Great Lakes Ecosystem Services Valuation: A Scoping Study

A report submitted to the
International Joint Commission by the
Great Lakes Science Advisory Board
Work Group on Great Lakes Ecosystem Valuation

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The Great Lakes Science Advisory Board (SAB) gratefully acknowledges the time and effort of the work group members and International Joint Commission (IJC) staff for providing knowledge and guidance on this project, and to the Potomac-Hudson Engineering contractor team who led the workshop and prepared a summary report with recommendations which formed the basis for this work group report. We also appreciate the advice and guidance received from the subject matter experts who participated in the June 2023 workshop.

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List of Acronyms

AOC   Area of Concern
BRI   Benefit relevant indicator
GLWQA Great Lakes Water Quality Agreement
HAB   Harmful algal bloom
IJC   International Joint Commission
SAB   Great Lakes Science Advisory Board

Executive Summary

The Great Lakes support economic activities, provide food and other resources, regulate natural processes, and offer recreational and cultural experiences. Values of ecosystem services with established commercial markets, including commercial fishing, tourism, and agriculture, are relatively well understood. However, non-market ecosystem services are more challenging to value and may be overlooked in traditional benefit-cost decision frameworks, risking ineffective or inefficient resource management and policy development. To inform sound decision-making regarding future management and policy affecting Great Lakes ecosystems, the International Joint Commission's (IJC) Great Lakes Science Advisory Board (SAB) recognizes the need to better understand, measure, and communicate the values of Great Lakes ecosystem services.

Currently, our understanding of the value of Great Lakes ecosystem services is limited. Only a handful of studies have applied non-market valuation methods to the Great Lakes, and most of these applied valuation data derived from regions outside of the Great Lakes rather than conducting new in-basin primary research. Consequently, the gap in valuation data directly relevant to the Great Lakes is immense. For this reason, the SAB undertook this scoping study to determine where the need for valuation data is greatest and to recommend the best options for a future Great Lakes ecosystem services valuation project.

Toward that end, this project focused on the following tasks:

1. Identify important information gaps from the existing literature regarding Great Lakes ecosystem service values.
2. Convene a workshop including the IJC Science Priorities Committee Valuation Work Group members (the work group), subject matter experts, and policymakers with the objective of prioritizing options for a future Great Lakes ecosystem service valuation study (Stage 2 study).
3. Prepare a project report describing project activities and outcomes.
4. Recommend the best options for a future Great Lakes ecosystem services valuation project.

The external contractor, in coordination with the work group and IJC staff, compiled information on Great Lakes ecosystem services, including an overview of existing studies relevant to the Great Lakes region. The team then used this information to prepare a conceptual model describing the various ecosystem services provided by the Great Lakes, and their inter-relationships. These materials were used as inputs for an expert workshop on Great Lakes Ecosystem Services Valuation. The workshop's objective was to gather input on options for a primary valuation study and to prioritize them using selection criteria developed by the work group.

Based on the outcomes of the literature review, the input provided by subject matter experts during the Great Lakes Ecosystem Services Valuation workshop, and the contractor team's recommendations, the work group provides the following recommendations for the IJC's consideration in planning a future primary valuation study. By helping the IJC and others better understand the value of Great Lakes ecosystem services, a future study will support the goals of

the Great Lakes Water Quality Agreement (GLWQA) by enabling better decision-making that leads to improved water quality and healthier ecosystems in the Great Lakes.

Recommendations

The non-market valuation study should include the following general features:

1. The geographic scope for the study should include broad coverage such that the results are representative of the Great Lakes basin both ecologically and demographically and potentially illuminate similarities and differences between the United States and Canada.

2. The study should measure the value of a "final ecosystem service" (e.g., birdwatching) and not a broader ecological change (e.g., improved water quality). This will provide more insight into what people value about the ecological change and also reduce the risk of double counting in the context of a benefits analysis.

3. The scope of the valuation study should be limited to measuring the value of one or two non-market ecosystem services to keep the study manageable, both logistically and financially, and to avoid respondent fatigue that can result from over-burdening survey respondents with information.

The non-market valuation study should include the following specific features:

4. Focus the ecosystem valuation study on Great Lakes coastal wetlands.

   - Great Lakes coastal wetlands play an important role in maintaining the water quality of the Great Lakes and provide many economic and non-market benefits. Coastal wetlands have the potential to capture excess nutrients originating from nonpoint sources, help to maintain natural movement and settlement of sediments from tributaries, support biological diversity of native species, provide a buffer of protection for shorelines by absorbing the energy of waves that would otherwise cause excessive erosion and property damage during storms, and can reduce the severity of flooding by absorbing large amounts of water and releasing it slowly following heavy rain. In addition, coastal wetlands have been a culturally important source of wild rice for centuries for tribes and First Nations.

