RECOMMENDATIONS

Great Lakes Advisory Board Final Report to EPA

April 6, 2022

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Executive Summary

In 2020, EPA asked the Great Lakes Advisory Board (GLAB) to provide advice and recommendations on (1) innovative strategies to address legacy phosphorus; (2) managing excess nutrients; (3) GLRI outreach; (4) invasive species; (5) outcome-based investments in the great lakes; and (6) GLRI's role in the vitality and reinvestment of Great Lakes communities. The GLAB's 65 recommendations and their rationales are the subject of this report.

Expanded Approach

While considering its charge questions, the GLAB remained acutely aware of two contextual forces: (1) the immediacy of climate change; and (2) the accelerated national momentum toward social justice, which includes environmental justice. Although the GLAB was assigned its charge questions by the previous administration, the Biden Administration has committed to reinvigorating and sustaining action on both issues. The GLAB, therefore, expanded the interpretation of its charge questions and crafted recommendations focused on the need for EPA to get in front of the curve on some of the most pressing challenges facing the Great Lakes today.

The GLAB recognized that implementing its recommendations will involve various levels of effort as well as a range of organizational, regulatory, and legislative complexity. Therefore, it categorized recommendations as follow:

> **Near-term recommendations** are those that are currently actionable under the Great Lakes Restoration Initiative (GLRI) and by the Great Lakes National Program Office.
>
> **Mid-term recommendations** are those that require additional research or development before they could be implemented under GLRI; however, that research and development could be a near-term activity.
>
> **Long-term recommendations** refer to activities that are within EPA purview but may require legislative changes, new partnerships, multi-stakeholder engagement, additional investments, or other development in order to implement.

Selected Recommendations

A full discussion of the recommendations is found in respective sections, and lists of recommendations by theme are appended. Here, we provide selected recommendations.

Themes 1. Seek Advice and Recommendations on Innovative Strategies to Address Legacy Phosphorus

The GLAB made nine recommendations under this theme. Among them, the GLAB recommends that EPA **support regional projects to identify critical source areas (CSAs) in the watershed** and then to use CSA information to prioritize and more effectively fund and implement strategies to maximize removal of legacy phosphorus and excess nutrients from the system.

The GLAB further recommends funding and implementing **long-term comprehensive watershed monitoring programs** to (1) evaluate the performance and costs of individual or combined avoid, control, and trap conservation practices; and (2) guide GLRI project funding decisions to maximize legacy P nutrient and sediment reduction.

Recommendations for theme 1 also include innovative funding strategies to support ongoing monitoring and assessment, such as **supporting the development of the GLRI-funded public–private partnerships and pay-for-performance conservation programs** and **supporting the creation on an endowment fund.**

To assist underserved communities with project identification and development, application for financial assistance, and project implementation and management, the GLAB recommends **supporting the development of a new GLRI-funded technical and grant management assistance program**.

Theme 2. Seek Advice and Recommendations on Managing Excess Nutrients

The GLAB addressed developed 13 recommendations in response to this theme's charge question. In addition to **supporting and funding regional projects to (1) identify watersheds where Great Lakes Water Quality Agreement target nutrient loads are consistently exceeded March–July, and (2) identify CSAs within those watersheds that contribute a disproportionately large amount of excess P to nutrient load,** the GLAB recommends that EPA **support additional research and funding for innovative technology/nutrient-removal systems along with innovative funding strategies to support long-term monitoring and assessment of these technologies to evaluate their effectiveness.** This recommendation is consistent with, and complements, the recommendations from the report produced by the Science and Information Subcommittee of the prior GLAB, which was charged in part with providing advice on how to incorporate duration and longevity considerations into GLRI proposal selection.

Examples of mid-term recommendations for this theme are the GLAB recommendations that EPA **support the development of new performance metrics to recognize and document potential reductions in nutrient loading that might result by implementing land use and watershed plans.** The metrics should be incorporated into land use models to identify potential land use controls or changes that maximize nutrient-reduction benefits within a watershed. In addition, the GLAB recommends that EPA **support regional policy and management committees to use land-use planning models, appropriately calibrated Soil and Water Assessment Tool models, and HUC-12 water quality monitoring data to validate model results to identify watersheds and CSAs that disproportionately contribute to excess P loads in the Great Lakes.** These models—whether new or existing—could be used by regional policy and management committees to prioritize watersheds for GLRI interventions and to evaluate the appropriate suite of practices, policies, and land-use changes needed to achieve nutrient-reduction targets within target watersheds.

Theme 3. Seek Advice and Recommendations on GLRI Outreach

The GLAB's 11 recommendations for theme 3 encourage EPA to focus more on communication, accessibility, collaboration, and accountability. Near-term recommendations include **developing and implementing community engagement metrics** to assess progress toward environmental justice outcomes and **establishing a framework and programs for engaging and supporting the relevant activities of community organizations, libraries, and nontraditional stakeholders, particularly those in disproportionately impacted areas, through meaningful engagement and communication.**

To promote accountability and community inclusion, the GLAB further recommends that EPA **prioritize reporting on the impacts of GLRI programs on environmental injustice and climate change** as significant environmental and natural resources issues affecting the Great Lakes.

Theme 4. Seek Advice and Recommendations on Invasive Species

The GLAB's 12 recommendations for theme 4 focusing on aquatic invasive species. GLAB recommendations considered pathways, coordination, collaboration, prevention, and management. Preventive recommendations include **improving coordination, information exchange, and database sharing at the federal, state, and local levels.** This is absolutely essential given that it takes only one weak link in the prevention network for AIS to invade and potentially spread. In addition, GLAB recommends increased access to critical information collected by government entities. In many cases, it is unclear what data are being collected and from where. One example of increased accessibility would be to improve the coordination and collation of fisheries and government research survey data so that effort, location, and species distribution data are available and can inform regional surveillance efforts and other research and management purposes. A regional database could inform many environmental management areas, as well as avoid redundancy and optimize surveillance and response efforts.

Continually invest in new technologies was another theme 4 recommendation, and GLAB suggested that EPA look into gene-drive technology, behavioral disruption technologies, and AIS-specific biocides. Among other mid-term recommendations for this theme were **coordinating with the International Joint Commission in the development and implementation of an early warning system in the Great Lakes** and **initiating a coordinated research and stakeholder engagement program** involving aquatic and molecular ecologists, ethicists, social scientists, biotech specialists, and venture capitalists to explore the feasibility, desirability, and legality of gene-drive technology as a control mechanism for AIS.

Theme 5. Outcome-Based Investments in the Great Lakes

The GLAB made nine recommendations for this theme, which focus on ways EPA can advance community inclusion and environmental justice, ensuring communities enjoy equal protection from health hazards and are meaningfully included in the prioritization, planning, and implementation of programs.

EPA partnership with communities should seek to improve the capacity-building, skills, training, and workforce development needs of these communities, individuals, and nongovernmental organizations that, in turn, can increase their ability to present and advocate their community's desired outcomes. Recommendations include **establishing a broad set of project outcomes that include environmental justice, climate, and public health impacts** and **establishing procedures to enable consideration for funding projects that require resources for long-term operations and maintenance** so that tribes and underserved communities can successfully compete for grants.

A significant portion of the theme 5 discussion focuses on traditional environmental knowledge (TEK); associated recommendations include **implementing a framework with specific environmental justice outcomes to support cohesive Great Lakes programs that recognize and appropriately incorporate the priorities of tribes and TEK,** and **incorporating qualitative and narrative data into outcome measures, including TEK.**

Theme 6. GLRI's Role in the Vitality and Reinvestment of Great Lakes Communities

GLAB brought climate change, climate justice, and environmental justice into this theme's discussions and formulated 11 recommendations. They include EPA's **supporting the assessment of climate change on the Great Lakes Basin that affects environmental, public health, and economic metrics, including drought and flood resiliency and sustainability** and **supporting ongoing research & development so that stakeholders can get an earlier understanding of emerging challenges, such as climate change impacts that could affect the magnitude or longevity of restoration efforts.**

The GLAB also saw potential in the in the development of the next GLRI five-year Action Plan to further address climate change and climate resilience and recommended that EPA **engage the public early in the development of the GLRI Action Plan IV** and prioritize community outreach and engagement with communities of color, Indigenous communities, and low-income communities; and, as a mid-term recommendation, to **update Action Plans to ensure environmental justice and climate change are included.** In addition, the GLAB recommends that EPA **incorporate Justice40 initiatives and priorities into the GLRI Action Plans and investments** and review environmental justice recommendations for environmental justice communities and tribes as pertinent to the Great Lakes.

From Restoration to Protection and Sustainability

Finally, the GLAB urges EPA to get ahead of the restoration curve; to set long-term, ambitious goals; and to devote significant, sustained resources to protecting what has been restored and ensuring that healthy water bodies stay healthy. For the GLAB's discussion on that topic, please see the section "GLRI Moonshot: From Restoration to Protection and Sustainability."

Like other treasures we protect, safeguarding the Great Lakes ecosystem will require a sustained monitoring effort that includes—but extends well beyond—restoration. Also, like other sustained initiatives, monitoring and maintenance will need to be a commitment, but it will be far less expensive than continuing a cycle of cleanup, inattention, degradation, and more cleanup.

By setting and achieving ambitious restoration goals, EPA could facilitate the natural programmatic shift of GLRI priorities from restoration to ongoing protection and management and establish a strong, sustained commitment for the protection of the Great Lakes Basin.

Contents

Introduction

While considering its charge questions, the Great Lakes Advisory Board (GLAB) remained acutely aware of two contextual forces: (1) the immediacy of climate change; and (2) the accelerated national momentum toward social justice, which includes environmental justice. Although the GLAB was assigned its charge questions by the previous administration, the Biden Administration has committed to reinvigorating and sustaining action on both issues. The GLAB, therefore, expanded the interpretation of its six charge questions and crafted recommendations focused on the need for EPA to get in front of the curve on some of the most pressing challenges facing the Great Lakes today.

EPA's charge questions fell under six themes. To better utilize the diversity of member backgrounds, experiences, and expertise, the GLAB established 4 workgroups:

> **Environmental justice** is the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation and enforcement of environmental laws, regulations and policies. —EPA

The **Nutrients Workgroup** focused on charge questions under themes 1 and 2:

- Theme 1: Seek Advice and Recommendations on Innovative Strategies to Address Legacy Phosphorus; and
- Theme 2: Seek Advice and Recommendations on Managing Excess Nutrients.

The **Invasive Aquatic Species Workgroup** focused on theme 4: Seek Advice and Recommendations on Invasive Species.

The charge questions related to the Great Lakes Restoration Initiative (GLRI) were addressed through a **Community-based Workgroup** and an **Ecological Workgroup,** both of which worked on the remaining themes:

- Theme 3: Seek Advice and Recommendations on GLRI Outreach;
- Theme 5: Outcome Based Investments in the Great Lakes; and
- Theme 6: GLRI's Role in the Vitality and Reinvestment of Great Lakes Communities.

The GLAB met solely through virtual means due to the pandemic. Nevertheless, discussions of challenges and solutions were robust, and the GLAB fielded an array of recommendations. Because the GLAB felt free to approach the charge questions based on the interests of the current administration, some recommendations went beyond the scope of the original charge question. Rather than reject those recommendations, the GLAB organized its final recommendations under each theme as follows:

Near-term recommendations are those that are currently actionable under GLRI and by the Great Lakes National Program Office (GLNPO).

Mid-term recommendations are those that require additional research or development before they could be implemented under GLRI; however, that research and development could be a near-term activity.

Long-term recommendations refer to activities that are within EPA purview but may require legislative changes, new partnerships, multi-stakeholder engagement, additional investments, or other development in order to implement.

The "terms" do not suggest the relative importance or urgency of any recommendations to the health and vitality of the Great Lakes. The GLAB simply recognizes that the recommendations involve a range of level of effort and organizational, regulatory, and legislative complexity to implement.

Finally, by design, the GLAB comprises members from tribal, public, private, nonprofit, activist, and academic institutions who approach the charge questions from different perspectives. (See Appendix 1 for GLAB members and affiliations.) These final recommendations to EPA, therefore, can only represent the GLAB's consensus, not each member's unanimous agreement on every recommendation, or on how any recommendation was phrased or framed.

Common themes run throughout the recommendations. One is the need to consider the projected impacts of climate change on the entire Great Lakes watershed and to take protective action. Another crosscutting theme urges EPA to set measurable standards for the implementation of programs that ensure community inclusion and genuine participation from the earliest phases and throughout the project lifespan. Finally, the GLAB urges EPA to get ahead of the restoration curve; to set long-term, ambitious goals; and to devote significant, sustained resources to protecting what has been restored and ensuring that healthy water bodies stay healthy. For the GLAB's brief discussion on that topic, please see the section "GLRI Moonshot: From Restoration to Protection and Sustainability."

The GLRI continues to make impressive progress with restoring our national treasure, the Great Lakes. As we enter the next decade of GLRI funding, the GLAB looks forward to building on past success and to further recommend ways that the GLRI can address our increasingly urgent environmental and social challenges.

Acronyms

ACT	avoid, control, and trap
AIS	aquatic invasive species
AOC	area of concern
BIL	Bipartisan Infrastructure Law
CSA	critical source area
DO	dissolved oxygen
DRP	dissolved reactive phosphorus
EPA	U.S. Environmental Protection Agency
FEMA	Federal Emergency Management Agency
GLAB	Great Lakes Advisory Board
GLIFWC	Great Lakes Indian Fish & Wildlife Commission
GLLCISP	Great Lakes and Lake Champlain Invasive Species Program
GLNPO	Great Lakes National Program Office
GLRI	Great Lakes Restoration Initiative
GLWQA	Great Lakes Water Quality Agreement
HABs	harmful algal blooms
HOW	Healing our Waters–Great Lakes Coalition
HSTS	home sewage treatment system
HUC	Hydrologic unit code
IPL	internal phosphorus loading
LAMPs	Lakewide Action and Management Plans
NGO	nongovernmental organization
NPDES	National Pollutant Discharge Elimination System
NPS-IS Plan	Nonpoint Source Implementation Strategic Plan
NRCS	Natural Resources Conservation Service
P	phosphorus
PAC	public advisory council
PFP	pay for performance
ROI	return on investment
SWAT	Soil and Water Assessment Tool
SWCD	Soil and Water Conservation District
TEK	traditional ecological knowledge
TMDL	total maximum daily load
USACE	U.S. Army Corps of Engineers
USCG	U.S. Coast Guard
USDA	U.S. Department of Agriculture
USDA–NRCS	U.S. Department of Agriculture–Natural Resources Conservation Service
VIDA	Vessel Incidental Discharge Act

Theme 1. Seek Advice and Recommendations on Innovative Strategies to Address Legacy Phosphorus

Legacy Phosphorus is defined as phosphorus that is already in the soil and water of the Great Lakes (and tributaries thereto) and that may require different considerations as part of the installation of any new or continuing best management practices to reduce nutrient loads.

Charge Question: Please identify any strategies, using traditional or innovative technologies or methods, to reduce legacy Phosphorus within the Lake Erie watershed (and other Great Lakes and tributaries thereto).

Introduction

The GLAB approached this charge question by first defining *legacy phosphorus* and then considering watershed-based and lake-based mitigation strategies. For our discussions, we defined legacy phosphorus as surplus phosphorus (P) that is stored and gradually released from the watershed as either particulate P or dissolved reactive phosphorus (DRP) or is stored in lakebed sediments that might be gradually released as DRP. Legacy P is derived from natural and anthropogenic P sources and is stored in soils and sediments, representing a potential P load; legacy P does not include contemporary excess P load. When mobilized, legacy P contributes to the baseline P load. As legacy P is released in the watershed from point and nonpoint sources, it is mobilized and remobilized along the land–freshwater transport continuum, acting as a continuing source of P to downstream water bodies for years, decades, or even centuries (Carpenter 2005; Sharpley et al. 2013). This characteristic makes controlling and reducing legacy P sources challenging.

The movement of P across landscapes requires both a source and a mechanism for transport (Sharpley et al. 2003). Legacy P serves as the source, with surface runoff, leaching, and erosion processes acting to remobilize and transport legacy P from land to water. Addressing the source and transport processes for legacy P is important for developing a nutrient management strategy. Below, we propose actions that can be taken on the landscape to address legacy P and the processes that transport legacy P to water bodies. We also propose lake-based strategies that can be implemented to address internal P loading from riverine and lake sediments.

