carried out at different scales by various jurisdictions. Phase 3 will be carried out only where data are available. Furthermore, local programs may have distinct priorities, so different species may be used to confirm the assessment depending on data availability. At a basin-wide scale, several projects may provide biota data, including those led by: Environment and Climate Change Canada; the U.S. Fish and Wildlife Service; state and provincial agencies; U.S. Geological Survey and; the Great Lakes Fishery Commission. Data and information from initiatives such as the GLWQA Great Lakes Water Quality Reporting Indicators (formerly SOLEC Indicators), the Great Lakes Coastal Wetland Monitoring Group and the Great Lakes Environmental Indicator (GLEI) initiative can also be used to support this phase. The GLEI project looks at key biological indicators to infer the state of the lakes and provides information regarding stressors impacting Great Lakes habitat which may be potentially applicable in developing plans to improve condition.

[8] CSMI implementation timeline: Year 1: Report communicating results from previous monitoring year & identification of science/monitoring needs; Year 2: Planning; Year 3: Year of cooperative science and monitoring; Year 4: Laboratory analysis; Year 5: Data analysis and report writing (and repeat cycle).

Measuring Future Progress:

Reassessment Cycle:

The purpose of the initial Survey is to establish a baseline against which to establish a target of net habitat gain and to measure future progress. To assess habitat change, repeated future assessments must be conducted. As the physical variables are slow to change, Phase 1 does not need to be repeated within the same frequency as Phase 2. Repeating the delineation and classification should be considered in five or ten year timeframes as data becomes more available for refining the maps and as new technology allows for improvements in the classification. The assessment of habitat condition through Phases 2 and 3 should be repeated concurrently one lake at a time, every five years on a rotational basis consistent with the Cooperative Science and Monitoring Initiative.

Data Sharing and Management:

The Survey will use information from many sources and consequently will require a mechanism for data coordination. It is anticipated that the reliance on data sharing amongst partners will be facilitated by the ongoing and future adoption of "open data" initiatives by Great Lakes partner agencies, organizations and communities. It is also important to store the survey data in a strategic, consistent, and accessible manner that allows comparisons to be made over time. A data management system is needed that includes a scalable spatial framework to organize the data. The spatial framework developed for the Great Lakes Aquatic Habitat Framework (GLAHF) could fulfil the need for a common, universal grid structure that allows a standard format to geo-reference data. The Baseline Survey will require mapping the conditions important to biota on a scale appropriate for the purpose of the assessment which will require a greater emphasis on nearshore coastal margin areas and wetlands.

Innovation and Adaptive Management:

Great Lakes science is quickly advancing; tools and methods for assessment regularly improve and new techniques emerge. The recommended approach represents the current knowledge and effort of the Task Team, but important innovations are likely and necessary to improve ability to assess the extent and condition of Great Lakes habitats. Areas of innovation include, but are not limited to: computational resources and cloud computing, Big Data storage, biological remote sensing (satellite, aerial, underwater) of sparsely monitored biological and physical variables and systems modeling. Survey implementers should evaluate the effectiveness of the Survey over time and make changes as needed, including regularly investigating emerging technologies, tools and methods to assess their applicability.

The Path Forward

Finalizing the variables of the Survey and determining how those variables are to be evaluated will require additional effort once implementation begins. Several topics will require further definition including:

- Confirming the variables for delineation, classification, and condition assessment.
- Determining individual thresholds and objectives of the variables.

- Combining information into a cumulative assessment of condition.
- Determining species and approaches for Phase 3, the biological confirmation of the Survey.
- Developing metrics that capture the degradation level based on comparison of biota with expected biotic potential for a given habitat unit.

Next steps involve establishment of an implementation team to further discuss these topics and reach consensus on the details and a path forward. This team would include experts with a range of backgrounds including biology, wetlands ecology, lake physical limnology, morphology and spatial analysis. Just as many new initiatives require careful consideration and testing before full scale adoption, it is recommended to test the proposed approach; and then review results, apply expert judgement, and as needed, make adjustments. A formal pilot study in advance of the first full-scale assessment is advised to demonstrate the efficacy of the approach. This will allow people to see the benefit of what is being proposed, identify data gaps, and garner necessary support through the organizations and agencies that could contribute, support and benefit from outcomes of this assessment. Partner support and collaboration will be a key to the success and long-term sustainability of the Survey and will build capacity for this kind of team approach.

Appendix: Baseline Assessment Task Team Membership

Co-Chairs:
Ralph Grundel – U.S. Geological Survey
Janette Anderson – Environment and Climate Change Canada (May 2015 – Present)
Jody McKenna - Environment and Climate Change Canada (Start - May 2015)

Members:
Brandon Krumwiede - National Oceanic and Atmospheric Administration
Beth Hinchey Malloy - US Environmental Protection Agency
Brad Eggold - Wisconsin DNR
Bob Krska- U.S. Fish and Wildlife Service
Brian Huberty - U.S. Fish and Wildlife Service
Mike Greer - U.S. Army Corps of Engineers
Molly Reif - U.S. Army Corps of Engineers
Beth Admire - Indiana Department of Environmental Management
Anne Remek - Indiana Department of Environmental Management
Jim Smith - Indiana Department of Environmental Management (Retired June 2014)
Pete Esselman – U.S. Geological Survey
Chris Fidler - New York DEC
Andrew Lewin - Fisheries and Oceans Canada
Susan Doka - Fisheries and Oceans Canada
Mike McMurtry – Ministry of Natural Resources and Forestry (Retired June 2015)
Julie Simard – Ministry of Natural Resources and Forestry
Julia Hatcher - Environment and Climate Change Canada
Lori White - Environment and Climate Change Canada
Brenda Lafrancois – National Park Service
Jay Glase - National Park Service