5. Focus the study on the valuation of one or two of the following prioritized list of coastal wetlands non-market ecosystem services.

   a) **Nutrient Sequestration**. Coastal Wetlands sequester nutrients that would otherwise contribute to eutrophication in the Great Lakes. Increased eutrophication can have negative impacts on boating, swimming, drinking water quality, fisheries, and habitat, for example.

b) **Coastal Resilience and Flood Protection.** Coastal wetlands help to mitigate the effects of wave action on shoreline erosion and also act as a sponge to reduce coastal flooding as water levels rise in the Great Lakes, either from seasonal variation or from the effects of climate change. Assessing the value of these ecosystem functions would provide useful data to inform decision-making regarding land use changes or wetland restoration projects.

c) **Coastal wetland bird composition and abundance**. Coastal wetlands provide critical habitat for over 340 bird species that depend on this ecosystem. Water quality, plant community, and adjacent land use all influence bird community composition and health in coastal wetlands. As such, the composition and abundance of bird species are recognized indicators of the health of coastal wetlands. Bird populations are also an important source of recreational values in coastal wetlands.

1.0 Introduction

The Great Lakes provide valuable goods and services to the economies of the United States and Canada. The basin is home to many millions of people, contains 20 percent of the world's surface fresh water supplies, and in aggregate support a regional economy of US$6 trillion (Council of the Great Lakes 2023). Among the many goods and services provided by the Great Lakes are a multibillion dollar sports fishing industry, drinking water for 38 million people, commercial shipping of 200 million tons per year, and cooling water for power generation (USNOAA 2023). The many benefits people receive from nature—clean air and water, fertile soil for crop production, pollination, and flood control – are often referred to as ecosystem services (USEPA 2023). These ecosystem services are important to environmental and human health and well-being, yet they are often poorly understood and taken for granted.

The Great Lakes Water Quality Agreement (GLWQA), first signed by Canada and the United States ("the Parties") in 1972 and updated in 1978, 1987 and 2012, commits both countries to "restore and maintain the chemical, physical, and biological integrity of the Waters of the Great Lakes." (IJC 2023) The International Joint Commission (IJC) is a binational organization that prevents and resolves disputes over the boundary waters of Canada and the United States. The IJC plays a key role in the GLWQA process. By evaluating efforts to restore the Great Lakes ecosystems, engaging the public, and conducting research on issues facing the lakes, the IJC assesses the effectiveness of government programs to meet the agreement's goals and objectives. Its triennial and biennial assessment reports and recommendations help the two countries expand or change approaches to particular challenges, and ensure the agreement evolves to address future issues facing the lakes.

The GLWQA includes several goals that directly recognize and reflect the important ecosystem services provided by the Great Lakes. These goals include:

  (i)   *Be a source of safe, high-quality drinking water.*
  (ii) *Allow for swimming and other recreational use, unrestricted by environmental quality concerns.*
  (iii) *Allow for human consumption of fish and wildlife unrestricted by concerns due to harmful pollutants.*
  (v)   *Support healthy and productive wetlands and other habitats to sustain resilient populations of native species.*

There is a growing awareness of the need to better understand, measure, and communicate the true value of the ecosystem services provided by the Great Lakes. The science of ecosystem service valuation, which brings together ecologists and economists, is an attempt to understand and quantify, usually in monetary units, the extent to which ecosystem services contribute to the welfare of society. The goal of ecosystem service valuation is to lead to better, more informed, and more transparent public decision making, explicitly considering the impact of ecosystem services on social welfare. A better understanding of the value of the ecosystem services provided by the Great Lakes would support management decisions that lead to improved water quality and help meet the goals of the GLWQA.

The IJC has an important role to play with respect to developing and promoting a better understanding of the value of the Great Lakes. For example, among the responsibilities laid out for the IJC in the GLWQA are:

> (c) *tendering advice and recommendation to the Parties on the following:*
> > (i) *the social, economic and environmental aspects of current and emerging issues related to the quality of the Waters of the Great Lakes …*
>
> (h) *engaging with the Public to increase awareness of the inherent value of the Waters of the Great Lakes, of the issues related to the quality of these waters, and the benefit of taking individual and collective action to restore and protect these waters.*

