Researchers deploy a remotely operated vehicle (ROV) to observe sinkholes at the bottom of Lake Huron. The ROV uses a camera to search the lake floor, take photos, and measure temperature, depth and conductivity. The water found at the bottom of these sinkholes is high in sulfate and low in oxygen, making them inhospitable for fish and other organisms normally found in the Great Lakes. With no competition, this makes the sinkholes, an ideal habitat for microorganisms known as cyanobacteria. Research on these fascinating underwater features and the unusual creatures they support is on-going. *Photo Credit: David J. Ruck/Great Lakes Outreach Media.*
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Cover photos: In 2017, NOAA GLERL deployed the world’s first freshwater Environmental Sample Processor (ESP) to track the concentration of dangerous toxins produced by cyanobacteria that bloom each summer in the western basin of Lake Erie. Shown outside of its casing on the front cover, when deployed, the ESP collects water samples, analyzes, and sends data in near real-time. In the Great Lakes, the ESP is used to monitor for microcystin, the dominant algal toxin in western Lake Erie. This allows NOAA GLERL to provide drinking water managers with data on algal toxicity in near real-time, before the water reaches municipal water intakes. Photo credits: Daryl Marshke/Michigan Photography.
Scientists from NOAA and Monterey Bay Aquarium Research Institute (MBARI) deploy a sentinel long-range autonomous underwater vehicle (LRAUV) into Lake Erie’s harmful algal bloom. The sentinel LRAUV’s mission is to map algae concentrations throughout the bloom and tell the 3rd generation environmental sample processor (3GESP) LRAUV where to measure for microcystin toxin levels. Photo credit: David J. Ruck, Great Lakes Outreach Media.
A MESSAGE FROM THE DIRECTOR

The National Oceanic and Atmospheric Administration (NOAA) Great Lake Environmental Research Laboratory (GLERL) was created in 1974 to “conduct research directed toward an understanding of the environmental processes in the Great Lakes and their watersheds.” As one of ten laboratories and programs within NOAA’s research division—Oceanic and Atmospheric Research (OAR)—our freshwater focus on Great Lakes, large lakes of the world, and coastal ecosystems makes us unique among NOAA OAR laboratories and programs. Our research contributes to the products and services that protect lives and livelihoods, the economy, and the environment of the Great Lakes region.

The Great Lakes basin is a vital freshwater resource that spans across U.S. and Canadian borders and enriches the lives of more than 34 million people who live, work, and recreate in the region. Our awareness and understanding of the fragile, complex, and interconnected nature of the Great Lakes is now more important than ever. As we look ahead, we must recognize the uncertainty that the dynamic forces of human-induced stressors and a changing climate bring to our work. NOAA’s commitment to protecting and securing Great Lakes water and resources for future generations will not waiver. Our science, service, and stewardship will continue to contribute to an awareness and understanding that spans across the region.

The science program at GLERL is foundational to and interwoven across the core NOAA mission and is guided by OAR’s goals—as described in the OAR Strategy 2020-2026—to explore the marine environment; detect changes in the ocean, Great Lakes, and atmosphere; make better forecasts; and drive innovation. Our approach to scientific research—integrated around physical, chemical, and biological interactions—serves as a framework to address the complex environmental challenges posed by a large-lake system in a state of flux, as well as a model for other freshwater and coastal ecosystems. Looking forward, we are strengthening our programs in ‘omics, uncrewed systems, Great Lakes acidification, and stakeholder engagement. In the years ahead, we will continue to enhance our science program through partnerships and collaborations within the private sector, and greater integration into academia.

This strategic plan outlines GLERL’s strategies, goals, and objectives for the next five years. We are poised to embrace future needs by building lasting partnerships, providing innovations in observing technology, leading cutting-edge experimental research, developing advanced ecosystem models, communicating science-based products and services, and contributing sound science to the Great Lakes management community.

Deborah H. Lee

Director, Great Lakes Environmental Research Laboratory
NOAA GLERL researchers collect field data from NOAA research vessels throughout the Great Lakes. GLERL focuses on priority ecological problems, and their interactive effects, in the Great Lakes and coastal ecosystems.
VISION, MISSION, VALUES

Deliver NOAA’s Future
A trusted scientific enterprise to advance observation, modeling, understanding, and prediction of the Great Lakes and coasts to sustain resilient ecosystems, communities, and economies.