Watershed-Based Strategies

Identification of Critical Source Areas

Within the watershed, the recognition and identification of critical source areas (CSAs) is essential for tackling legacy P. Effective application of agricultural, urban, and other nonpoint source management practices requires that they are properly planned, sited, and sized. An important aspect of the planning process is identifying CSAs, which are areas in the watershed that contribute disproportionately to the legacy P load. These are the locations where a legacy P source in the landscape coincides with active hydrologic transport mechanisms. Because a relatively small area of a watershed can generate a disproportionate amount of legacy P, identifying CSAs can help prioritize conservation practices to protect water quality and reduce costs (EPA 2018). Moreover, CSAs have a temporal component, as P loads will be greatest after storm events due to both higher

flow and erosive forces moving particulate P across the landscape. In the Western Basin of Lake Erie, the critical loading period that drives harmful algal blooms (HABs) is March 1 through July 31 (EPA 2015; GLWQA Nutrients Annex Subcommittee 2015). In addition, studies have shown that tile drain P loads are highest in the winter months, especially those from fields without winter cover crops (Lam et al. 2016; Clement and Steinman 2017).

Near-term Recommendation

- **Support regional projects to identify CSAs in the watershed.** Then, use CSA information to prioritize and more effectively fund and implement strategies to maximize removal of legacy P and excess nutrients from the system. (This recommendation also supports theme 2.)

Management Strategies

There are numerous ways to manage legacy P as it is released from the watershed. One practice-based framework is the U.S. Department of Agriculture–Natural Resources Conservation Service (USDA–NRCS) avoid, control, and trap (ACT) conservation approach. To effectively implement ACT, a regulatory approach might be required that includes, but is not limited to, fertilizer applicator certification, seasonal and weather-related restrictions on nutrient application, mandatory nutrient management plans, and inspection and management of home sewage treatment systems (HSTSs). A general description and examples for these management practices are provided below.

Avoiding Practices

Avoiding practices are conservation practices that manage nutrient handling, improve soil health, and optimize nutrient use for crop production. Avoiding practices are the first line of defense in preventing nutrient runoff or augmenting legacy P. These practices are implemented to avoid scenarios that pose an increased risk for nutrient and sediment movement. Examples of avoiding practices are provided in table 1.

Table 1. Examples of USDA–NRCS ACT Avoiding Practices

NRCS Practice Name
Nutrient Management
Cover Crops
Conservation Cropping Systems (Crop Rotations)
Amending Soil with Gypsum Products

Note: See USDA–NRCS Field Office Technical Guide for additional details.

An innovative and effective approach to nutrient management is the 4R Nutrient Stewardship program.[1] The 4R Nutrient Stewardship program considers the economic, social, and environmental dimensions of nutrient management. The concept is simple: apply the right source of nutrients at the right rate, at the right time, and in the right place. By targeting specific areas with the right amount of nutrients, excess nutrients will not be incorporated into the soil or sediment to become future sources of legacy P.

1. See https://nutrientstewardship.org/4rs/.

Controlling Practices

In situations where avoiding conservation practices are not well established, or where unforeseen, excessive, or even normal weather-related precipitation causes nutrient-laden transport of runoff and drainage water to occur, controlling practices can be implemented to reduce effects (erosion, runoff rate, and volume) in which transport pathways have a role. Examples of controlling practices are provided in table 2.

Table 2. Examples of USDA–NRCS ACT Controlling Practices

NRCS Practice Name
Residue and Tillage Management
Grade Stabilization Structures
Drainage Water Management
Grassed Waterway
Critical Area Planting

Note: See USDA–NRCS Field Office Technical Guide for additional details.

Strategies to control legacy P can be further divided into upland-based and water-based strategies. The majority of traditional conservation practices are in the upland areas of the watershed, starting within crop fields and terminating at edge-of-field. In addition, numerous opportunities exist to implement additional transport pathway control strategies (i.e., slow the flow) as we move downstream.

Examples of transport pathway control practices include enhanced implementation of two-stage ditches (Davis et al. 2015); cascading waterways such as found in the Chesapeake Bay and Great Lakes (the Nature Conservancy, n.d.); treatment trains implemented in Grand Lake St. Marys, Ohio; off-stream chemical stormwater treatment or nutrient-reduction facilities such as the Dixie Drain Phosphorus Removal Facility in Idaho (Sharp 2018); stormwater treatment areas (Newman and Pietro 2001); and constructed treatment/nutrient-reduction wetlands such as found in the Maumee River watershed, Ohio (Berkowitz et al. 2020; State of Ohio 2021).

Historically, flood control detention basins have been used for short-term storage of flood waters, which are then gradually released to minimize downstream effects of flood and erosion. These basins could be retrofitted with wetlands or engineered sediment and nutrient-reduction systems to enhance water quality while reducing impacts from high flow events.

Trapping Practices

Trapping conservation practices represent the last line of defense in agricultural water quality conservation. The majority of annual agricultural nutrient and sediment loading usually occurs during only a handful of runoff and drainage events, making it important that well-considered and -designed trapping practices are installed to trap, infiltrate, and retain as much of the runoff and nutrients during these events as possible. Slowing down and retaining runoff waters also reduces stressors on stream channels (such as stream bank erosion) and can provide more sustained base flow to the tributary system. Slowing the flow and retaining flood waters increase opportunities for natural assimilation and processing of nutrients in the aquatic system throughout the year. Examples of trapping practices are provided in table 3.

Table 3. Examples of USDA–NRCS ACT Trapping Practices

NRCS Practice Name
Filter Strips/Filter Areas
Constructed Wetlands
Underground Outlets (Blind Inlets)
Phosphorus Removal System
Denitrifying Bioreactor
Water and Sediment Control Basin
Riparian Forest Buffer
Irrigation Reservoir
Saturated Buffer

Note: See USDA–NRCS Field Office Technical Guide for additional details.

Trapping conservation practices that promote the retention of sediment and nutrients (filter strips, buffer zones, and constructed wetlands) are effective in reducing off-site movement and protecting downstream water quality. Examples of trapping practices include harvesting or removing terrestrial and aquatic plant biomass to reduce nutrient levels (Bartodziej, Blood, and Pilgrim 2017); installing iron slag filters and other types of engineered nutrient-removal systems (Hua et al. 2016); and constructing new coastal or riparian wetlands and reconnecting existing managed wetlands to capture sediments and process nutrients (Berkowitz et al. 2020; State of Ohio 2021). Moreover, the accumulated sediments trapped by these conservation practices could be beneficially reused. One potential reuse is to implement agricultural field placement programs where P-laden sediments are incorporated back into agricultural fields, thereby reducing the need for newly applied fertilizer (ESPP, n.d.).

Looking Ahead

A recent analysis of the data collected at Ohio USDA–Agricultural Research Service edge-of-field monitoring locations indicates that soil legacy P contributes 80% of the P loss, and newly applied (excess P) from fertilizer or manure contributes the remaining 20% (Osterholz 2021). If correct, this would suggest that an emphasis on the implementation of controlling and trapping approaches rather than on avoiding approaches might be more effective because they disrupt both legacy and excess P transport processes and alter pathways to the receiving water body. This does not imply that efforts to manage excess fertilizer or manure applications on the landscape (i.e., avoiding practices) should be reduced, as these nutrients also serve as the source for new legacy P.

Because there are numerous factors that influence the release of legacy P, no single practice or solution will fully address the release of legacy P-laden sediments or nutrients from the watershed. Site-specific characteristics and local agronomic decisions will determine the most effective nutrient management measures. In addition, an economic analysis of P removal and the impact of climate change should be incorporated into project criteria for selection and prioritization. Full-cost accounting allows for the evaluation of proposed projects and involves the inclusion of externalities, improved discount rates, and other factors, and can serve as both a funding decision criterion and a metric to track project performance.

Climate change has a vast potential impact on legacy P and must be incorporated into the design of legacy P mitigation projects and recommendations, for example, by sizing projects to accommodate

future flow rates and loading through the design life of the practice. Climate predictions indicate more extreme events, resulting in increased nutrient loads into receiving water bodies. In addition, earlier onset and later breakdown of lake stratification will increase duration and severity of anoxia, exacerbating internal loading and biotic stress (Søndergaard, Peder, and Jeppesen 2003; Gibbons and Bridgeman 2020). Changes in flow, duration, and frequency should be incorporated into the designs of future projects so they remain functional across a range of different water level or flow regimes.

Near-term Recommendations

- **Fund and implement long-term comprehensive watershed monitoring programs** to (1) evaluate the performance and costs of individual or combined ACT conservation practices; and (2) guide GLRI project funding decisions to maximize legacy P nutrient and sediment reduction.
- **Support and fund projects that evaluate the relative contributions of soil legacy P and applied P to total P loss.**

Mid-term Recommendation

- **Coordinate GLRI funding and technical expertise to develop regional tools to implement the most effective combination of ACT practices at federal, state, and local levels** as identified in the USDA–NRCS ACT program to maximize legacy P nutrient and sediment reduction at HUC-12 watershed scales.

Lake-Based Strategies

Legacy P can accumulate in lake and river sediments. When lake-based legacy P is released into the water column, this process is referred to as internal phosphorus loading (IPL). IPL can be defined as "all physical, chemical, and biological processes by which P is mobilized and translocated from the benthic environment" (Steinman and Spears 2020, 4). IPL is known to occur in Lake Erie (Matisoff et al. 2016; Anderson, Johengen, Godwin et al. 2021; Wang et al. 2021), although its relative importance as a legacy P source is debated.

Management strategies to control IPL depend on the mechanism by which the P is leaving the sediment and entering the water column. (For more detailed discussions on this topic, see Cooke et al. 2016; and Steinman and Spears 2020). Key physical, chemical, and biological management treatments are discussed briefly below. Because of logistical or financial constraints, some of these treatments are not feasible in the open water of Lake Erie. However, they may be operational in certain embayments or tributaries, as well as in other parts of the Great Lakes, as has been shown for drowned river mouth lakes (Steinman and Ogdahl 2012).

Physical Treatments

Sediment removal and aeration are two common methods to physically control IPL. Sediment removal can involve either excavation (whereby overlying water is first removed) or dredging (removal of sediment without water drawdown). In cases where legacy P-laden sediments have accumulated in shallow riparian or managed coastal wetlands or in shallow lakes or detention

basins, it may be possible to excavate and remove the P-laden sediment to prevent the release of DRP from sediments saturated with legacy P. The removed sediment could be used for agricultural field placement (with appropriate water management and nutrient-reduction controls) or for other environmentally beneficial uses.

In larger riverine and lake systems, in-water dredging with upland placement is a viable mechanism to permanently remove legacy P from the environment. For example, the U.S. Army Corps of Engineers (USACE) typically will dredge up to 1.5 million cubic yards of sediment from eight federal harbors along the Ohio Lake Erie coastline every year. USACE will dredge 600,000 to 1 million cubic yards of P-laden sediment from the Toledo federal navigation channel every year. Effective July 1, 2020, the State of Ohio banned open-lake placement of dredge material into the Ohio waters of Lake Erie. In the fall of 2020, more than 635,000 cubic yards of P-laden dredge material were placed into the Port of Toledo's Facility 3 Confined Disposal Facility instead of the open-waters of Lake Erie. Although sediment removal eliminates legacy P from the water body, there are drawbacks to in-water dredging that include short-term degradation of local water quality during dredging; removal of the benthic community; location and availability of a disposal site for appropriate placement; overall costs to dredge, transport, and place the material; and regulatory and permitting issues (Lürling, Smolders, and Douglas 2020).

Aeration (also including oxygenation) prevents hypoxia (< 2 mg/L dissolved oxygen [DO]) or anoxia (<0.1 mg/L DO) from forming at lake bottoms. Keeping DO concentrations elevated promotes the binding of P to Fe^{3+}, preventing the P from diffusing into the water column. While commonly implemented, the results are mixed (see Lürling, Smolders, and Douglas 2020). Moreover, the application of aeration in large systems is not practical or cost effective. However, aeration could be applied in more localized settings, such as in smaller nutrient-reduction wetlands or detention basins that are sufficiently deep to stratify and go hypoxic to prevent the release of DRP from retained sediments.

Chemical Treatments

There are two main classes of materials used to chemically manage IPL: those that oxidize the upper sediment layer, and those that inactivate P directly in-situ (that is, within the water column or sediment [Lürling, Smolders, and Douglas 2020]). Adding chemicals to oxidize the sediment assumes the sediments are already anoxic and might be releasing P. By providing electron acceptors such as nitrate or manganese (e.g., as calcium nitrate and other formulations), the sediments remain oxic and P remains bound to the oxidized form of iron (Fe^{3+}). Recent work in Lake Erie has shown how the transition among oxic conditions can strongly influence P release (Anderson, Johengen, Miller et al. 2021).

Phosphorus inactivants can be added to water bodies in liquid or solid form. Aluminum- and iron-based salts are the most common liquid formations, applied either to the water column, where they can strip P as they settle to the sediment, or injected directly into the sediment to avoid resuspension. The efficacy of these inactivants varies widely based on sediment and lake characteristics and generally ranges from less than one year to more than 20 years (Cooke et al. 2016). Many different solid phase P adsorbents have been developed recently; perhaps the most well studied is lanthanum-modified bentonite (Phoslock [Spears et al. 2013]). With all these

chemical treatments, application concentration must be carefully determined to ensure sufficient material to bind P but not so much as to cause ecotoxicity.

Biological Treatments

Biomanipulation, usually involving the removal of benthivorous fish (e.g., gizzard shad) to avoid sediment disturbance and subsequent release of P into the water column, has had success in small inland lakes (Godwin et al. 2011), but its feasibility in large, open waters is more doubtful. In addition, other organisms such as chironomids can be major bioturbators, and biomanipulation could stimulate their activity which might promote the release of legacy P.

Near-term Recommendation

- **Support the physical removal or chemical/biological sequestration of legacy P–laden sediments** as effective methods to remove legacy P from the lake environment. Also encourage GLRI coordination with the USACE and local communities to develop innovative ways to sequester or beneficially reuse dredge sediment for agricultural field placement, habitat restoration, or other environmentally suitable uses.

Long-Term Monitoring and Maintenance

The controlling and trapping conservation practices described above could concentrate P at specific locations in the watershed, including within wetlands and detention basins. These practices will effectively reduce short-term excess P loads while simultaneously creating a potential future source of legacy P. As a result, the anticipated rate of downstream water quality improvement could be reduced over time by offsetting releases of legacy P from saturated sediments (i.e., IPL). This delay, referred to as lag-time, can be in the range of years, decades, or even centuries. Given the variable time frame, traditional post-management monitoring periods of five to ten years might be insufficient to capture the true and total impacts (or benefits) of implementing these conservation practices (Sharpley et al. 2013).

Long-Term Monitoring

Moreover, there is a need to re-assess current monitoring approaches. GLRI-funded water quality projects are typically monitored when the GLRI grant award is active (generally three to five years), but in many cases are not physically monitored at all. The nutrient-reduction metrics used are based on regional assumptions of the P-reduction performance of a specific type or class of project to calculate pounds of P removed to meet long-term goals and targets. The current monitoring program (though it is beginning to improve) is inadequate and does not provide the information or data necessary to understand how well these GLRI-funded projects perform over time.

Mid-term Recommendation

- **Fund and implement a comprehensive long-term monitoring program to assess GLRI-funded project performance and provide the information necessary to guide future GLRI investments in water quality and more effectively manage nutrient pollution in the Great Lakes.** (This recommendation also supports theme 2.)

Critical Need for Long-Term Funding

Long-term monitoring and maintenance of legacy P nutrient-reduction projects will require a commitment to dedicated long-term funding. Funding mechanisms to support long-term monitoring are particularly challenging because federal and state agencies are limited in their ability to make long-term financial commitments due to annual or biennial budget cycles.