Currently, our understanding of the Great Lakes' contribution to social welfare is limited. Only a handful of studies have applied non-market valuation methods to the Great Lakes, and the majority of these applied primary valuation research methods and data derived from regions outside of the Great Lakes rather than conducting new in-basin primary research. Previous studies have attempted to describe the ecosystem services provided by the Great Lakes and identify steps that should be taken to improve our understanding of these services and their value to society. Steinman et al. (2017) conducted an expert workshop with participants from a range of scientific disciplines, to summarize the current state of understanding of Great Lakes ecosystem services and their value. This resulted in the general consensus that:

1. a comprehensive inventory of ecosystem services throughout the Great Lakes is a desirable goal but would require considerable resources;
2. more spatially and temporally intensive data are needed to overcome our data gaps, but the arrangement of data networks and observatories must be well-coordinated;
3. trade-offs must be considered as part of ecosystem services analyses; and
4. formation of a Great Lakes Institute for Ecosystem Services, to provide a hub for research, meetings, and training is desirable.

Sterner et al. (2020) built on this work, and a related workshop, convened in May 2023, further emphasized the need for reframing "ecosystem restoration" as not only improving the environment, but also including the human and social systems that co-exist with biophysical systems (Williams et al., 2023).

The IJC's SAB recognizes the importance of obtaining a better understanding of the value of Great Lakes ecosystem services. However, the geographical extent of the Great Lakes basin, the vast range of ecosystem services, and the immense knowledge gaps that exist make it necessary to narrow and focus the scope of an initial valuation undertaking. In light of this, the SAB initiated this scoping project to examine potential topics that could be the subject of a future Great Lakes-focused primary valuation study to help close some of the data gaps surrounding this topic. The outcomes of this project are intended to inform the design of a future Stage 2 study.

Toward that end, this scoping project focused on the following tasks:

1. Identify important information gaps from the existing literature regarding Great Lakes ecosystem service values.

2. Convene a workshop including the IJC Science Advisory Board Valuation Work Group members, subject matter experts, and policymakers with the objective of prioritizing options for a future Great Lakes ecosystem service valuation study.
3. Prepare a report describing project activities and outcomes.
4. Recommend the best options for a future Great Lakes ecosystem services valuation project.

The study began in October 2022 with the formation of the Ecosystem Services Work Group. The IJC contracted the services of Potomac-Hudson Engineering Inc., in collaboration with Industrial Economics, Inc., and LimnoTech, to assist the work group. The work group met several times with the contractor over the spring and summer of 2023 and a virtual workshop was held in late June 2023 with subject matter experts, the work group, the contractor, and IJC staff. The work group met again in early September to provide feedback on the contractor's draft report and its recommendations. The contractor's final report was received in early October 2023. The work group met again towards the end of November 2023 to discuss and form the recommendations contained in this report. This work group report is an extension of the contractor's final report, which itself is appended to this report. Several sections of this report are taken directly from the contractor's final report; others reflect the specific opinions, deliberations, and recommendations of the work group.

2.0 Background on Ecosystem Service Valuation

This section provides non-technical definitions of key concepts and terms used in the report, a classification of ecosystem service values, and a brief overview of the state of knowledge regarding ecosystem service valuation in the Great Lakes basin.

2.1 Definitions

Final ecosystem services: Final ecosystem services (sometimes referred to as ecosystem service endpoints or final ecosystem goods and services) are identified by carefully linking changes in ecosystem structure and/or process to individual benefits accruing to particular beneficiary groups (Boyd et al., 2015; Olander et al., 2018). For example, the Great Lakes provide angling opportunities for recreational fishers, bird watching opportunities for birders, and boating opportunities for boaters, all of which are final ecosystem services that would be classified as recreation under the systems listed above. On the other hand, nutrient filtration services of wetlands may be considered an intermediate ecosystem service. The associated water quality improvements then contribute to final ecosystem services, such as drinking water, boating, and swimming. Including intermediate services for valuation purposes risks double-counting, as intermediate services underpin the production of one or more final ecosystem services. By focusing on final ecosystem services, we avoid double-counting issues and maintain compatibility across classification systems.

Benefit relevant indicators: Benefit relevant indicators (BRIs) translate final ecosystem services into measurable metrics that are directly relevant to human welfare (Olander et al., 2018). For example, the impact of harmful algal bloom (HAB) reduction on swimming may be measured using the change in number of "swimmable" days. A BRI for wild rice harvest could be tons of rice harvested. BRIs form the basis for subsequent valuation and may also become a direct input into decision-making when monetary valuation is not possible or appropriate (e.g., for measuring cultural significance).

Nonmarket valuation: Some ecosystem services (e.g., commercial fish harvest) can be valued using market prices. However, markets do not exist for many ecosystem services due to their public good characteristics. Nonmarket valuation is a set of methodologies (e.g., specialized models, survey design practices, statistical tools) that can be applied to estimate the economic value of ecosystem services that are not traded in traditional markets (Kriström, Johansson, & Wohl, 2015). Primary valuation methods fall under two general categories: revealed preference (e.g., travel-cost, hedonic pricing) and stated preference (e.g., contingent valuation, contingent behavior, choice experiments). The most appropriate method depends upon the ecosystem service and the valuation context. Note that for some ecosystem services (e.g., tribal cultural or spiritual values), valuation in monetary terms may not be appropriate. In these cases, alternatives to traditional nonmarket valuation should be considered.

Benefit transfer: Primary valuation using stated or revealed preferences is not always feasible due to budget and/or time constraints. As an alternative, analysts may apply benefit transfer

methods, the process of utilizing results from one or more primary studies to derive a valuation estimate at a new site. Typically, transfer errors are reduced when the primary study site(s) resemble the new site across as many natural and human dimensions as possible (Johnston, Rolfe, Rosenberger, & Brouwer, 2015). This is an important concept as a key objective of the primary valuation study prioritized through the project and workshop was that it would produce transferable information for future economic analyses of Great Lakes projects and activities.

2.2 Classification of Ecosystem Services

The value of some impacts to ecosystem services can be readily obtained using market data (e.g., commercial fishing or agricultural production), whereas well-defined markets do not exist for others. To produce additive information, the Stage 2 study should focus on impacts to nonmarket ecosystem service values. Table 1 classifies nonmarket ecosystem services according to whether they produce value through direct use or non-use (i.e., existence or bequest value). Well-established techniques exist for estimating both use and many categories of non-use values in monetary terms. However, it is possible, and in some circumstances preferred, to rely upon alternative means of assessing and communicating value, for example developing narratives or community-member quotes in the context of cultural identity and spiritual significance.

Table 1 Classification of common ecosystem services by the type of value they generate

Market	Nonmarket direct-use	Nonmarket non-use
• Drinking water • Other consumptive water use • Commercial fishing • Navigation, transportation, shipping • Flood protection • Tourism and other secondary economic impacts	• Recreational fishing • Beach recreation • Recreational boating • Coastal trail use • Bird watching • Traditional practices (e.g., wild rice harvest)	• Cultural identity and spiritual significance • Aesthetics • Biodiversity and protection of endangered species
Note: Some ecosystem services span multiple categories of value. For example, the total economic value of traditional practices like wild rice harvest may involve the value derived from market sales, a nonmarket use value (e.g., enjoyment) from engaging in the process, and a non-use value associated with maintaining cultural identity.		

2.3 Literature Overview

The ecosystem services valuation literature is vast. However, few studies focus on nonmarket ecosystem services provided by the Great Lakes. Table 2 summarizes existing primary valuation studies focusing on this area. With the exception of recreational fishing, we identified limited information on values for nonmarket ecosystem services in the Great Lakes, including one primary valuation study each for beach recreation, aesthetics, and endangered species. The remaining studies utilize the hedonic pricing method, which relates environmental quality to the value of nearby real estate.

Table 2 Existing primary valuation studies of ecosystem services in the Great Lakes.

Study	Method	Lake	A	B	C	D	E	F	G	H	I	J	K
(Braden, Won, et al., 2008)	Hed/CE	Erie										✓	
(Braden, Taylor, et al., 2008)	Hed/CE	Michigan										✓	
(Gardner, 2022)	Hed	Michigan										✓	
(Isely, Isely, Hause, & Steinman, 2018)	Hed/TC/CV/CB	Michigan										✓	
(Isely, Nordman, Howard, & Bowman, 2017)	Hed	Michigan											✓
(Wolf, Gopalakrishnan, & Klaiber, 2022)	Hed	Erie											✓
(Wilkinson & Melstrom, 2022)	Hed	Michigan										✓	
(Zhang & Sohngen, 2018)	CE	Erie	✓							✓			
(Awondo, Egan, & Dwyer, 2011)	TC/CB	Erie		✓									
(Bishop, Boyle, & Welsh, 1987)	CV	Michigan									✓		
(Hunt, Phaneuf, Abbott, & Fenichel, 2021)	CE	All	✓										
(Hunt, Boots, & Boxall, 2007)	DC	Superior	✓										
(Hushak, Winslow, & Dutta, 1988)	TC	Erie	✓										
(Lupi, Hoehn, & Christie, 2003)	TC	Huron	✓										
(Melstrom & Lupi, 2013)	TC/DC	All	✓										
(Ready et al., 2012)	TC	Erie	✓										