One solution that has been successfully applied is the creation of an endowment fund to provide the resources to support long-term environmental protection and restoration efforts in Muskegon Lake (Steinman and Ogdahl 2004). There are a variety of ways to capitalize such an endowment fund, including fines from environmental violations and bond initiatives. Experience has shown that several revenue streams would likely be necessary for capitalization of the fund. GLRI could manage such a fund, and the $375 million dollars appropriated annually to GLRI is an important potential source of funding for long-term monitoring, with the caveat that the endowment fund disbursements would carry a match requirement from a non-federal entity. Below, we identify several alternative mechanisms to fund long-term monitoring and maintenance.

1. **GLRI funding:** Redirect 2% of the annual GLRI appropriation (FY 2021–2022: $7.5 million) to a long-term monitoring and maintenance endowment fund, which would be available as part of a competitive proposal process.
2. **Pay-for-Performance (PFP) Conservation:** Provide flexible conservation options to farmers while delivering quantifiable water quality benefits in agricultural watersheds.[2]
3. **Public–private partnerships:** Encourage these partnerships, which allow leveraging of resources through private donations and promote broad community engagement (Meissner 2019).[3]
4. **Match requirements:** For certain projects, require a cash match that would go into the monitoring and maintenance endowment fund.

The monitoring effort described above is designed to evaluate the success and ongoing performance of specific projects. In addition, a more collective assessment of GLRI progress in specific embayments or whole lakes can be assessed by evaluating existing regional monitoring programs for improvements in (1) State of the Lakes Ecosystem Conference indicators over time; (2) trends in long-term monitoring data collected through GLNPO annual monitoring using the Lake Guardian; and (3) results of the five-year intensive lake monitoring surveys implemented by the Cooperative Science and Monitoring Initiative. All three of these initiatives are led or conducted by the GLNPO monitoring and indicators branch. It is important that these monitoring programs

2. See http://glpf.org/funded-projects/reducing-phosphorus-loads-from-agriculture-creating-a-pay-for-performance-program-using-field-specific-information/.
3. See https://outdoordiscovery.org/project-clarity/.

continue to be supported over time to assess the overall condition of the lakes, emerging issues, and progress that is being made through GLRI investments.

Investments in Underserved Communities

In addition to long-term monitoring, innovative funding mechanisms are needed to address water quality degradation due to nutrient loading in smaller urban or rural communities and areas that do not have the financial or technical capacity to apply for or manage GLRI grant funds.

1. **GLRI funding:** Redirect a percentage of the annual GLRI appropriation to an endowment fund, which would provide long-term capacity building and financial support to smaller underserved urban or rural communities to address historic and current water quality degradation due to nutrient loading.
2. **Technical and grant management assistance program:** Develop and implement new GLRI-funded technical and grant management assistance programs (including third-party engagement) designed to assist underserved communities with project identification and development, application for financial assistance, and project implementation and management.
3. **Financial assistance:** Establish criteria and thresholds to eliminate non-federal match requirements for underserved communities that lack the financial or technical capacity to apply for or manage GLRI grant funds.
4. **Innovative financing:** Encourage GLRI-funded public–private partnerships and PFP conservation programs to address historic and current water quality degradation due to nutrient loading in underserved communities.

Short-term Recommendation

- **Support the development of a new GLRI-funded technical and grant management assistance program** designed to assist underserved communities with project identification and development, application for financial assistance, and project implementation and management.

Mid-term Recommendations

- **Support the creation of an endowment fund** to provide a stable, long-term funding source to support the continued monitoring and assessment of GLRI-funded nutrient-reduction projects and to provide long-term capacity building and financial support to underserved smaller urban or rural communities. (This recommendation also supports theme 2.)
- **Support the development of GLRI-funded public–private partnerships and PFP conservation programs** to support the continued monitoring and assessment of GLRI-funded nutrient-reduction projects and to address historic and current water quality degradation due to nutrient loading in underserved communities.

See appendix 2 for a list of theme 1 recommendations.

Theme 2. Seek Advice and Recommendations on Managing Excess Nutrients

The issue of nutrient (especially phosphorus) loading has been a very significant and public ecosystem health issue in Lake Erie, primarily due to the creation of Harmful Algal Blooms (HABs) that negatively impact drinking water systems, tourism, and other commercial activities in the Great Lakes.

Charge Question: Balancing the need for the continued production of agricultural commodities in the Great Lakes region, the contribution to excess nutrient loading in Lake Erie associated with agricultural production activities, and the need to significantly reduce the extent and duration of HABs on Lake Erie, what innovative actions could reasonably be taken to accelerate the reduction of excess nutrients and HABs or duration of HAB events in Lake Erie? Consider if there are new or different applications of traditional federal funding sources, opportunities to partner with the private sector (including tourism, drinking water systems, and others affected by HABs), or community-driven or market-based approaches to financing water quality improvements.

Introduction

The GLAB approached the charge question by defining *excess nutrients* (i.e., excess phosphorus [P]) and then exploring potential structural (physical) and nonstructural (policy, regulatory, and market-based) watershed nutrient-reduction strategies. Addressing the sources and transport processes for excess nutrients is important for developing sound nutrient-management strategies. Excess nutrients include those derived from urban and suburban point and nonpoint sources (e.g., wastewater treatment facilities, stormwater outfalls, surface runoff); agricultural nonpoint sources (e.g., fertilizer, manure, agricultural drain tiles, drainage ditches); and other point and nonpoint sources such as HSTSs (Chen et. al 2015; Cornell 2011). Regardless of source, all nutrients that exceed agronomic and food web requirements and are released and transported downstream are considered to be excess nutrients and collectively contribute to eutrophication, hypoxia, and HABs in the Great Lakes (Madenjian et al., 2002; Scavia et al., 2014).

Surface runoff, leaching, and tile drainage are the primary mechanisms or pathways that mobilize and transport excess nutrients from the landscape into streams and rivers. Excess nutrients originating from all land uses transported to streams and rivers ultimately end up in the Great Lakes (Allan 2004; Robertson and Saad 2011). Moreover, excess nutrients, when incorporated into soils or bound to sediment, might also be a source of future legacy P.

To address increasing impacts of excessive nutrient loads into the Great Lakes, the Great Lakes states have developed and are implementing nutrient-reduction plans across all sectors and sources to achieve nutrient-reduction goals (see, for example, IEPA, IDOA, and University of Illinois Extension 2015; State of Ohio 2020; State of Michigan 2018). These plans describe multiple approaches to nutrient reduction including structural approaches that control or trap excess nutrients across the landscape, and nonstructural practices that attempt to minimize excess nutrients at the source through governance, regulatory, and market-based means.

Identification of Critical Source Areas

An important aspect of the planning process is the identification of CSAs, which are areas in the watershed that contribute a disproportionately large amount of excess P to the nutrient load. These are the locations where sources of excess nutrients on the landscape coincide with active hydrologic transport mechanisms. Because a relatively small area of a watershed can generate a disproportionate amount of excess nutrients, identifying CSAs can help prioritize conservation practices to better protect water quality and reduce costs (EPA 2018).

CSAs can be identified by determining where Great Lakes Water Quality Agreement (GLWQA) target nutrient loads (or total maximum daily loads [TMDLs]) are consistently exceeded during the critical March–July timeframe. Those watersheds contributing the highest loads can then be prioritized. Land use practices or specific locations within those watersheds that contribute excess nutrient loads can be addressed by applying appropriate structural (controlling and trapping) practices or nonstructural (avoiding) practices to minimize excess nutrient loads. (See theme 1 for a discussion of structural and nonstructural strategies.)

Examples of nonstructural (controlling) practices include limiting the amount of commercial fertilizer or manure applied to the landscape as a function of season and crop rotation and understanding the mobilization and transport pathways from CSAs through the watershed such as surface runoff, leaching, tile drainage, or other means. Moreover, to maximize nutrient-reduction benefits, structural nutrient-removal systems should be located near the pour points (or outlets) of CSAs. In instances where multiple input sources and multiple HUC-12 watersheds are cumulatively contributing excess nutrients to a receiving water body, it might be most efficient to implement large-scale structural nutrient-removal projects closer to the impacted receiving water body. There are efficiencies to be gained as larger-scale projects might be easier to maintain and monitor over a long period of time. If sited properly, these projects have the potential to remove excess nutrients that have not been addressed by best management practices and watershed practices further upstream.

Near-term recommendation

- **Support and fund regional projects to (1) identify watersheds where GLWQA target nutrient loads are consistently exceeded March–July, and (2) identify CSAs within those watersheds that contribute a disproportionately large amount of excess P to nutrient load.** Use watershed and CSA information to prioritize and more effectively target excess P management strategies to maximize removal of excess P from the system.

Mid-term recommendation

- **Encourage, support, and fund large nutrient-reduction projects within lower watershed tributaries near or adjacent to receiving water bodies** to maximize potential nutrient-reduction benefits.

Structural Nutrient-Removal Systems

Structural nutrient-removal systems are focused primarily on controlling and trapping excess nutrients as they are mobilized and transported by surface runoff, leaching, and tile drainage from the landscape into water. (See theme 1 for a summary of specific conservation practices based on the ACT and associated recommendations.)

Innovative Technologies/Nutrient-Removal Systems

Table 4 provides a list and general status of innovative structural nutrient-removal practices that are being considered or are being implemented within the basin. These practices might require additional research or funding to support initial pilot projects and long-term monitoring and assessment.

Table 4. Innovative Technology and Nutrient-Removal Systems

Structural Practice	Ongoing	Pilot	Location considerations	Managing entity
P removal traps (e.g., slag filters)	X	X	site specific	federal, state, local
End of tile treatments	X		field runoff, field tiles, or agricultural drains	USDA, NRCS, SWCDs
End of legal drain treatments	X		field tiles, agricultural drains	county drainage boards
Dredging removal/sequestration of high particulate P (and legacy P)	X	X	federal/state commercial and recreational harbors	USACE, federal, state, private
Chemical inactivant injection system		X	smaller lakes & tributaries	local, private
Algal harvesting/filtration technologies		X	smaller lakes & tributaries	federal, state, local
Hybrid technology/natural infrastructure projects		X	coastal and riparian wetlands	federal, state, local
Peak flow management nutrient-removal system		X	riparian overflow wetlands	federal, state, local
Sequential nutrient-removal and processing system	X	X	landscape/system scale	federal, state, local
Flow management, retention, treatment	X	X	field runoff, field tiles, or agricultural drains	USDA, NRCS, SWCDs, FEMA

Note: USDA (United States Department of Agriculture); NRCS (Natural Resource Conservation Service); SWCD (Soil and Water Conservation District); USACE (U.S. Army Corps of Engineers); FEMA (Federal Emergency Management Agency).

Near-term Recommendation

- **Support additional research and funding for innovative technology/nutrient-removal systems along with innovative funding strategies to support long-term monitoring and assessment of these technologies to evaluate their effectiveness.** This recommendation is consistent with, and complements, the recommendations from the report produced by the Science and Information Subcommittee of the prior GLAB, which was charged in part with providing advice on how to incorporate duration and longevity considerations into GLRI proposal selection (EPA 2016).

Mid-term Recommendation

- **Coordinate GLRI funding and technical expertise to develop regional tools to implement the most effective combination of ACT practices at federal, state, and local levels** as identified in the USDA–NRCS ACT program to maximize excess P nutrient and sediment reduction at HUC-12 watershed scales.

Currently state and federal agencies, academic institutions, and consulting firms are collecting data and conducting modeling efforts to understand the sources and amount of nutrients contributing to algal blooms in the Western Basin and hypoxia events in the Central Basin of Lake Erie. Unfortunately, these efforts are not well-coordinated at a regional or cross-jurisdictional level. There may be an opportunity for GLRI to fund efforts to develop mechanisms to foster cross-jurisdictional coordination at a regional landscape or basin-wide scale. This would create an opportunity to apply landscape conservation design principles to systematically link structural nutrient-reduction practices to maximize nutrient-removal efficiencies.

Near-term Recommendation

- **GLNPO should coordinate and GLRI should fund cross-jurisdictional coordination efforts to identify CSAs and implement regionally coordinated watershed scale structural nutrient-reduction practices** (by applying landscape conservation design principles) to maximize nutrient-removal efficiencies.

Nonstructural Practices, Planning, and Market-Based Incentives

Nonstructural nutrient-removal systems are focused primarily on avoiding and controlling nutrient-reduction practices as they are applied to the landscape. Nonstructural approaches also include policy, planning, or market-based activities that result in changes in behavior, investments, or land use that result in nutrient load reductions within a watershed. An example would be land-use planning efforts that change the percentage of developed land versus the percentage of agricultural land within a watershed that result in a reduction of nutrient loads. (See theme 1 for a summary of specific conservation practices based on the ACT nonstructural practices, and associated recommendations.)

Land-Use Planning

The most effective way to control nutrients entering the Great Lakes is to prevent watersheds from developing land uses that increase nutrient runoff and loading to streams. Research has shown that the percentages of urban, suburban, and agricultural land use in a watershed are indicative of stream health (Wiley et al. 2010; Allan 2004).

Watershed land use (percentage of developed land area, percentage of drained agricultural land area) and variable weather or storm runoff events (e.g., precipitation) collectively account for up to 94% of the annual variation in riverine total P fluxes (Tang et al. 2005; Wiley et al. 2010; LaBeau et al. 2014; Chen et. al 2015).

Land-use planning can be used to guide local entities (such as local governments, local and regional planning commissions, and soil and water conservation districts) to promote land use change and encourage conservation practices that reduce nutrient loading to streams. However, there are limited funding opportunities available to support the development and implementation of watershed plans in watersheds that are not already degraded. EPA 319 funds [Section 313(h) of the 1972 Clean Water Act] and GLRI funding are usually directed to areas where nutrient loading is high, current land uses are problematic, and remediation is required. That funding must be maintained. However, GLRI also needs to develop competitive funding opportunities to develop and implement land-use plans that protect and preserve existing high-quality watersheds that have low to moderate nutrient loads.

In addition, current land-use planning models might not consider potential water quality or nutrient-reduction benefits due to changes in land use that result in reduced runoff and trap and process nutrients on the landscape. It may be possible to incorporate modeling results that estimate nutrient load reductions resulting from the implementation of new land-use and watershed plans (Tang et al. 2005). New performance metrics are required to document potential reductions in nutrient loading that could result from changes in land use.

Near-term Recommendation

- **Support and fund the development and implementation of watershed land-use plans and conservation practices that protect and maintain *existing high-quality watersheds* that do not contribute significant excess nutrient loads to the basin.** In other words, protect and preserve what is already working.

Mid-term Recommendations

- **Support the development of new performance metrics to recognize and document potential reductions in nutrient loading that might result by implementing land use and watershed plans.** The metrics should be incorporated into land use models to identify potential land use controls or changes that maximize nutrient-reduction benefits within a watershed.

Market-Based Approaches

Healthy ecosystems provide numerous benefits such as clean water and air, flood prevention, healthy soils, and wildlife habitat. Collectively, these environmental benefits are referred to as ecosystem services. When ecosystem services can be measured and quantified, they can be sold and purchased through emerging ecosystem or environmental credit markets.

Companies and corporations of various sizes across many industries are announcing new corporate sustainability commitments. They are focusing on the public goodwill they will earn as consumers see them as playing a part in improving our climate and our water, air, and soil resources; practicing conservation; increasing biodiversity; and creating pollinator and wildlife habitats. These companies are establishing corporate sustainability programs and investing in environmentally sustainable development projects and ecosystem credit markets.

The ecosystem credit markets are constantly evolving, and many are under development or being refined in pilot stages. Regardless of the stage of development, several common themes exist throughout all ecosystem credit markets. Chief among them is a voluntary, incentive-based structure that connects buyers and sellers of ecosystem services credits. Typically, farmers will be the generator and the seller of the credits. They will receive payment for using conservation stewardship practices proven to meet established ecosystem benefit criteria.

Another market-based approach is the tradable permit model, which requires an authorized federal or state agency (such as EPA or Department of Natural Resources) to set limits on the amount and type of pollutants that can be discharged into the system. Permits are then allocated, distributing a portion of the permitted limit to each operator. Operators can then exercise their permit or sell their allocation to another licensed operator. This structure ensures that annual limits are not exceeded, and it incentivizes efficiency.

Discharging facilities that have upgraded their systems and discharge less than their permitted amount can sell the excess to a less efficient operator. Less efficient operators now must pay more to discharge their pollutants and in time can be more efficient by upgrading their systems. The efficient operators get some financial return for their investment in cleaner technologies.