Method Legend	
Revealed preference	**Stated preference**
Hed – Hedonic TC – Travel cost DC – Discrete choice	CE – Choice experiment CV – Contingent valuation CB – Contingent behavior
Ecosystem service legend	
A – Recreational fishing B – Beach recreation (swimming) C – Coastal trail use D – Boating E – Bird watching F – Traditional practices G – Cultural identity/spiritual significance H – Aesthetics I – Endangered species J – Water quality* K – Invasive species*	

* Not a final ecosystem service

In addition to the primary valuation studies, several studies have relied on benefit transfer to estimate values for nonmarket ecosystem services provided by the Great Lakes. Benefit transfer studies of Great Lakes ecosystem services are summarized in Table 3. These results suggest that suitable estimates may exist for recreational fishing, beach recreation (swimming), recreational boating, and aesthetics. Existing benefit transfers have not attempted to value coastal trail use, bird watching, nutrient sequestration, coastal resilience and flood protection, traditional practices, cultural identity/spiritual significance, and endangered species. These ecosystem service endpoints appear to be understudied relative to the others.

Table 3 Existing valuation studies of Great Lakes ecosystem services utilizing benefit transfer.

Study	Project	Lake	A	B	C	D	E	F	G	H	I	J
(Bingham, Sinha, & Lupi, 2015)	HABs	Erie	✓	✓		✓						
(Fletcher & Christin, 2015)		Superior								✓		
(Fletcher & Cousins, 2019)		Superior								✓		
(Hayder, 2019)	Invasive species	All	✓	✓		✓						
(Palm-Forster, Lupi, & Chen, 2016)	HABs	Erie		✓								
(Rabinovici, Bernknopf, Wein, Coursey, & Whitman, 2004)		Michigan				✓						
(Smith, Bass, Sawyer, Depew, & Watson, 2019)	HABs	Erie										✓
(Ontario, 2010)	Habitat	All	✓							✓		✓
(Wang, Alkire, Perry, & Phillips, 2019)	HABs	Erie	✓	✓								

Ecosystem service legend:

A – Recreational fishing	F – Traditional practices
B – Beach recreation (swimming)	G – Cultural identity/spiritual significance
C – Coastal trail use	H – Aesthetics
D – Boating	I – Endangered species
E – Bird watching	J – Tourism

3.0 Selection Criteria

The SAB identified criteria to evaluate the suitability of and prioritize options for a nonmarket valuation study. During its deliberations, the work group modified the criteria, mainly by elevating the importance of the criterion of producing valuation data that are generalizable and, hence suitable for benefit transfer, for future management decisions by the Parties affecting Great Lakes water quality. The criteria are organized under the headings of policy relevance, suitability for benefit transfer, and ability to estimate biophysical relationships:

1. **Policy relevance**
   a. **Multinational relevance**: The Stage 2 study topic should be of relevance to the United States, Canada, and Indigenous communities.
   b. **Influential**: The Stage 2 topic should have the potential to influence policy by properly accounting for ecosystem service benefits (for a prospective project) or by demonstrating the usefulness of nonmarket valuation.
   c. **Understudied**: Knowledge gained should be additive to existing knowledge of Great Lakes ecosystem service values.

2. **Suitability for benefit transfer**
   a. **Ecosystem service importance**: The ecosystem service(s) evaluated should be ones that are likely to be affected by many projects (e.g., land development projects or restoration projects) so as produce useful data that can be applied to value outcomes from a wide range of future management decisions.
   b. **Geographic scale of project impact**: The sample frame for the Stage 2 study should be as representative as possible of the geographic and demographic variability within the Great Lakes to increase the applicability of the data produced to a wide range of future management decisions throughout the basin.

3. **Ability to estimate biophysical relationships**
   a. High quality ecosystem service valuation studies of a given project rely on understanding the linkages between the project and ecological and ecosystem service endpoint(s) to accurately describe the change to be valued.[1] This involves drawing on existing scientific information and models, and potentially traditional knowledge regarding ecosystems. Due to the complexity associated with modeling how projects affect ecosystems (e.g., abundance of a particular species), primary valuation studies often evaluate hypothetical biophysical changes (e.g., a 20 percent increase in population size or recovery of an endangered species).

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[1] The empirical linkages between project and ecosystem service, while necessary, may not require precision. For example, we recognize that there may be significant time lags, confounding factors, and other sources of uncertainty that limit accurate modeling. For most ecosystem services, understanding the range of potential outcomes induced by a project is sufficient for designing an appropriate valuation study.

4.0 Recommendations

The contractor's final report included general recommendations concerning the structure of a future non-market valuation study. These have been adopted by the work group and are included among its recommendations. Specifically, the non-market valuation study should include the following features:

1. The geographic scope for the study should include broad coverage such that the results are representative of the Great Lakes basin both ecologically and demographically and potentially illuminate similarities and differences between the United States and Canada. This will help ensure the valuation study is of binational interest and will increase the transferability of the results to coastal wetlands throughout the Great Lakes basin.

2. The study should measure the value of a "final ecosystem service" (e.g., birdwatching) and not of a broader ecological change (e.g., improved water quality). This will provide more insight into what people value about the ecological change and also reduce the risk of double counting in the context of a benefits analysis.

3. The scope of the valuation study should be limited to measuring the value of one or two non-market ecosystem services to keep the study manageable, both logistically and financially, and to avoid respondent fatigue that can result from over-burdening survey respondents with information.

The next set of recommendations concern the choice of specific ecosystem services that are suitable for a future valuation project. The contractor's final report, which synthesized the discussions and rankings of the workshop proceedings, indicates that the topics of greatest interest to workshop participants were restoration of Areas of Concern (AOCs), wetland restoration, and mitigation and management of harmful algal blooms (HABs).

Among these three broad areas, coastal wetlands restoration is the area the work group considers to best fit the criteria for selecting an area of focus for a future valuation study. Coastal wetlands are of binational interest, play an important role in maintaining the water quality of the Great Lakes, provide a wide variety of ecosystem services, and can be impacted by a wide range of public projects. In addition, there exist no primary valuation studies of the Great Lakes coastal wetlands.

The work group believes that by helping to better understand the value of coastal wetlands ecosystem services, the Stage 2 study will support the goals of the GLWQA by enabling better decision-making that leads to improved water quality and healthier ecosystems in the Great Lakes and achieve the objectives of supporting healthy and productive wetlands and other habitats to sustain resilient populations of native species. Therefore, the next set of recommendations are:

4. Focus the ecosystem valuation study on Great Lakes coastal wetlands.

Great Lakes coastal wetlands play an important role in maintaining the water quality of the Great Lakes and provide many economic and non-market benefits. Coastal wetlands have the potential to capture excess nutrients originating from nonpoint sources, help to maintain natural movement and settlement of sediments from tributaries, support biological diversity of native species, provide a buffer of protection for shorelines by absorbing the energy of waves that would otherwise cause excessive erosion and property damage during storms, and can reduce the severity of flooding by absorbing large amounts of water and releasing it slowly following heavy rain. In addition, coastal wetlands have been a culturally important source of wild rice for centuries for tribes and First Nations.

However, the area of Great Lakes coastal wetlands has been reduced to about one-half of historic levels, largely because of development activities (epa.gov/great-lakes-monitoring/why-monitoring-great-lakes-coastal-wetlands-important). Development continues to impinge on coastal wetland area and the possibility of extremes in water levels due to climate change adds a new threat (Environment and Climate Change Canada, 2022). Conservation to prevent further decline and restoration to reverse the decline will be costly. Whether the costs are direct expenditure of taxpayer dollars or the opportunity cost of foregone benefits of further land development, they are easy to quantify and are highly visible. The benefits of conserving and restoring coastal wetlands are neither easy to quantify nor highly visible. However, the work group believes that undertaking a future study to quantify the value of coastal wetlands ecosystem services will provide a step in the direction of providing objective evidence of the benefits of conservation and restoration.

To keep the scope of the valuation project manageable, both logistically and financially, the work group agrees with the contractor's recommendation to limit the valuation study to one or two of the many ecosystem services delivered by coastal wetlands. After careful consideration of the options discussed in the workshop, the work group recommends the following ecosystem services, in order of priority, as subjects for a future valuation study:

   a. **Nutrient Sequestration.** Coastal Wetlands sequester nutrients that would otherwise contribute to eutrophication in the Great Lakes. Increased eutrophication can have negative impacts on several final ecosystem services such as boating, swimming, drinking water quality, fisheries, and species richness. Assessing the value placed on the sequestration capability of wetlands provides useful data to inform decision-making regarding projects that would enhance or diminish the integrity and size of coastal wetlands. As indicated earlier, nutrient sequestration is an intermediate, not a final ecosystem service. Thus, care must be taken in the study design to clearly indicate to respondents what final ecosystem services are impacted by the hypothetical enhancement of a coastal wetland. A critical first step with this valuation project is to determine and then communicate to respondents the biophysical linkages between a hypothetical change in wetland area, say, and the resulting impact on eutrophication, and ultimately on final ecosystem services, in the relevant Great Lake. The next step is to elicit the values respondents place on the impacts of the change in the sequestration capability of

wetlands using, for example, a choice experiment approach that would make it possible to statistically identify the contribution of each final ecosystem service to the total value (see He et. al., 2017 for example).