The tradable permit model is well suited to an impaired watershed where a TMDL has been established for the watershed and EPA has set maximum P discharge limits. All point sources already have National Pollutant Discharge Elimination System (NPDES) permits from EPA and are required to do regular testing to document their discharge amounts. To implement a tradable permit system for nutrients, EPA (or other authorized agency) would need to calculate the amount of P that could be discharged by each NDPES holder each year to meet TMDL limits.

In addition, nonpoint sources—such as county agricultural drains, discharging septic systems, confined animal feeding operations, end of tile treatment (as deemed appropriate by NRCS technical guidance) for any new tile installations, and other large sources of P not currently required to have NPDES permits—would have to be brought into the permitting system. (Currently, any drainage treatment or filtering before leaving the property is largely voluntary.) The most efficient way to accomplish this would be to require large nonpoint source P contributors to meet NPDES requirements within the TMDL area. Within this category, permit holders would be allocated their share of the load they could discharge annually. Such a requirement would incentivize the use of targeted best management practices, increase the number of non-discharging septic systems, and ensure that overall TMDL limits for the watershed are not exceeded. (See table 5 for a summary of market-based approaches to nutrient reduction.)

Table 5. Market-Based Approaches for Nutrient Reduction

Practice/Program	Ongoing	Pilot Test	Managing Entity
Great Lakes Impact Investment Platform	X		Conference of Great Lakes St. Lawrence Governors & Premiers
Water Quality Trading (permits)	X	X	State EPAs, agricultural depts, soil and water conservation districts, communities
Public–Private Partnerships	X	X	State EPAs, agricultural depts, soil and water conservation districts, communities, businesses, investors
Pay-for-Performance Conservation	X	X	NPDES permit holders, public water supplies, state EPAs, agricultural departments, soil and water conservation districts, communities, NGOs

One example of a PFP project is taking place in the Saginaw Bay Watershed. This initiative, funded in part through GLRI, offers a nontraditional conservation funding option for land users. Through the PFP model, participants receive annual payments based on the sediment load reductions they achieve by implementing new soil conservation practices.[4]

Mid-term Recommendations

- **Support the development of an incentive-based ecosystem credit marketplace or program that administers trades between buyers and sellers (or funders and suppliers) of ecosystem services.** There might be an opportunity to link these trades to the Conservation Reserve Enhancement Program administered by USDA–NRCS or other emerging projects with an emphasis on excess nutrient reduction and water quality improvement (e.g., the Blue Accounting Coastal Wetland Project).
- **EPA and GLNPO should explore opportunities to link Tradable Permit Model to TMDL/distributed load watersheds and potential regulatory or governance changes in NPDES permits.**
- **In watersheds with TMDL implementation requirements, EPA and GLNPO should consider regulatory options within their respective jurisdictions when voluntary and practice-based approaches are deemed insufficient to achieve necessary nutrient reductions to meet GLWQA targets.** Considerations could include increased regulation or requirements on septic systems, elevating unregulated nonpoint source discharges to regulated point sources falling under NPDES requirements, and decreasing NPDES permit discharge limits for P.

Long-term Recommendation

- **Develop mechanisms to leverage public–private or PFP funds to support nutrient-reduction practices in the basin.** Market-based incentives provide the opportunity to leverage local, state, and federal funds with corporate and private funds. The

4. More information is available at https://www.conservationgateway.org/ConservationByGeography/NorthAmerica/UnitedStates/michigan/projects/Pages/SagBayPayforPerformance.aspx

development of corporate sustainability programs provides opportunities to invest in environmentally sustainable development projects and ecosystem credit markets.

Governance and Regulatory Considerations

Regulatory considerations presented here are intended to provide options within EPA's jurisdictions when voluntary and practice-based approaches are deemed insufficient to achieve necessary nutrient reductions to meet GLWQA targets.

Total Maximum Daily Load

Total maximum daily load is based on the loading capacity of a water body and is used to allocate pollutant (in this case, nutrient and sediment) loads among different sources to achieve desired water quality standards. Point and nonpoint sources of nutrient loading within the watershed and their relative contributions are identified, and a portion of the allowable load is allocated to sources, usually by reducing source loads to achieve target loads that meet water quality goals. TMDLs have been used with some success in the Chesapeake Bay region, where EPA has mandated specific implementation strategies based on the ability to meet TMDLs developed by the states to achieve broader-scale water quality objectives in Chesapeake Bay.

The Chesapeake Bay TMDL is unique because of the extensive measures EPA and the jurisdictions have adopted to ensure accountability for reducing pollution and meeting deadlines for progress. The accountability framework includes successful implementation of Watershed Improvement Plans, two-year progress milestones, tracking and assessment of restoration progress, and the implementation of specific federal actions if the jurisdictions do not meet their commitments. Salient elements from the Chesapeake TMDL include:

- Establish clear goals and targets for TMDL implementation;
- Identify implementation scales;
- Establish a clear timeline for progress with benchmarks;
- Identify clear implementation strategies;
- Set implementation milestones;
- Monitor and assess progress;
- Incorporate adaptive management strategies; and
- Impose regulatory consequences if TMDL commitments are not met.

TMDLs and Distributed Load Model for the Maumee River Watershed

A nutrient TMDL is currently under development for the Maumee River watershed of Lake Erie. TMDLs are intended to establish an average daily nutrient load limit and then develop practices and policies that will keep loading below this limit. Most actions considered in TMDL implementations are practice based. Past TMDL work in the Maumee River watershed has been focused on (near-field) stressors impacting aquatic habitat health, not necessarily nutrient loads driving (far-field) HABs or water quality in the Western Basin of Lake Erie. The following are recommendations for the Maumee River nutrient TMDL based on lessons learned from other TMDLs in large agricultural and urbanizing landscapes.

For Western Lake Erie, TMDL implementation should clearly identify the links between water quality degradation due to excess productivity resulting in HABs in the Western Basin of Lake Erie; identify point and nonpoint sources of nutrient loads causing the excess productivity; and establish nutrient load reductions needed to meet applicable nutrient load targets.

Multiple modeling studies using regional-scale Soil and Water Assessment Tool (SWAT) models have been applied to many Great Lakes watersheds (Martin et al. 2021; Scavia et al. 2016). For the Maumee River watershed, regional SWAT models are calibrated to the Waterville gage located on the lower mainstem of the Maumee River. When results from these regional models are applied to HUC-12 subwatersheds within the Maumee River watershed, the predicted SWAT modeling results do not match the field-based subwatershed water quality sampling and validation data. In addition, incomplete geospatial datasets such as a lack of fine-scale land use and conservation data could also contribute these calibration errors.

As part of a comprehensive mass balance study implemented by the Ohio EPA, an extensive water quality monitoring network has been established by Ohio EPA and the National Water Quality Center at Heidelberg University in which the pour points of HUC-12 watersheds are monitored three times daily for water quality (State of Ohio 2020). These high-resolution data sets are combined with a nutrient mass balance approach that integrates nutrient load data from three primary sources: (1) nonpoint landscape sources (agricultural, developed, and natural lands); (2) point sources (NPDES permits); and (3) HSTSs to establish TMDLs at individual HUC-12 pour points at a subwatershed scale.

The distributed load approach provides the flexibility to evaluate different combinations of nutrient-reduction measures to optimize nutrient-reduction benefits from agricultural, developed, and natural lands at local subwatershed scales. These loads can be used to guide the development of Nine-Element Nonpoint Source Implementation Strategic Plan (NPS-IS Plan) within HUC-12 subwatersheds (State of Ohio 2020). As nutrient management actions are implemented by farmers, property owners, and communities at a local level, these NPS-IS Plans provide a critical linkage between nutrient-reduction projects implemented by local stakeholders and the HUC-12 TMDL loading targets. Moreover, using a mass balance approach, nutrient loads can be integrated across all HUC-12 watersheds, and individual HUC-12 loading targets (as well as associated nutrient-reduction projects to achieve those targets) can be modified to meet regional TMDL loading targets for the entire watershed.

TMDLs and Septic System Discharges

Controlling septic system and wastewater discharges not only reduces the amount of P loading to streams and the Great Lakes annually, but also can impact the amount of legacy P that is reactivated causing algal blooms in Great Lakes water bodies. Current research has determined that HSTS discharges can account for up to 20% of the P loading to the Great Lakes (Wan et al. unpublished data).

Currently many soil types in the Great Lakes basin and specifically in the Western Basin of Lake Erie are not suitable for standard leach field systems (Mancl and Slater 2001). Septic system regulations can vary by state and usually are controlled by the county or state board of health, State EPA office,

or local government agency. Some jurisdictions with increasing development pressure are exploring and implementing new requirements to protect human health, protect water quality, and reduce P loading into streams and rivers.

All septic leach field systems have useful life limitations (most under 25 years), yet few communities have useful life monitoring or inspection requirements. Some communities are addressing septic system issues by requiring subdivisions to develop and maintain either cluster systems (multiple houses on one system) with maintenance paid for by homeowner association dues or requiring new subdivisions to be connected to the local municipal sewage treatment system. Should additional measures be required to meet TMDL limits in the western Lake Erie watershed, three HSTS recommendations could be considered: (1) require new septic systems to be compatible with soil characteristics; (2) require maintenance or useful life requirements for existing systems; and (3) require new subdivision development to have cluster systems or to be connected to a publicly owned sewage treatment system.

Near-term Recommendation

- **Support and fund TMDL implementation using a distributed mass balance approach applied at the HUC-12 subwatershed scale in combination with the funding, development, and implementation of Nine-Element NPS-IS Plan as an effective way to link local subwatershed nutrient-reduction projects to regional TMDL/distributed load water quality targets.**

Mid-term Recommendation

- **Support regional policy and management committees to use land-use planning models, appropriately calibrated SWAT models, and HUC-12 water quality monitoring data to validate model results to identify watersheds and critical source areas that disproportionately contribute to excess P loads in the Great Lakes.** These models—whether new or existing—could be used by regional policy and management committees to prioritize watersheds for GLRI interventions and to evaluate the appropriate suite of practices, policies, and land-use changes needed to achieve nutrient-reduction targets within target watersheds.

See appendix 3 for a list of theme 2 recommendations.

Theme 3. Seek Advice and Recommendations on GLRI Outreach

Under the GLRI and GLWQA, a number of mechanisms are utilized to inform the general public about activities and efforts underway to improve the health of the Great Lakes ecosystem, including but not limited to, press releases, GLRI.us.; binational.net; asiancarp.gov; annual GLRI Reports to Congress, 5-year LAMPs and annual reports for each Great Lake, triennial Progress Reports of the Parties, triennial State of the Great Lakes Highlight Reports.

Charge Question: How well are EPA and its federal, state, and tribal partners communicating the goals, challenges, and accomplishments of GLRI? Are there stakeholder groups that could be more effectively communicated with? What additional and/or innovative tools could be used to improve outreach to citizens, elected officials, and partners?

Introduction

This theme concerns EPA's use of press releases, websites, reports, and other one-way, informational communication to reach stakeholders. The GLAB approached the charge questions with broader expectations for EPA communications. To meet the urgent needs posed by today's environmental threats and to ensure EPA can cut through the communication noise to reach important audiences, GLAB believes the majority of EPA communications should not be one-way, but rather full circle. Instead of remaining satisfied with products that seek to merely inform key audiences, EPA should seek to authentically engage them. And rather than measure success by assessing how visible EPA and GLRI are to the public, we suggest that success should be measured by determining how visible the diverse Great Lakes communities are to EPA. In our view, communication is not just a tool for projecting visibility but for increasing involvement and accountability among all stakeholders.

Outreach and Engagement

The GLRI is an important partner and beneficiary of international organizations and institutions in and around the Great Lakes states that support the health and vitality of the freshwater basin. While the GLRI benefits from a skilled and passionate community of professionals and advocates, it can be somewhat lacking in diverse perspectives and engagement.

EPA engagement efforts should focus on increasing participation from communities affected by pollution and climate change so they can be a part of identifying ways to mitigate the ill effects on individual health, community health, livelihoods, way of life, and quality of life. According to EPA data (see, for example, EPA 2021a) these negative effects are—and will continue to be—disproportionately borne by low-income communities and communities of color, including Indigenous communities. Engaging environmental justice communities from the earliest stages of planning for programs that will affect their lives will allow communities to have a say in program priorities, implementation, and outcomes. Such participation is crucial to ensuring program appropriateness, success, and sustainability.

Promising practices for reaching and engaging audiences are plentiful. For example, the GLAB reviewed a publication from Healing Our Waters–Great Lakes Coalition that made several recommendations for how EPA could operationalize its commitment to environmental justice by incorporating environmental justice and equity objectives into GLRI restoration initiatives. (See appendix 4 for Healing Our Waters–Great Lakes Coalition recommendations of particular relevance to this workgroup.)

At the state level, the GLAB learned of the successful Waterway Restoration Partnership in the Milwaukee Estuary Area of Concern (AOC).[5] This AOC partner coalition is committed to authentic and comprehensive community engagement with a focus on equity, justice, and representation in environmental decision-making. (See appendix 5 for environmental justice actions being rolled out by this coalition.)

The International Joint Commission's Water Quality Board employs public surveys to gauge U.S. and Canadian opinions regarding the importance of protecting the environmental health and water quality of the Great Lakes, and on protecting the lakes for the purposes of fish and wildlife, recreation, and the economy (GLWQB 2021). There are promising models for community inclusion beyond the Great Lakes region and in other EPA programs such as Brownfield and Superfund remediation, and Lead and Copper Rule revisions. Facing similar needs and criticisms, program administrators conducted extensive, regional community feedback sessions online for recommendations to improve meaningful public engagement, especially in environmental justice neighborhoods. The GLRI could learn from these programmatic responses.

Near-term Recommendations

- **Develop and implement community engagement metrics** to assess progress toward environmental justice outcomes.
- **Adapt models of successful outreach efforts by other Great Lakes-focused collaborations.**

Engaging communities early in the planning process is an essential practice that allows communities to shape programs and form a sense of ownership. To be successful a diversity of community voices must be invited to the table and actively included in conversation. One way to increase meaningful engagement with communities is to more fully utilize Public Advisory Councils (PACs). EPA should take care to ensure that PACs are truly representative. Currently, PACs—the entities charged with increasing public awareness, representing public priorities, and ensuring project implementation—are not accountable for meeting specific standards for community representation, and public engagement varies geographically (HOW n.d.). The first step, then, is to set standards (demographic, socioeconomic, etc.) for what PAC representation by impacted communities looks like. The next step would be to draw on PAC member experiences and knowledge to increase engagement among environmental justice communities, such as by consulting PACs and implementing their ideas on ways to develop practices that attract and meaningfully engage their communities.

5. Rebecca L. Fedak, pers. com.

Near-term Recommendation

- **Establish standards for the Public Advisory Councils regarding outreach, staffing, and accountability.**

Rather than inform communities about predetermined or expert recommendations to address environmental concerns, GLRI partners should be encouraged to look for opportunities to support the activities of community organizations that advance overall engagement objectives. In particular, the GLNPO should deploy an array of thoughtful strategies to increase the public's understanding of restoration issues and prepare them to meaningfully participate in crafting solutions to achieve widely desired outcomes. Libraries, for instance, might be the only place residents in some communities can access the internet. Libraries also host public meetings, organize learning events, and house important regulatory documents. We recommend that EPA explore opportunities to partner with these trusted community-based organizations to achieve communication and engagement goals.

Moreover, GLRI outreach must convene stakeholders in environmental justice communities and engage them in an assessment of environmental and climate response needs to improve their awareness of and engagement in GLRI initiatives, including Lakewide Action and Management Plans. New funding should address the need for outreach and accountability for environmental justice outcomes, such as by requiring grant applicants to propose strategies to achieve successful outreach and communication goals. The GLAB recognizes that desired objectives (both processes and outcomes) are unique to each community. GLNPO metrics could be further improved and informed by providing skilled facilitators for engagement events to ensure a diversity of community stakeholders are heard. The GLRI could benefit from a comprehensive engagement program across its federal agencies and partners to coordinate programs, projects, and resources across Great Lakes regions and communities.