b. **<u>Coastal Resilience and Flood Protection.</u>** Coastal wetlands help to mitigate the effects of wave action on shoreline erosion and act as a sponge to reduce coastal flooding as water levels rise in the Great Lakes, either from seasonal variation or from the effects of climate change. Assessing the value of these ecosystem functions would provide useful data to inform decision-making regarding land use changes or wetland restoration projects. This type of study could use a valuation approach called the "production" approach. Coastal wetlands "produce" flood protection and coastal resilience benefits. If one estimates first the biophysical relationships between changes in the areal extent of coastal wetlands and the resulting changes in the risk of overland flooding and shoreline erosion, then one can estimate, via calculations, the value of structures and land protected. Although this production approach is based on estimating the impact on the value of land and structures using readily available market data, the public-good nature of some of these ecosystem services provided by coastal wetlands qualify this as a non-market valuation exercise. At the same time, the presence of private-good elements means that public spending to reduce flood protection and erosion can be a cause of moral hazard; that is, private incentives to self-protect can be reduced by the expectation of public support. Any recommendations based on a study on this topic must recognize the potential for creating moral hazard.

c. **<u>Coastal wetland bird composition and abundance</u>**. Coastal wetlands provide critical habitat for over 340 bird species that depend on this ecosystem. Water quality, plant community, and adjacent land use all influence bird community composition and health in coastal wetlands. As such, the composition and abundance of bird species are recognized indicators of the health of coastal wetlands (epa.gov/great-lakes-monitoring/great-lakes-cwmp-results-and-major-findings). Bird populations are also an important source of recreational values in coastal wetlands.

The work group recommends consideration be given to two types of valuation studies of coastal wetlands bird composition and abundance. While the detailed elements of the study should be determined by the contractor in partnership with the IJC SAB, the work group recommends first a travel-cost study designed to estimate the recreational values of birds, at a small number of diverse coastal wetland sites (with an equal number of US and Canadian sites). Ideally, the study will select an equal number of coastal wetlands in each of the Canadian and US Great Lakes coastal regions, or that straddle the border between the two countries. For example, one common wetland and one in each of the two countries might be selected. The team will select bird species that will be the subject of valuation in each of the selected wetlands. Ideally, some of the species will be common to all the wetlands. Others may be unique to each wetland and are highly targeted by birders and/or are species that are sensitive to habitat quality. The study will estimate the relative and incremental recreational value of specific bird species and should estimate the impact of population density of specific species on value (as it affects spotting rates, for example). By estimating the individual and relative values of specific bird species, the

transferability of the valuation data to other coastal wetlands within the Great Lakes will be enhanced. The study must be designed to capture the impact of the presence of substitute sites for bird watching in the valuation exercise.

The second approach for consideration is a stated preference study of bird abundance and composition that captures a broader set of values including non-use values. Subject to budget constraints, these two approaches could be conducted in tandem for the same selection of coastal wetlands. The stated preference approach, however, would attempt to elicit from respondents a wider range of values for bird species including, potentially, the value of birds as an indicator of water quality.

4.1 Other Considerations

AOC remediation and HABs mitigation also received strong support by workshop participants and are worthy of valuation studies, though were ranked by the work group as lower priority than coastal wetlands for the reasons described below.

AOC remediation was ranked below coastal wetlands as a candidate for a first valuation study because (1) some primary valuation studies of the valuation of AOC by property owners exist in the literature (Isely et. al., 2018; Gardner et. al., 2022; Braden et. al. 2008a, 2008b) and (2) AOC remediation appears to be already accepted as a public policy priority, particularly in the United States with the allocation of millions of dollars for AOC remediation under the Great Lakes Restoration Initiative. Thus, while it would be useful to have a more comprehensive understanding of the values for restoring beneficial uses in AOCs, the likelihood of influencing public policy is limited.

HABs mitigation is a costly undertaking. For example, billions of dollars have been invested in conservation programs over the past several decades in the United States alone (Ribaudo, 2015; Claasen et. al., 2018). Understanding the social benefits of mitigation efforts is important and clearly merits a comprehensive valuation exercise. However, this topic was ranked below coastal wetlands mainly because there is a slightly smaller knowledge gap with respect to the benefits of HABs mitigation. See the estimated impact of HABs on the value of recreational fishing (Wolf et. al., 2017; Zhang et. al., 2018) and property values (Wolf et. al., 2022).