Near-term Recommendations

- **Establish a framework and programs for engaging and supporting the relevant activities of community organizations, libraries, and nontraditional stakeholders, particularly those in disproportionately impacted areas, through meaningful engagement and communication.**
- **Engage more with business and industry to leverage their sustainability plans and vision with GLRI ecological services.**
- **Explore connections between food, energy, water and transportation instead of working in silos toward shared goals.**

Accountability for Outcomes

To respond directly to the first charge question—*How well are EPA and its federal, state, and tribal partners communicating the goals, challenges, and accomplishments of GLRI?*—the GLAB believes EPA is not doing a good job at this essential task. Overall, GLRI initiatives are not visible to the general population, so the public might underappreciate the range of GLRI program undertakings and benefits. The GLAB recommends that EPA work directly with public relations specialists skilled

in reaching diverse corporate and community stakeholders in urban, suburban, and rural settings. Acknowledging that the GLRI has produced many remarkable benefits over the years, the GLAB believes that EPA can do more to ensure that communities most impacted by pollution and climate change both enjoy the benefits of restoration initiatives and have access to timely reports and other information that allows them to hold implementing partners accountable. For instance, how do non-scientists and lay people access non-technical reports from EPA to clearly see where the dollars have gone and what has resulted from the spending? The GLAB advises that data about GLRI programs be presented in formats and languages that are accessible to GLRI partners and communities alike. Accessible reports would help EPA to demonstrate the successes and local benefits of GLRI restoration initiatives.

Near-term Recommendations

- **Drawing on high-quality public relations expertise, implement programs and metrics to increase GLRI visibility and recognition among the general public and stakeholder communities; include local participants in outreach and evaluation efforts.**
- **Provide publicly accessible summaries of GLNPO reports to Congress** that describe GLRI benefits and improvements to impacted communities regarding restoration, mitigation, communication, and education with special reports on GLRI improvements in environmental justice communities, tribes, and Indigenous communities.

Regarding environmental justice outcomes, Garcia and colleagues (2021) researched equity in GLRI programs. Their research was driven by concerns that despite significant economic and ecological successes—much by way of AOC delisting—they found little evidence on whether GLRI programs minimized environmental risks and remediated environmental inequities in legacy communities. The study included ArcGIS geo-visualization software to map the distribution of GLRI restoration projects, along with social demographic data for each of the four AOC communities they reviewed for social disparities and patterns of equity. Their data were supplemented with community interviews. Among their conclusions was the importance of connecting and empowering community organizations—especially underrepresented grassroots groups that work with people of color—to work within AOCs on restoration work and facilitate equitable collaboration and information sharing.

The GLAB believes that recommendations from HOW and from Garcia and colleagues are strong starting points for GLRI partners to begin conducting robust assessments and improvements of programs and operations through an environmental justice lens.

Near-Term Recommendations

- **Prioritize reporting on the impacts of GLRI programs on environmental injustice and climate change** as significant environmental and natural resources issues affecting the Great Lakes.
- **Provide management assistance funding to states and Tribes** to hire boots-on-the-ground staff in technical areas, social sciences, and community engagement.

Mid-term Recommendation

- **Map Brownfield sites, Opportunity Zones, and other agency and community programs with GLRI program proposals to maximize awareness and leverage opportunities.**

See appendix 6 for a list of theme 3 recommendations.

Theme 4. Seek Advice and Recommendations on Invasive Species

Invasive species control and prevention continues to be a challenge for the Great Lakes. Perhaps the most visible example are the efforts to control Asian Carp from entering Lake Michigan.

Charge Question: Balancing the need for continued commercial, recreational, and other activities on the Great Lakes, what innovative actions could reasonably be taken to accelerate the control of existing invasive species, and what methods or strategies can be deployed to prevent the establishment of future infestations?

Introduction

The Great Lakes ecosystem has been impacted by the introduction of more than 180 non-native aquatic invasive species (AIS) that have caused tremendous ecological and economic damage. A cost-effective approach to accelerate control and prevent the establishment of future infestations is to consider the pathways (or vectors) through which invasions have occurred or could occur, rather than to focus on individual species. Focusing on vectors, the GLAB considered preventative programs (building on, strengthening, or combining existing programs), as well as innovative recommendations that can be used independently or in combination.

Invasive species means an alien species whose introduction does or is likely to cause economic or environmental harm or harm to human health. https://www.invasivespeciesinfo.gov/executive-order-13112-section-1-definitions

Aquatic (water-dwelling) invasive species are non-native plants, animals, and other organisms that have evolved to live primarily in water (aquatic habitats) rather than on land (terrestrial habitats). Aquatic habitats are habitats that are covered with water all or part of every year. From oceans to bogs, many types of aquatic habitats exist.

An excellent resource for additional information on AIS in the Great Lakes is available at: https://www.blueaccounting.org/issue/aquatic-invasive-species.

Preventing the introduction of AIS is the most cost-effective management strategy (Vander Zanden et al. 2010). It is critical that prevention continues to be a primary management focus and that we optimize its implementation. Prevention is geared toward stopping future impacts and does not, in itself, restore ecosystems impacted by AIS, which requires different management options.

Vectors and Pathways

Numerous vectors have introduced AIS into the Great Lakes. These include vessel discharge, hydrologic connection with canals and waterways, recreational activities, aquaculture, and trade. Furthermore, miscellaneous vectors present a risk for introductions and should be monitored. These include avian pathways, setting “pets” free (e.g., releasing goldfish into waterways), and cultural or religious practices. Below, we examine these vectors in more detail to provide context for our recommendations in the next section.

Vessel Discharge

The GLAB considered all the vessel discharges that could occur from oceangoing vessels (commonly referred to as salties); lakers (including tug-barges operating exclusively on the Great Lakes); and river barges (excluding lakers).

Signed into U.S. federal law in December 2018, the Vessel Incidental Discharge Act (VIDA) resolved debate concerning state and federal government regulatory roles in maritime vessel discharges. VIDA required EPA to set vessel discharge standards based on technology determinations. EPA consulted the states and issued proposed standards in October 2020. The U.S. Coast Guard (USCG) is responsible for implementing enforcement regulations that reflect EPA standards. USCG must consult the states and issue regulations within two years of final standards set by EPA. Currently, the priority focus for inland barges has been the guidance documents.

VIDA authorizes EPA GLNPO to establish the Great Lakes and Lake Champlain Invasive Species Program (GLLCISP).[6] GLLCISP identifies eight purposes regarding the introduction and spread of AIS, including monitoring, detection, rapid response, management actions, and ballast water. Funding was authorized at a level of $50 million per year for five years beginning in 2018. To date, EPA has not requested an appropriation under VIDA. Rather, it has diverted GLRI funds to support the GLLCISP.

Numerous initiatives are underway to study tools to minimize the risk of AIS transfer toward the Great Lakes. Federal and state agencies engaged in this research are working with representatives of the navigation and river barge industry to determine feasibility, navigational safety impacts, navigational security impacts, and general operational impacts.

Canal and Waterways

The GLAB relied heavily on the Great Lakes and Mississippi River Interbasin Study of 2013. USACE and partner agencies identified 36 areas of concern regarding the transfer of AIS between basins. The majority of the USACE study was the movement of invasive carp from the Mississippi River basin into the Great Lakes; however, other AIS were looked at for potential transfer.[7] The challenge will be for EPA to coordinate with other federal agencies and states to ensure that lessons learned about AIS are shared.

Recreational Activities

The Great Lakes states have their own regulations regarding recreational activities, including recreational boating and jet skiing. The GLAB did not document each state's regulations; however, we did note several of the regulations that would impact the recreational community in an attempt to prohibit the transfer of AIS.

6. See VIDA Section 903(g).
7. For other pathways, please refer to the GLMRIS website at https://glmris.anl.gov/other-pathways/.

Aquaculture/Organisms in Trade

Net Pens

Net pens are considered a high-risk aquaculture method because of the potential for organisms to escape and for the surrounding environment to become contaminated via their waste products.

Commerce of Live Invasive Carp

Invasive carp became a problem in the late 1970s after a series of floods impacted stock ponds in which fish were being used for biological controls. Four species of invasive carp are a concern for the Great Lakes. One of the most prolific of these is the grass carp. Twenty-eight states allow the sale of triploid grass carp, which are permitted by U.S. Fish and Wildlife Service and are certified as sterile. Currently, 10 states have banned grass carp sales and importation completely. However, seven states allow for diploid grass carp to be imported and sold within their states.

Organisms in Trade

Historically, the importation and sale of aquatic species is the second largest invasion pathway for new species into the Great Lakes, introducing more non-native species than any pathway other than shipping. Effective prevention for this pathway requires a good understanding of what species are being transported and sold, and how and why potential invasive species are being released into the environment. This includes working with the many public and private entities involved with the aquarium, water garden, aquaculture, bait, and live food industries to identify and remove harmful species and encourage the use of low-risk or native alternatives. Education and outreach can also encourage industry stakeholders and consumers to adopt practices that ensure that plants and animals are not released into the wild. Best practices are promoted through outreach campaigns such as Habitattitude, RIPPLE, and Be a Hero Release Zero.

Management of live trade pathways is one example where progress is being made at the state, provincial, and federal levels; the focus is on complementary policies (prohibited species list, least wanted lists) and the sharing of risk assessments across jurisdictions to avoid duplication of effort via a Risk Assessment Clearing house, managed by the Great Lakes Aquatic Nonindigenous Species Information System.

Education and voluntary best practices are supplemented with consistent policies at the U.S. and Canadian state, provincial, and federal level. These policies could regulate the import, sale, transportation, possession, and release of invasive species. Consistent policies create a level playing field for industry and consumers and help proactively ensure that harmful species used as bait—in water gardens, in aquariums, or for any other purpose—will not be accidentally or deliberately released into the Great Lakes Basin. More attention also needs to be paid to prohibited species, as gaps still exist at the state level (Davidson et al. 2021; see figure 1).

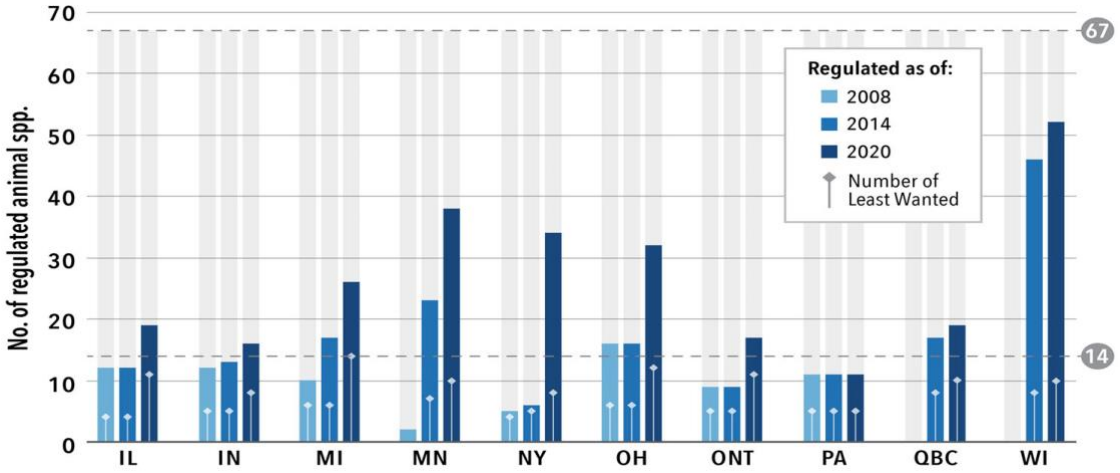

Fig. 1. Number of animal species regulated by jurisdiction, as of the start of 2008, 2014, and 2020 with the total number of unique species regulated in one or more jurisdiction (67) and the number of regulated "least wanted" species (out of 14). From Davidson et al. 2021, figure 3.

Other Vectors and Pathways

We consolidated a number of other pathways into this group:

- Pet stores and the pet trade (excluding professional, licensed establishments) releasing unwanted "pets" or "animals" into the environment;
- Cultural, religious, and indigenous practices, involving intentional or unintentional releases; and
- Assisted or unassisted animal transfer of AIS. This refers to situations in which control is not viable. Examples include an invasive fish species picked up by a bird of prey and potentially "lost" while transferring basins, or cyanobacterium akinetes (resting spores) being transferred via birds from subtropical lakes to the Great Lakes (Hong et al. 2006).

Introductions through these other pathways represent an area where education and community outreach are strongly needed and are likely to obtain the best results. The federal priority on environmental justice provides opportunities for inclusiveness; the key is to develop meaningful partnerships and engender trust. These partnerships need to include cultural and religious practices in their education and outreach activities. The GLAB believes one focus should be on the release of AIS as part of cultural or religious practices. Better communication and mutual understanding can result in practices that lead to better management of AIS.

Recommendations

Preventative

Near-term Recommendations

- **Fund strategies to manage AIS that pose the greatest impediment to the restoration of key sites and habitats across the Great Lakes (such as coastal wetlands and coastal spawning reefs) while continuing efforts at the vector and pathway level to maintain a coordinated prevention approach.**

Much of the financial allocation in the AIS field is based on a small number of high-profile species, such as silver carp, *Phragmites*, and sea lamprey. While the rationale for these allocations is obvious, it might not be the most effective approach to dealing with the problem of AIS, as it tends to be reactive instead of proactive. We believe focused funding on the control or eradication of these problematic taxa should be continued, as several projects are showing some success, at least as proofs of concept (e.g., control of *Phragmites*[8] and the grass carp response program[9]). But there is a need for a more holistic and strategic approach that considers which suite of AIS needs to be controlled to facilitate restoration of critical sites and habitats across the Great Lakes. An example of this approach would be the experimental control of dreissenids on native fish spawning reefs at Good Harbor reef.[10]

- **Improve coordination, information exchange, and database sharing at the federal, state, and local levels.** This is absolutely essential given that it takes only one weak link in the prevention network for AIS to invade and potentially spread. In addition, we recommend increased access to critical information collected by government entities. In many cases, it is unclear what data are being collected and from where. One example of increased accessibility would be to improve the coordination and collation of fisheries and government research survey data so that effort, location, and species distribution data are available and can inform regional surveillance efforts and other research and management purposes. A regional database could inform many environmental management areas, as well as avoid redundancy and optimize surveillance and response efforts.
- **Address vessel discharge by including a GLNPO budget request to fund the GLLCISP authorized by Section 903(g) of the VIDA, giving priority to monitoring and technology development related to vessels.**

Mid-term Recommendations

- **Address vessel discharge by (1) Working with Canada to align ballast regulations that provide consistent regulatory controls across the Great Lakes; and (2) Collaborating with USCG and other stakeholders, including the Great Lakes Carrier's Association, to develop materials to instruct the general public on laws pertaining to AIS.** Guidance and training materials could include a summary, flow chart, timeline, fiscal impacts, international status.
- **Strengthen, or expand and refine, a system-wide, coordinated, early detection and response system.** Trebitz and colleagues (2017) identified a set of science-related recommendations involving early detection monitoring. These include:

8. https://www.greatlakesphragmites.net/research/control-options/.
9. https://www.sciencedirect.com/science/article/pii/S0380133020300770/.
10. https://invasivemusselcollaborative.net/research-and-projects/imc-pilot-project-draft/.

    - Better data to support risk assessments that guide choice of taxa and locations to monitor.
    - Improved understanding of spatiotemporal scales for sample collection.
    - Further development of DNA target markers, reference barcodes, genomic presented a set of workflows, and synergies between DNA-based and morphology-based taxonomy.
    - Tools and information management systems for better evaluating and communicating survey outcomes and uncertainty.
- **Include climate change scenarios when anticipating or modeling future invasions;** changing conditions in terms of water temperature, salinity, and nutrients, among others, will influence the ability of future invaders to colonize and thrive.

The U.S. Fish and Wildlife Service's monitoring programs provide a template for the expansion of regional surveillance programs, and the interstate surveillance working group has developed regional site and species priorities (Tucker et al. 2020; Davidson et al. 2021) and, along with others, communication protocols. There remains limited coordination with ancillary fisheries and ecosystem monitoring, which also have the potential to add to the surveillance network. The improvement in genomic-based detection methods (including next generation sequencing; see recommendation below) makes the concept of early detection a more realistic proposition.

Innovative

Near-term Recommendations

- **Continually invest in new technologies.** This umbrella recommendation is offered as a suggestion to take more risks when it comes to assessing (and potentially implementing) new technologies that show promise. Some examples include:
    - **Gene-drive technology.** Briefly, gene drive is a process that increases the chance of inheriting a certain gene variant to something greater than the 50% inheritance that is present in the parents. Gene-drive technology can allow a desirable gene variant to spread relatively quickly through a given population. The advantage of this technology is that it can be used to manipulate certain populations to carry some particularly advantageous traits. Hence, it might be possible to manipulate invasive populations to limit reproduction. The main disadvantage is the fear and uncertainty associated with manipulating genes. For example, what happens if individuals with these drive genes spread to their native range and breed with native populations? Current research suggests that gene-drive has potential, and the Bureau of Reclamation is already funding the development of a dreissenid mussel gene drive. While the science is still in its infancy, we recommend that priority be given to starting the consultation and education process with stakeholders, in combination with assessing risk and addressing any unforeseen or unintended consequences of releasing genetically manipulated individuals into the wild.

- **Behavioral disruption technologies.** Several new approaches to deter invasive carps are being assessed, including bubble barriers; hydroacoustics, strobe lights, and CO_2 injections. This is an appropriate mindset, and we recommend that other approaches—as long as they pass a scientific standard—be evaluated and not simply rejected out of hand.
- **AIS-specific biocides.** The molluscicide Zequanox is a registered biopesticide derived from a strain of the naturally occurring soil bacterium *Pseudomonas fluorescens*. A recent study showed effectiveness on a localized basis (i.e., a rocky reef in Good Harbor Bay in Lake Michigan near the Sleeping Bear Dunes National Lakeshore).[11] The introduction of biocides has the potential for significant unanticipated consequences, so it is essential that assessment of their field application include a rigorous screening process and that we proceed with utmost caution.

- **Incentivize the commercial use of AIS.** Although many, if not most, AIS have limited or no commercial value, there are some species whose market value could make them attractive as commodities. For example, numerous companies are harvesting invasive carp and bringing them to market in various ways: Colgan Carp Solutions is working with fishers in Maine to use invasive carp as lobster bait; Sorce Freshwater Company is identifying bait, fertilizer, and pet food markets for invasive carp; and Wilder Harrier has introduced an invasive carp-based dog food.

  Various states have provided small grants and loans to incentivize business development around invasive carp. However, vigilance is also required to ensure commercialization does not unintentionally lead to the spread or maintenance of AIS populations, as has occurred with various non-native marine aquaculture and freshwater sport fish, as well as other terrestrial pests like rabbits in Australia and New Zealand.
- **Create an AIS Prize.** Companies and philanthropy could join to fund an annual competition for the most creative and effective AIS management idea. This could be funded by a public–private partnership with support from family and community foundations. Such an AIS prize could catalyze and reward a range of AIS research and development, information management and exchange, and innovative business and community practices. The State of Michigan, for example, offered a prize to address the invasive carp problem.

Mid-term Recommendations

- **Coordinate with the International Joint Commission in the development and implementation of an early warning system in the Great Lakes.** Unlike a widespread surveillance and monitoring system recommended above, an early warning system is designed to take a scientifically based framework and detect and

11. https://invasivemusselcollaborative.net/wp-content/uploads/2020/12/Final_Report_Good_Harbor_Zequanox.pdf/.

identify emerging stressors and threats using available data.[12] This proactive approach, as opposed to the more commonly used reactive approach, would allow agencies charged with AIS prevention and eradication to mobilize resources in advance of an invasion, protecting the Great Lakes ecosystem and making more efficient use of limited human and monetary resources.

- **Initiate a coordinated research and stakeholder engagement program** involving aquatic and molecular ecologists, ethicists, social scientists, biotech specialists, and venture capitalists to explore the feasibility, desirability, and legality of gene-drive technology as a control mechanism for AIS.
- **Develop a regional grant program, using both private and public funds, that addresses all AIS and has funding of sufficient size to attract a large pool of applicants.** One emphasis of this program should be on the development of new methods. In addition, some grant opportunities should extend longer than two years, include long-term monitoring to assess the success of the program, and have the flexibility to allow adaptation as research progresses. The Department of Defense Strategic Environmental Research and Development Program could serve as a good model.

See appendix 7 for a list of theme 4 recommendations.

12. https://ijc.org/en/sab/towards-great-lakes-early-warning-system/.

Theme 5. Outcome-Based Investments in the Great Lakes

This Administration has prioritized outcomes and deliverables from all agency programs. Since its inception in 2010, GLRI has produced measurable results, but are we moving the needle, specifically on AOC delisting, nutrients, invasive species, and habitats.

Charge Question: As we enter the next decade of GLRI funding, what are appropriate annual ecological and community-based outcomes (coupled with appropriate baselines and monitoring) to show that we are making progress in the areas of AOC remediation and delisting, invasive species control and prevention, nutrient reduction, and habitat restoration and protection, such that we can show a good return on investment?

Introduction

Regarding AOC delisting, nutrients, invasive species, and habitats, the GLAB focused on GLRI outcomes and deliverables that address the priorities and perspectives of affected communities, impacted residents, and tribal governments.

Defining Success

EPA and communities should form consensus early in project development about what it means to declare that an area has been "cleaned up" or "restored." EPA should ensure that communities are aware of the benefits a completed project can bring to an area and also the role such projects and restoration can play in the overall economic development of restored riverfront and lakefront land, both public and private. From a community perspective, the benefits of restoration projects can precipitate new concerns such as increased property taxes, crowds and other impacts to quality of life that can make areas inaccessible to residents or could even displace them. It is essential that these direct impacts of improvements be discussed and addressed early to ensure all stakeholders are included. GLRI cleanup of AOCs should advance environmental justice, which, by EPA's definition, ensures communities enjoy equal protection from health hazards as well as meaningful involvement in the prioritization, planning, and implementation of programs.

Though not equivalent by any means, the experiences of Indigenous people resonate with the environmental justice community as they advocate for the enforcement of pollution laws and the cleanup of their communities. Throughout, communities want to receive a fair share of opportunities that arise from GLRI initiatives, including the economic and employment opportunities that come with or result from program implementation. A range of indicators should apply to environmental justice concerns, such as degree of public access, number of community residents hired, and whether restoration results not just in improved ecological outcomes, but in improved quality of life, as defined by local communities.

To keep community wants and needs central, EPA must measure program success by considering not only the scientific elements of initiatives, but also the nontechnical elements. Examples include the degree of meaningful participation from impacted, frontline, and fenceline communities, as well as the value communities place on program goals in terms of environmental, economic, and social

benefits. Communities differ, so EPA should anticipate that communities will have a variety of perspectives on what benefits they hope to see from each restoration initiative.

Underserved communities applying for grants might face capacity and technical challenges that limit their ability to successfully compete for program funding. A major challenge is the ability of some communities to secure non-federal sponsor matching funds. A second challenge faced by communities is their ability to fund and carry out long-term operation and maintenance. In some cases, communities lack the technical expertise and resources to develop proposals. These and other challenges faced by underserved communities can be addressed by providing funding that meets the full range of community needs associated with the project. For example, GLRI could fund the cost of the project and its long-term operation and maintenance, where needed.

To help underserved communities remain competitive, the application could include balancing criteria; for example, ROI analyses could include non-market valuation. Other options to help communities be more competitive could include assigning communities the assistance of a vetted economist, engineer, or scientist to provide expertise and relieve principal investigators from finding an expert on their own. Ideally, these experts would be involved with communities from the planning stages to implementation.

EPA partnership with communities should therefore seek to improve the capacity-building, skills, training, and workforce development needs of these communities, individuals, and nongovernmental organizations that, in turn, can increase their ability to present and advocate their community's desired outcomes.

Near-term Recommendations

- **Engage state and tribal partners actively in the identification, prioritization, and selection and funding of projects.**
- **Establish a broad set of project outcomes that include environmental justice, climate, and public health impacts.**
- **Support funding for long-term environmental justice and tribal sustainability and prioritize projects through the establishment of funding criteria and scoring that meets these objectives** (e.g., extra points for competitive grants in impacted or disadvantaged communities).
- **Establish procedures to enable consideration for funding projects that require resources for long-term operations and maintenance** so that tribes and underserved communities can successfully compete for grants.
- **When assessing and forecasting the benefits of ecosystem services, use valuation systems that account for secondary and tertiary consequences, as well as local traditions and place-based values.**

Traditional Ecological Knowledge and Environmental Sustainability

It is important for EPA to understand that *how* outcomes are achieved and sustained is as important to many communities as what is achieved. Just as a "whole of government" approach to the GLRI is needed to address multi-factor, multi-jurisdictional problems and challenges, a "whole of natural world" perspective is equally needed. Indigenous communities often use holistic approaches to protect and nurture healthy environments and promote community well-being. These approaches, including traditional ecological knowledge (TEK), draw on generations of observational knowledge along with traditional principles, practices, and values (Koski et al. 2021).

The GLAB recognizes the successful work of GLRI partners to learn, share, and incorporate Indigenous knowledge to guide protection and restoration efforts of the Great Lakes. Important exchanges in 2021 included the Great Lakes Traditional Ecological Knowledge Speaker Series, co-sponsored by the University of Minnesota–Twin Cities Department of American Indian Studies and the GLWQA Science Annex Traditional Ecological Knowledge Task Team, which brought together numerous tribal, Indigenous, academic, governmental, nongovernmental, and other participants in the United States and Canada to bridge knowledge systems that apply to the restoration of the Great Lakes.[13] Similarly, the U.S. Fish and Wildlife Service's TEK guides and fact sheets posted on its National Native American Programs website demonstrate longstanding collaborations inside and outside of the Great Lakes region to merge Western science with Native science.[14] As TEK is an evolving foundation of information, practices, beliefs, and traditions, a recent guidance document by the U.S. caucus of the TEK Task Team of the GLWQA provides the following description:

> *TEK is the term used for what has come to be recognized as the subset of Indigenous knowledge systems that is specific to ecology…. However, it is important to acknowledge and understand that TEK is directly connected to, and therefore inseparable from, broader Indigenous Knowledge systems as a whole. It is also important to understand that TEK encompasses not only the knowledge systems held by Indigenous communities, but also the underlying beliefs, philosophies, relationships, and practices. Although there are multiple definitions or interpretations of TEK and what type of information it includes, these definitions should be viewed as fluid. While this makes it difficult to define TEK, this guidance attempts to provide a beginning that is firm and substantive enough to offer a useful introduction to how Indigenous knowledge systems can play a role in resource management contexts.*
>
> *TEK is commonly recognized to be based upon relations with one another and the natural world. These relationships include direct environmental observations, connections, and interactions that are customarily transmitted interpersonally and orally from generation to generation through stories, oral histories, songs, ceremonies, customary laws, and other ways. TEK is intrinsically linked to spiritual beliefs, cultural practices, and ways of life and encompasses the whole being—mind, spirit, and emotion. (Koski et al. 2021, 8–9)*

13. https://cla.umn.edu/ais/news-events/events/great-lakes-traditional-ecological-knowledge-tek-speaker-series/.
14. See https://www.fws.gov/program/native-american/.

Koski and colleagues provide lake-wide and AOC priority-setting recommendations along with TEK approaches to address a range of issues, including threats to habitats and adapting to climate change. The GLAB advises EPA to familiarize itself with the guidance to better address the evolving and changing threats to Indigenous communities and to identify appropriate indicator.

Near-term Recommendations

- **Implement a framework with specific environmental justice outcomes to support cohesive Great Lakes programs that recognize and appropriately incorporate the priorities of tribes and TEK.**
- **Incorporate qualitative and narrative data into outcome measures, including TEK.**

Long-term Recommendations

- **Develop companion legislation to the Legacy Act that allows the program to be implemented anywhere in the Great Lakes to address contaminated sediment.**
- **Establish a regional committee to undertake the expansion of program performance metrics for tracking preservation and protection.**

See appendix 8 for a list of theme 5 recommendations.

Theme 6. GLRI's Role in the Vitality and Reinvestment of Great Lakes Communities

This Administration has prioritized clean-up, redevelopment and reuse of abandoned, blighted and contaminated properties. There are numerous examples around the Great Lakes where clean-up of waterways is followed by development and economic prosperity. In addition, under President Trump's Executive Order on "Modernizing America's Water Infrastructure" which formally establishes the Water Subcabinet, there are opportunities for even better leveraging of resources and expertise across the Federal family.

Charge Question: How can GLRI projects and funding be further leveraged across Federal agencies and programs, including Opportunity Zones and Brownfields, to maximize environmental and economic benefits to Great Lakes communities?

Introduction

The GLAB's response to theme 6 reflects a need to align GLRI investment based with the programmatic needs and priorities of the times. By engaging communities early in the process, there will be new opportunities to leverage resources across federal agencies and obtain more equitable environmental benefits. Vitality and sustainability objectives, measures, and resources should support native residency and resiliency and increase local capacity to adapt to potential economic and demographic changes (including tourism and the unintended consequences of gentrification) that could result from GLRI investments and benefits.

As GLRI partner agencies and grant programs assess the success of their role in the vitality of the Great Lakes and the outcomes of federal investment, the GLAB suggests focusing attention on the question: *How do we determine GLRI success in the context of climate change?*

Climate change refers to any significant change in the measures of climate lasting for an extended period of time. In other words, climate change includes major changes in temperature, precipitation, or wind patterns, among others, that occur over several decades or longer. —EPA

Climate justice has emerged from the idea that historical responsibility for climate change lies with wealthy and powerful people—and yet it disproportionately impacts the poorest and most vulnerable. It has primarily been used to frame the contrast between industrialized nations that have been burning large volumes of fossil fuels freely for centuries and the poorer regions that are most susceptible to rising temperature… The scope of climate justice is broad and, since its popularization in the 1990s, the term has come to encompass the unequal distribution of impacts on a variety of groups, including Indigenous people, people of color, women and disabled people. —CarbonBrief (https://www.carbonbrief.org/in-depth-qa-what-is-climate-justice)

Climate Change, Climate Justice, and Environmental Justice

The Great Lakes foodshed is a historically bountiful region with lake-effect moderate temperatures conducive to the production of fruits. In 2009, it was estimated that "17% of Great Lakes at-risk foods … particularly wild edible plants, fish and game—have historic and current ties to indigenous or First Nations communities" (Nabhan, Trotter, and Walker 2009, 2–3). Perhaps no other native food source is as intrinsic to Great Lakes Anishinaabe

people as wild rice or *manoomin*. The plant is critical to Ojibwe culture and is considered to be "a sacred, animate, more-than-human being and not an inanimate resource" (Panci et al. 2018). For this reason and more, the Great Lakes Indian Fish & Wildlife Commission (GLIFWC)—an intertribal organization representing eleven Ojibwe bands in Michigan, Minnesota, and Wisconsin that has pursued the protection and enhancement of wild rice beds since 1984—has completed their Climate Change Vulnerability Assessment. The GLIFWC concluded:

> *While the treaty rights of the Ojibwe people in their Ceded Territories are now firmly established in law, a different force is affecting their ability to hunt, fish, and gather resources: climate change. Climate change poses many threats to the natural resources upon which tribes rely. As a changing climate affects entire ecosystems, various beings/species … utilized by tribes may experience declines, range shift out of Ceded Territory areas where the Ojibwe exercise their treaty rights, or become extinct. With the loss of beings/species, many of the cultural connections to the natural world are changing or are being lost. For example, tribal members have expressed concern that younger generations will never see a snowshoe hare in their backyard, and traditional knowledge and stories about snowshoe hares will soon only be memories. Collectively, climate change threatens local plant and animal beings/species, ecosystems, and tribal sovereignty, economy, and culture.*
>
> *Manoomin was the most vulnerable being/species in this assessment, and has already begun to respond to climate-related effects. There are numerous climate-related threats to manoomin, and it is sensitive to different potential climate effects in each stage of its life cycle. It is also sensitive to many anthropogenic changes. Factors that affected the vulnerability of manoomin include natural barriers, human land use changes, limited dispersal, thermal and hydrological niche, disturbance, dependence on snow and ice, uncommon landscape features, sensitivity to pathogens and predators, competition, and genetic variation. (Panci et al. 2018, 28)*

The GLIFWC's striking example shows that environmental threats could severely disrupt—and possibly destroy—fragile ecological habitats, economies, drinking water sources, and the standing of sovereign nations. These climate harms are irreversible. Therefore, we advise EPA to explore through GLAB the possibility for the next decade of GLRI funding to include more research and assessment of food supply chain access and non-AOC risk sites for frequent consumers of fish, fowl, plants, and other edible life from Great Lakes' water. There is a need to address the problem of contaminated sediment anywhere in the Great Lakes Basin, not only in designated AOCs.