Finally, there was widespread recognition among workshop participants of the need to better understand values associated with indigenous and traditional practices and incorporate traditional ecological knowledge into valuation and decision-making; however, the concern was also expressed that conducting a meaningful assessment of these topics would likely exceed the scope of this project. Any study that addresses traditional knowledge and cultural values should be based on engagement and co-production with Indigenous communities. Additionally, a study focused on traditional and cultural values should consider non-monetary value indicators such as the benefit relevant indicators discussed earlier (Manero et. al., 2022). Consequently, the work group recommends that attempting to address this important topic within the scope of the current study would not do it justice; rather, a dedicated study of the topic, perhaps following and benefiting from the SAB's ongoing project on building a framework towards bridging traditional ecological knowledge and western science, is warranted

5.0 Conclusions

Our understanding of the value of Great Lakes ecosystem services is limited. Only a handful of studies have applied non-market valuation methods to the Great Lakes and most of these applied valuation data derived from regions outside of the Great Lakes rather than conducting new in-basin primary research. While there are large gaps in primary valuation data, there are also so many ecosystem services provided by the Great Lakes - such as recreational benefits, wildlife habitat, biodiversity protection, drinking water, commercial shipping - that the potential scope for primary valuation research is daunting. The purpose of this study is to narrow the scope for this research by determining where the need for valuation data is greatest and to recommend the best options for a future Great Lakes ecosystem services valuation project.

The work group considered HABs and AOCs in the Great Lakes as possible areas on which to focus but settled on coastal wetlands as the most promising area for a primary valuation study. Of the many ecosystem services provided by coastal wetlands in the Great Lakes, the working group chose the nutrient sequestration function of coastal wetlands as the most important to study for valuation. Assessing the value of nutrient sequestration services will provide useful data to inform decision-making regarding land use changes that have negative impacts on coastal wetlands by quantifying some of the previously unknown costs of development so they can be weighed against the benefits. Likewise, valuation data will inform decisions about investments to restore coastal wetlands by quantifying some of the previously unknown benefits of restoration so they can be weighed against the investment costs.

The work group recommends that the IJC SAB assign a small group to the task of developing a proposal for a primary valuation study of the nutrient sequestration benefits of coastal wetlands in the Great Lakes that has the following features:

1. The nonmarket valuation project will use primary valuation methods and may include both stated preference methods (such as a choice experiment approach) and revealed preference methods (such as a travel-cost approach).
2. At least two (but ideally more) coastal wetlands should be studied for their nutrient sequestration benefits, with equal representation on the US and Canadian sides of the Great Lakes. The selection of the specific coastal wetlands is critical. They may be selected by the SAB work group or their identification could be set as one of the requirements of respondents to a request for proposal. The latter option would be a useful criterion against which to judge the expertise and experience of respondents. Either way, the coastal wetlands selected should satisfy the following features:
   - be located adjacent to an area of a Great Lake subject to significant eutrophication caused by nutrient loadings.
   - the eutrophication should affect a variety of final ecosystem services such as recreational activities, drinking water, fishing, and habitat.
   - be wetlands that have been diminished by human activities and have the potential for some degree of restoration.
3. The timeline for the study is likely to be approximately 12 – 18 months.
4. The budget for the study is likely to be approximately US$150,000.

5. The work group for the study should be comprised of ecologists with knowledge of wetland function; ecologists with knowledge of Great Lakes coastal wetlands; economists with knowledge of nonmarket valuation methodology and practices; and sociologists with knowledge of the human dimensions of environmental changes.
6. In addition to the above, the successful respondent to a request for proposal is expected to be able to:
   - identify the final ecosystem services that are affected by nutrient sequestration for the specific wetlands chosen.
   - establish a link between a change in wetland size and characteristics associated with a restoration effort or development and the likely impacts on nutrient loadings into the adjacent water body and resulting eutrophication.
   - establish linkages between the estimated changes in nutrient loadings/eutrophication and the impact on the final ecosystem services that have been identified (such as swimming, boating, fishing, drinking water, habitat).
   - develop a primary valuation research methodology for estimating the public's valuation of the changes in final ecosystem services that are the result of the changes in wetland size and/or character. The plan must include what values are being estimated (use and non-use values) and the scope of the affected population. Because a number of final ecosystem services are to be valued, it is important to develop a methodology that would make it possible to statistically identify the individual contribution of each final ecosystem service to the total value (see He et. al., 2017 for example).

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