As a result of the GLIFWC's work, GLIFWC climate change staff are expanding upon a follow-up climate change vulnerability assessment of over 60 beings and species to understand how climate change could affect treaty resources. It will use TEK and scientific ecological knowledge to examine the vulnerability of beings and species to climate change. A better understanding of how beings and species might respond to climate change will help GLIFWC respond to it in accordance with the cultural values of its member tribes.

Near-term Recommendations

- **Support the assessment of climate change on the Great Lakes Basin that affects environmental, public health, and economic metrics, including drought and flood resiliency and sustainability.**
- **Engage environmental economists to establish baseline data needs, ecosystem services metrics, evaluation, and milestones using both traditional ecological knowledge and scientific ecological knowledge.**

Mid-term Recommendation

- **Support ongoing research & development so that stakeholders can get an earlier understanding of emerging challenges, e.g., climate change impacts that could affect the magnitude or longevity of restoration efforts.**

GLRI Action Plan Improvements and Climate Resilience

International attention to the irreversible effects of human activities on the earth's climate has often highlighted the health and importance of the Great Lakes Basin. The detrimental impacts of climate change are widely apparent as Indigenous people have warned for generations and as climate scientists predict with increasing certainty. Founders of the GLRI saw all too well the fragile and declining state of health for this freshwater system and successfully acquired long-term support to address multiple stressors and promote its sustainability.

In the GLAB's assessment, there is still much room for improvement in the development of the next GLRI five-year Action Plan on climate change and climate resilience. Prior Action Plans have not fully recognized or addressed the grave threats posed by climate change and extreme weather events in the Great Lakes Basin. The next generation of Action Plans will have to do more to capture climate change impacts in weather conditions (such as precipitation and heat levels) and vulnerabilities they present to current GLRI focus areas and the growth of extreme challenges, including flooding, drought, and non-climate stressors such as deteriorating infrastructure.

Great Lakes climate initiatives such as the U.S. Climate Resilience Toolkit[15] and the Great lakes Climate Adaptation Network[16] offer important community resilience information with attention to equity. These and similar projects could enhance the education, training, communication, and outreach objectives of the GLRI's Action Plan IV.

Tribal governments and communities have long been at the forefront of experiencing, assessing, and attempting to mitigate the impacts of climate change. The National Climate Assessment mapping of Indigenous People's Resilience Actions[17] demonstrates a variety of activities to adapt or implement for forest management, climate-informed expansion of sugar maple syrup production, coastal fishery vulnerability assessments, snowshoe hare habitats, solar initiatives, and more.

15. https://toolkit.climate.gov/regions/great-lakes/building-resilience-great-lakes/.
16. https://glisa.umich.edu/glcan/.
17. https://biamaps.doi.gov/.

However, federal and state governments have not often recognized the traditional knowledge and perspectives of Indigenous peoples that can be used to manage natural resources and help them adapt to changing conditions.

Education and training in these and other sustainable development practices and methodologies are important components taught by tribal colleges and governments and should be incorporated in the next GLRI Action Plans. These practices provide important bases of awareness and intersection with environmental concerns in disadvantaged communities of color and low-income areas, particularly in AOCs where the incorporation of climate resilience and climate change strategies are critical objectives.

Climate justice advocates and universities have documented the crisis of climate change risks and impacts on environmental justice communities (see, for example, Columbia Climate School 2020). Socioeconomic status, health, access to resources, language barriers, and educational disparities in Great Lakes communities can predict disproportionate environmental impacts. In addition, extreme weather events are contributing to local disasters that impact hunter, gatherer, agricultural, and fishing communities; exacerbate poor air quality, and bring toxic mixes to flooded coasts and Superfund sites (Carter and Kalman 2020). GLRI will be required to appreciate and approach these added challenges in order to mitigate harms and restore vitality to these communities.

The Biden Administration's Executive Order 14008 calls for the establishment of the National Climate Task Force among federal agencies. GLNPO might benefit from exploring the approaches that EPA and GLRI partner agencies intend to take to incorporate this mandate across the Great Lakes. The executive order also formalizes the President's "commitment to make environmental justice a part of the mission of every agency by directing federal agencies to develop programs, policies, and activities to address the disproportionate health, environmental, economic, and climate impacts on disadvantaged communities" (White House 2021a). The GLAB advises EPA to develop and disseminate an Action Plan and report on this directive.

These matters are paramount for environmental justice communities, particularly in light of EPA research that finds "the most severe harms from climate change fall disproportionately upon underserved communities who are least able to prepare for, and recover from, heat waves, poor air quality, flooding, and other impacts. EPA's analysis indicates that racial and ethnic minority communities are particularly vulnerable to the greatest impacts of climate change" (EPA 2021b). Within the GLRI, Action Plan programs could provide critical insights and data for Great Lakes communities. Such initiatives could fall under the third GLRI Action Plan's fifth Focus Area, "Foundations for Future Restoration Areas," which aims to assess overall ecosystem health and the identification of significant remaining problems. The GLAB encourages prioritizing the implementation of climate change resiliency programs in AOC and nonpoint source pollution control projects for disadvantaged communities.

Near-term Recommendations

- **Incorporate the Biden Administration's government-wide approach to climate change across the Great Lakes.**

- **Engage the public early in the development of the GLRI Action Plan IV,** and prioritize community outreach and engagement with communities of color, Indigenous communities, and low-income communities.

Mid-term Recommendation

- **Update Action Plans to ensure environmental justice and climate change are included.**

Incorporating Justice40 Initiatives and Implementation Strategies

Justice40 activities and discussions are already taking place among participants in many state, local, tribal, and nongovernmental organizations and are anticipated to accelerate when the White House Council on Environmental Quality issues its much awaited Justice40 full implementation guidance in early 2022. A set of guidelines for implementing the Bipartisan Infrastructure Law (BIL) was issued by the White House to governments and partners in January 2022. In the guidelines, GLRI was listed among other geographic programs to improve national, tribal, and territorial waters (White House 2022). Additionally, the BIL recognizes and funds coastal storm risk management, hurricane, and storm damage reduction projects along the nation's coasts, including the Great Lakes. In USACE contract awards, the GLAB encourages GLNPO to engage USACE to determine and develop the latter's metrics toward climate resilience projects in environmental justice committees and in partnership with state, local, tribal and territorial governments.

Through Interim Implementation Guidance for the Justice40 initiative, agencies that manage covered Justice40 programs are required to follow a set of actions to distribute, calculate, and report on benefits toward reaching the 40% goal of the initiative (White House 2021b). The GLAB urges GLNPO to identify more ways that GLRI current and future programs and partners can advance Justice40 implementation outcomes and increase equitable participation and benefits. Among them are six EPA programs that intersect GLRI focus areas, including Clean Water and Drinking Water State Revolving Funds, Brownfields Program, Superfund Remedial Program, Reducing Lead in Drinking Water, and Diesel Emissions Reductions Act Program. These—along with the BIL's funding of the National Oceanic and Atmospheric Administration's National Oceans and Coastal Security Fund, and Ocean and Coastal Observing Systems fund for partial support of the Great Lakes—provide unprecedented opportunities and responsibilities for engagement with recipients.

Benefits and investments across Great Lakes regions and communities have been significantly uneven and risk exacerbating existing climate change harms; GLRI programs must do much more to address these disparities and have been afforded vast federal resources to make meaningful resolutions toward them. The GLAB believes that GLNPO would benefit from an environmental and climate justice multi-stakeholder task force on GLRI programs (including funding) that focuses on equity and capacity building and strongly suggests leadership from EPA to initiate this endeavor.

GLAB members further note that, as residents of states and territories that experience significant drought, fires, and other effects of climate change relocate to less impacted areas of the United States, increased migration to the resource-rich Great Lakes region will further challenge community resiliency and the strength of healthy ecosystems. To better understand population

growth impacts on the Great Lakes Basin, the GLAB recommends an analysis of migration from outside the Great Lakes states. This research would anticipate higher demands on Great Lakes land and waters and sociopolitical indicators such as rural zoning changes, urban and suburban growth, farm closures, pressures on protected ecosystems.

Near-term Recommendations

- **Incorporate Justice40 initiatives and priorities into the GLRI Action Plans and investments,** and review environmental justice recommendations for environmental justice communities and tribes as pertinent to the Great Lakes.
- **Ensure benefits reach and improve disadvantaged communities by including perspectives from scientists on addressing climate vulnerabilities.**

Mid-term Recommendations

- **Analyze pressures to migrate into the region and anticipate changing, and likely higher, demands on Great Lakes Basin land and water.**
- **Leverage GLRI to increase employment and education opportunities locally and to support long-term project operation and maintenance.**
- **Develop models that include not only ecosystem dynamics but also policy, public health, and economic forces.**

See appendix 9 for a list of theme 6 recommendations.

GLRI Moon Shot: From Restoration to Protection and Sustainability

> *The Great Lakes Restoration Initiative accelerates efforts to protect and restore the largest system of fresh surface water in the world—the Great Lakes.*
>
> —GLRI website

Restoration is central to the GLRI mission—and so is protection. But restoration efforts alone will never get the Great Lakes Basin ahead of the curve: while devoting resources to restoring one area, another succumbs. Pristine areas need protection from threats, and restored areas need continual monitoring and maintenance to safeguard the restoration investment.

Protecting the Great Lakes will never cease to be a need, but it is worth envisioning an end to GLRI's focus on restoration. The GLAB believes there are several benefits to intentionally setting a target date for concluding GLRI *restoration initiatives*—perhaps in 15 years—and evolving GLRI into a program that funds management and protection initiatives in perpetuity. It may seem unrealistic. But just as the decision to land a mission on the moon seemed impossible at the time, setting the goal inspired a powerful coalescence of people and resources who kept their eyes on the goal and achieved a remarkable feat. Determining a realistic date to complete GLRI restoration activities could create a similar dynamic, generating a sense of urgency and cooperation among nations, states, tribes, agencies, organizations, and communities. It will demand vision, planning, and accountability. Importantly, communicating the scope, level of effort, and long-term effort needed to achieve the goal will enhance public appreciation for the importance of prevention and conservation efforts.

The GLAB is not alone in desiring increased GLRI attention to prevention and protection. Garcia and colleagues (2021) recommend shifting GLRI policy focus away from restoration. Their revitalization proposal (see theme 3) would expand funding for community outreach, education, and stewardship programs to support ongoing maintenance of delisted AOCs. The researchers also advocate for the inclusion of climate vulnerability considerations in the GLRI alongside equity elements. Garcia and colleagues assert that "if the AOC program is understood as a checklist to complete ecological restoration objectives, it does not support space for equity and justice considerations" (Garcia et al. 2021, 80). EPA must redouble its efforts to ensure benefits reach environmental justice and tribal communities now and throughout the term of GLRI's restoration activities.

The Great Lakes Basin is an irreplaceable source of natural beauty that is also critical to this nation's economic, social, and homeland security. Restoring and protecting this magnificent resource will be forever in the national interest.

As such, these waters and lands warrant increased importance on the federal agenda. The GLAB suggests that the Great Lakes states and nation as a whole would be well served by elevating the profile of Great Lakes restoration and protection initiatives among federal agencies, states, tribes, local governments, and other stakeholders. This could mean increasing attention to GLRI programs and needs at existing or new interagency workgroups, raising the salience of issues that affect the Great Lakes Basin with congressional staff, and creating opportunities to increase understanding of restoration and management issues across federal agencies. Our hope is that, with EPA leadership,

the Cabinet, Congress, and courts will come to view protecting our waters as important as protecting our homeland, our health, our safety, and other common goods.

Like other treasures we protect, safeguarding the Great Lakes ecosystem will require a sustained monitoring effort that includes—but extends well beyond—restoration. Also, like other sustained initiatives, monitoring and maintenance will need to be a commitment, but it will be far less expensive than continuing a cycle of cleanup, inattention, degradation, and more cleanup.

By setting and achieving ambitious restoration goals, EPA could facilitate the natural programmatic shift of GLRI priorities from restoration to ongoing protection and management and establish a strong, sustained commitment for the protection of the Great Lakes Basin.

Appendix 1. GLAB Members

Co-chairs

Kyle Dreyfuss-Wells | Chief Executive Officer, Northeast Ohio Regional Sewer District

Steve Galarneau | Director of the Office of Great Waters–Great Lakes & Mississippi River, Wisconsin Department of Natural Resources

Members

Larry Antosch | Senior Director, Ohio Farm Bureau Federation

Frank Ettawageshik | Executive Director of the United Tribes of Michigan

Lisa Frede | Director of Regulatory Affairs, Chemical Industry Council of Illinois

John Hull | Founder and Chairman, Hull & Associates Inc.

Val Klump | Retired, Dean and Professor of the School of Freshwater Sciences, University of Wisconsin–Milwaukee

Scudder Mackey | Chief of the Office of Coastal Management, Ohio Department of Natural Resources

Brian Miller | Retired, Illinois–Indiana Sea Grant and Illinois Water Resources Center

Kay Nelson | Director of Environmental Affairs, Northwest Indiana Forum

Sylvia Orduño | Organizer, Michigan Welfare Rights Organization

Laura Rubin | Director of the Healing Our Waters–Great Lakes Coalition

Alan Steinman | Director of Annis Water Resources Institute, Grand Valley State University

Jeff Stollenwerk | Director of Government and Environmental Affairs, Duluth Seaway Port Authority

Jim Williams | Tribal Chairman, Lac Vieux Desert Band of Lake Superior Chippewa Indians

Edlynzia Barnes | Designated Federal Officer

Appendix 2. Theme 1 Recommendations

Theme 1: Legacy Phosphorus is defined as phosphorus that is already in the soil and water of the Great Lakes (and tributaries thereto) and that may require different considerations as part of the installation of any new or continuing best management practices to reduce nutrient loads.

Charge Question: Please identify any strategies, using traditional or innovative technologies or methods, to reduce legacy Phosphorus within the Lake Erie watershed (and other Great Lakes and tributaries thereto).

Note: **Near-term recommendations** are those that are actionable under GLRI by GLNPO. **Mid-term recommendations** are those that need additional research or development before they could be implemented under GLRI; however, the research or development could be a near-term activity. **Long-term recommendations** are those that are within EPA purview, but may require legislative changes, new partnerships, multi-stakeholder engagement, additional investments, or other development.

Near-term Recommendations

- **Support regional projects to identify critical source areas in the watershed.** Then, use critical source area information to prioritize and more effectively fund and implement strategies to maximize removal of legacy phosphorus and excess nutrients from the system. (This recommendation also supports theme 2.)
- **Fund and implement long-term comprehensive watershed monitoring programs** to (1) evaluate the performance and costs of individual or combined avoid, control, and trap conservation practices; and (2) guide Great Lakes Restoration Initiative project funding decisions to maximize legacy phosphorus nutrient and sediment reduction.
- **Support and fund projects that evaluate the relative contributions of soil legacy phosphorus and applied phosphorus to total phosphorus loss.**
- **Support the physical removal or chemical/biological sequestration of legacy phosphorus–laden sediments** as effective methods to remove legacy phosphorus from the lake environment. Also encourage Great Lakes Restoration Initiative coordination with the U.S. Army Corps of Engineers and local communities to develop innovative ways to sequester or beneficially reuse dredge sediment for agricultural field placement, habitat restoration, or other environmentally suitable uses.
- **Support the development of a new Great Lakes Restoration Initiative-funded technical and grant management assistance program** designed to assist underserved communities with project identification and development, application for financial assistance, and project implementation and management.

Mid-term Recommendations

- **Coordinate Great Lakes Restoration Initiative funding and technical expertise to develop regional tools to implement the most effective combination of avoid, control, and trap practices at federal, state, and local levels** as identified in the U.S. Department of Agriculture–Natural Resources Conservation Service's Avoid, Control, and Trap program to maximize legacy phosphorus nutrient and sediment reduction at HUC-12 watershed scales.
- **Fund and implement a comprehensive long-term monitoring program to assess Great Lakes Restoration Initiative-funded project performance and provide the information**

necessary to guide future Great Lakes Restoration Initiative investments in water quality and more effectively manage nutrient pollution in the Great Lakes. (This recommendation also supports theme 2.)

- **Support the creation of an endowment fund** to provide a stable, long-term funding source to support the continued monitoring and assessment of Great Lakes Restoration Initiative-funded nutrient-reduction projects and to provide long-term capacity building and financial support to underserved smaller urban or rural communities. (This recommendation also supports theme 2.)
- **Support the development of Great Lakes Restoration Initiative-funded public–private partnerships and pay-for-performance conservation programs** to support the continued monitoring and assessment of Great Lakes Restoration Initiative-funded nutrient-reduction projects and to address historic and current water quality degradation due to nutrient loading in underserved communities.

Appendix 3. Theme 2 Recommendations

Theme 2: The issue of nutrient (especially phosphorus) loading has been a very significant and public ecosystem health issue in Lake Erie, primarily due to the creation of Harmful Algal Blooms (HABs) that negatively impact drinking water systems, tourism, and other commercial activities in the Great Lakes.

Charge Question: Balancing the need for the continued production of agricultural commodities in the Great Lakes region, the contribution to excess nutrient loading in Lake Erie associated with agricultural production activities, and the need to significantly reduce the extent and duration of HABs on Lake Erie, what innovative actions could reasonably be taken to accelerate the reduction of excess nutrients and HABs or duration of HAB events in Lake Erie? Consider if there are new or different applications of traditional federal funding sources, opportunities to partner with the private sector (including tourism, drinking water systems, and others affected by HABs), or community-driven or market-based approaches to financing water quality improvements.

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Near-term recommendations

- **Support and fund regional projects to (1) identify watersheds where Great Lakes Water Quality Agreement target nutrient loads are consistently exceeded March–July, and (2) identify critical source areas within those watersheds that contribute a disproportionately large amount of excess phosphorus to nutrient load.** Use watershed and critical source area information to prioritize and more effectively target excess phosphorus management strategies to maximize removal of excess phosphorus from the system.
- **Support additional research and funding for innovative technology/nutrient-removal systems along with innovative funding strategies to support long-term monitoring and assessment of these technologies to evaluate their effectiveness.**
- **Great Lakes National Program Office should coordinate and Great Lakes Restoration Initiative should fund cross-jurisdictional coordination efforts to identify critical source areas and implement regionally coordinated watershed scale structural nutrient-reduction practices** (by applying landscape conservation design principles) to maximize nutrient-removal efficiencies.
- **Support and fund the development and implementation of watershed land-use plans and conservation practices that protect and maintain *existing high-quality watersheds* that do not contribute significant excess nutrient loads to the basin.**
- **Support and fund total maximum daily load implementation using a distributed mass balance approach applied at the HUC-12 subwatershed scale in combination with the funding, development, and implementation of Nine-Element NPS-IS Plan as an effective way to link local subwatershed nutrient-reduction projects to regional total maximum daily load/distributed load water quality targets.**

Mid-term recommendations

- **Encourage, support, and fund large nutrient-reduction projects within lower watershed tributaries near or adjacent to receiving water bodie**s to maximize potential nutrient-reduction benefits.
- **Coordinate Great Lakes Restoration Initiative funding and technical expertise to develop regional tools to implement the most effective combination of avoid, control, and trap practices at federal, state, and local levels** as identified in the U.S. Department of Agriculture–Natural Resources Conservation Service avoid, control, and trap program to maximize excess phosphorus nutrient and sediment reduction at HUC-12 watershed scales.
- **Support the development of new performance metrics to recognize and document potential reductions in nutrient loading that might result by implementing land use and watershed plans.** The metrics should be incorporated into land use models to identify potential land use controls or changes that maximize nutrient-reduction benefits within a watershed.
- **Support the development of an incentive-based ecosystem credit marketplace or program that administers trades between buyers and sellers (or funders and suppliers) of ecosystem services.**
- **U.S. Environmental Protection Agency and Great Lakes National Program Office should explore opportunities to link Tradable Permit Model to total maximum daily load/Distributed load watersheds and potential regulatory or governance changes in National Pollutant Discharge Elimination System permits.**
- **In watersheds with total maximum daily load implementation requirements, U.S. Environmental Protection Agency and Great Lakes National Program Office should consider regulatory options within their respective jurisdictions when voluntary and practice-based approaches are deemed insufficient to achieve necessary nutrient reductions to meet Great Lakes Water Quality Agreement targets.**
- **Support regional policy and management committees to use land-use planning models, appropriately calibrated SWAT models, and HUC-12 water quality monitoring data to validate model results to identify watersheds and critical source areas that disproportionately contribute to excess phosphorus loads in the Great Lakes.**

Long-term Recommendation

- **Develop mechanisms to leverage public–private or pay-for-performance funds to support nutrient-reduction practices in the basin.**

Appendix 4. Healing Our Waters–Great Lakes Coalition Recommendations for Great Lakes Restoration Initiative

- Provide additional Great Lakes Restoration Initiative grants to communities of color, Indigenous communities, and low-income communities, recognizing ecosystem restoration can also revitalize our communities and our economies at the same time.
- Restore previously used language in Requests for Applications that prioritized environmental justice, community engagement, and contracting with disadvantaged business enterprises.
- Coordinate with the Environmental Justice Interagency Working Group on ways to expand community engagement. Consistent efforts must be made to continually reach out to more communities for input on projects, impacts, and desired results.
- Start the process for public engagement on the Great Lakes Restoration Initiative Action Plan IV earlier and prioritize community outreach and engagement with communities of color, Indigenous communities, and low-income communities.
- Set standards for community representation and inclusion on Public Advisory Councils that include demographic and socioeconomic indicators.
- Hold councils accountable that fail to meet these standards.
- Enlist Public Advisory Councils earlier in the decision-making process to ensure robust community engagement to ensure projects are meeting community needs.
- Provide funding to Public Advisory Councils to implement these changes.

Source: Healing Our Waters–Great Lakes Coalition. n.d. *Restoring the Great Lakes, Prioritizing Communities that have Suffered the Greatest Harms*, information sheet. Accessed January 16, 2022. https://1bgfed3gunqq3wtodz172r4o-wpengine.netdna-ssl.com/wp-content/uploads/2021/02/HOW-Equity-and-the-GLRI-4-pager.pdf

Appendix 5. Waterway Restoration Partnership Environmental Justice Actions

- Re-envisioning the Community Advisory Committee to include members with diverse backgrounds, ethnicities, geographies, and community perspectives.
- Establishing guiding principles to facilitate meaningful engagement that focus on trust-building, anti-racism, realistic expectations, stewardship development, empowering residents, meaningful inclusion, hospitality, culturally aware communication, barriers to participation, and community leadership.
- Enhancing outreach and community engagement capacity for GLRI projects–funding both the people and time to do this work.
- Developing measures of progress for environmental justice.
- Identifying other resources (e.g., other EPA grants to support environmental justice engagement efforts that might not be GLRI) and ways to more easily connect these funding sources with GLRI funding.
- Requiring climate change be considered when making decisions about remediation and restoration projects and impacts to all communities.

Source: Rebecca L. Fedak, personal communication.

Appendix 6. Theme 3 Recommendations

Theme 3: Under the GLRI and GLWQA, a number of mechanisms are utilized to inform the general public about activities and efforts underway to improve the health of the Great Lakes ecosystem, including but not limited to, press releases, GLRI.us.; binational.net; asiancarp.gov; annual GLRI Reports to Congress, 5-year LAMPs and annual reports for each Great Lake, triennial Progress Reports of the Parties, triennial State of the Great Lakes Highlight Reports.

Charge Question: How well are EPA and its federal, state, and tribal partners communicating the goals, challenges, and accomplishments of GLRI? Are there stakeholder groups that could be more effectively communicated with? What additional and/or innovative tools could be used to improve outreach to citizens, elected officials, and partners?

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Near-term Recommendations

- **Develop and implement community engagement metrics** to assess progress toward environmental justice outcomes.
- **Adapt models of successful outreach efforts by other Great Lakes-focused collaborations.**
- **Establish standards for the Public Advisory Councils regarding outreach, staffing, and accountability.**
- **Establish a framework and programs for engaging and supporting the relevant activities of community organizations, libraries, and nontraditional stakeholders, particularly those in disproportionately impacted areas, through meaningful engagement and communication.**
- **Engage more with business and industry to leverage their sustainability plans and vision with Great Lakes Restoration Initiative ecological services.**
- **Explore connections between food, energy, water and transportation instead of working in silos toward shared goals.**
- **Drawing on high-quality public relations expertise, implement programs and metrics to increase Great Lakes Restoration Initiative visibility and recognition among the general public and stakeholder communities; include local participants in outreach and evaluation efforts.**
- **Provide publicly accessible summaries of Great Lakes National Program Office reports to Congress** that describe Great Lakes Restoration Initiative benefits and improvements to impacted communities regarding restoration, mitigation, communication, and education with special reports on Great Lakes Restoration Initiative improvements in environmental justice communities, tribes, and Indigenous communities.
- **Prioritize reporting on the impacts of Great Lakes Restoration Initiative programs on environmental injustice and climate change** as significant environmental and natural resources issues affecting the Great Lakes.

- **Provide management assistance funding to states and Tribe**s to hire boots-on-the-ground staff in technical areas, social sciences, and community engagement.

Mid-term Recommendation

- **Map Brownfield sites, Opportunity Zones, and other agency and community programs with Great Lakes Restoration Initiative program proposals to maximize awareness and leverage opportunities.**

Appendix 7. Theme 4 Recommendations

Theme 4: Invasive species control and prevention continues to be a challenge for the Great Lakes. Perhaps the most visible example are the efforts to control Asian Carp from entering Lake Michigan.

Charge Question: Balancing the need for continued commercial, recreational, and other activities on the Great Lakes, what innovative actions could reasonably be taken to accelerate the control of existing invasive species, and what methods or strategies can be deployed to prevent the establishment of future infestations?

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Near-term Recommendations

- **Fund strategies to manage AIS that pose the greatest impediment to the restoration of key sites and habitats across the Great Lakes (such as coastal wetlands and coastal spawning reefs) while continuing efforts at the vector and pathway level to maintain a coordinated prevention approach.**
- **Improve coordination, information exchange, and database sharing at the federal, state, and local levels.**
- **Address vessel discharge by including a Great Lakes National Program Office budget request to fund the Great Lakes and Lake Champlain Invasive Species Program authorized by Section 903(g) of the Vessel Incidental Discharge Act, giving priority to monitoring and technology development related to vessels.**
- **Continually invest in new technologies.**
- **Incentivize the commercial use of AIS.**
- **Create an AIS Prize.**

Mid-term Recommendations

- **Address vessel discharge by (1) Working with Canada to align ballast regulations that provide consistent regulatory controls across the Great Lakes; and (2) Collaborating with U.S. Coast Guard and other stakeholders, including the Great Lakes Carrier's Association, to develop materials to instruct the general public on laws pertaining to AIS.**
- **Strengthen, or expand and refine, a system-wide, coordinated, early detection and response system.**
- **Include climate change scenarios when anticipating or modeling future invasions;** changing conditions in terms of water temperature, salinity, and nutrients, among others, will influence the ability of future invaders to colonize and thrive.
- **Coordinate with the International Joint Commission in the development and implementation of an early warning system in the Great Lakes.**

- **Initiate a coordinated research and stakeholder engagement program** involving aquatic and molecular ecologists, ethicists, social scientists, biotech specialists, and venture capitalists to explore the feasibility, desirability, and legality of gene-drive technology as a control mechanism for aquatic invasive species.
- **Develop a regional grant program, using both private and public funds, that addresses all AIS and has funding of sufficient size to attract a large pool of applicants.**

Appendix 8. Theme 5 Recommendations

Theme 5: This Administration has prioritized outcomes and deliverables from all agency programs. Since its inception in 2010, GLRI has produced measurable results, but are we moving the needle, specifically on AOC delisting, nutrients, invasive species, and habitats.

Charge Question: As we enter the next decade of GLRI funding, what are appropriate annual ecological and community-based outcomes (coupled with appropriate baselines and monitoring) to show that we are making progress in the areas of AOC remediation and delisting, invasive species control and prevention, nutrient reduction, and habitat restoration and protection, such that we can show a good return on investment?

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Near-term Recommendations

- **Engage state and tribal partners actively in the identification, prioritization, and selection and funding of projects.**
- **Establish a broad set of project outcomes that include environmental justice, climate, and public health impacts.**
- **Support funding for long-term environmental justice and tribal sustainability and prioritize projects through the establishment of funding criteria and scoring that meets these objectives** (e.g., extra points for competitive grants in impacted or disadvantaged communities).
- **Establish procedures to enable consideration for funding projects that require resources for long-term operations and maintenance** so that tribes and underserved communities can successfully compete for grants.
- **When assessing and forecasting the benefits of ecosystem services, use valuation systems that account for secondary and tertiary consequences, as well as local traditions and place-based values.**
- **Implement a framework with specific environmental justice outcomes to support cohesive Great Lakes programs that recognize and appropriately incorporate the priorities of tribes and traditional ecological knowledge.**
- **Incorporate qualitative and narrative data into outcome measures, including traditional ecological knowledge.**

Long-term Recommendations

- **Develop companion legislation to the Legacy Act that allows the program to be implemented anywhere in the Great Lakes to address contaminated sediment.**
- **Establish a regional committee to undertake the expansion of program performance metrics for tracking preservation and protection.**

Appendix 9. Theme 6 Recommendations

Theme 6: This Administration has prioritized clean-up, redevelopment and reuse of abandoned, blighted and contaminated properties. There are numerous examples around the Great Lakes where clean-up of waterways is followed by development and economic prosperity. In addition, under President Trump's Executive Order on "Modernizing America's Water Infrastructure" which formally establishes the Water Subcabinet, there are opportunities for even better leveraging of resources and expertise across the Federal family.

Charge Question: How can GLRI projects and funding be further leveraged across Federal agencies and programs, including Opportunity Zones and Brownfields, to maximize environmental and economic benefits to Great Lakes communities?

Note: **Near-term recommendations** are those that are actionable under GLRI by GLNPO. **Mid-term recommendations** are those that need additional research or development before they could be implemented under GLRI; however, the research or development could be a near-term activity. **Long-term recommendations** are those that are within EPA purview, but may require legislative changes, new partnerships, multi-stakeholder engagement, additional investments, or other development.

Near-term Recommendations

- **Support the assessment of climate change on the Great Lakes Basin that affects environmental, public health, and economic metrics, including drought and flood resiliency and sustainability.**
- **Engage environmental economists to establish baseline data needs, ecosystem services metrics, evaluation, and milestones using both traditional ecological knowledge and scientific ecological knowledge.**
- **Incorporate the Biden Administration's government-wide approach to climate change across the Great Lakes.**
- **Engage the public early in the development of the Great Lakes Restoration Initiative Action Plan IV,** and prioritize community outreach and engagement with communities of color, Indigenous communities, and low-income communities.
- **Incorporate Justice40 initiatives and priorities into the Great Lakes Restoration Initiative Action Plans and investments,** and review environmental justice recommendations for environmental justice communities and tribes as pertinent to the Great Lakes.
- **Ensure benefits reach and improve disadvantaged communities by including perspectives from scientists on addressing climate vulnerabilities.**

Mid-term Recommendations

- **Support ongoing research & development so that stakeholders can get an earlier understanding of emerging challenges, e.g., climate change impacts that could affect the magnitude or longevity of restoration efforts.**
- **Update Action Plans to ensure environmental justice and climate change are included.**
- **Analyze pressures to migrate into the region and anticipate changing, and likely higher, demands on Great Lakes Basin land and water.**
- **Leverage Great Lakes Restoration Initiative to increase employment and education opportunities locally and to support long-term project operation and maintenance.**

- **Develop models that include not only ecosystem dynamics but also policy, public health, and economic forces.**

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