Research, Develop, Transition
Conduct research to understand and predict the Great Lakes and coastal ecosystems; develop technology to improve NOAA science, service, and stewardship; and transition the results so they are useful to society.

Commit to Diversity
Strive to create a diverse workforce and an environment where all feel included, regardless of position, background, trait, or status. Recognize that a diverse workforce and an inclusive culture positions us to be the strongest and best equipped to serve all communities of the Great Lakes.

Explore to Solve
Conduct preeminent research, aligned with NOAA goals, to advance the state of science and knowledge that promotes sound decision making and ecosystem management. Integrate an interdisciplinary approach and use partnerships to strengthen research capacity.

Uphold Scientific Integrity
Execute research with integrity and quality, abiding by quality management, safety standards, and environmental compliance.

Engage from Local to Global
GLERL is involved locally, regionally, and internationally to understand the changing environment and inform stakeholders.
NOAA GLERL’s Lake Michigan Field Station (LMFS) is located on Lake Michigan, in Muskegon Michigan, right next to a popular pier that draws thousands of visitors year-round (top). This location provides a unique opportunity for engagement with tourists, recreational users, and community members of this diverse region. Based at the field station, the RV Laurentian (bottom) is NOAA GLERL’s largest research vessel. NOAA GLERL’s research staff and vessel operators coordinate to collect data to support integrated scientific research for NOAA and external partners.
COMMITMENT TO DIVERSITY & INCLUSION

At GLERL we strive to create a diverse workforce and an environment where all feel included, regardless of position, background, trait, or status. We recognize that a diverse workforce and an inclusive culture positions us to be the strongest and best equipped to serve all communities of the Great Lakes.

Across the federal government, including at NOAA, there is increased focus on the work that is needed to strengthen the Federal workforce through the promotion of diversity, equity, inclusion, and accessibility. GLERL is firmly committed to increasing the diversity within its workforce and creating inclusive work environments where everyone feels valued and experiences a true sense of belonging. The term “diversity” means the practice of including the many communities, identities, races, ethnicities, backgrounds, abilities, cultures, and beliefs of the American people, including underserved communities. The term “inclusion” means the recognition, appreciation, and use of the talents and skills of employees of all backgrounds. An inclusive culture values the unique attributes of all team members, and it provides an environment which is respectful, collaborative, supportive, and one that allows for equitable access. Inclusion requires active and intentional engagement on the part of everyone and provides a feeling of belonging.

GLERL will take direct steps to increase the diversity of its workforce as well as provide an inclusive, equitable, and accessible work environment for all employees. GLERL maintains an active diversity and inclusion committee, open to all staff, that promotes a range of initiatives. This committee also collaborates with groups outside of GLERL on diversity, inclusion, and equal employment opportunity activities.

GLERL strives to make current and future staff able to contribute their talents in a place they feel welcome, supported, and empowered to support NOAA’s mission. In an effort to create an environment that is as diverse as the region it serves, GLERL will work to provide a “seat at the table” for all staff and stakeholders in the region, and provide everyone an opportunity to speak for themselves. We know the best results come from a diverse set of perspectives and we will work to foster a culture of respect and inclusion for all persons. The people of GLERL and the capabilities they provide are its greatest asset.

GLERL follows OAR’s guiding principles for an inclusive work environment:

• We will treat each other with respect, always, regardless of rank or grade.
• Every employee deserves a work environment free from discrimination, disrespect, and fear.
• We promote open expression of our individuality and diversity within the bounds of courtesy, sensitivity, and respect, and will promote an environment of professionalism in our facilities.
• We will routinely seek to attract diverse talent in our workforce.
• We seek to resolve workplace conflicts in a prompt, impartial, confidential, nondiscriminatory, and constructive manner, without fear of reprisal, and at the lowest level through open communication.
• All employees are valued and included for the unique contributions they bring to the organization.
• Leaders and supervisors have a special responsibility to build and preserve this climate and culture of inclusion and mutual respect for all.
• People First, Mission Always.
OUR ORGANIZATION

The Great Lakes Environmental Research Laboratory (GLERL) is a Federal scientific research facility based in Ann Arbor, Michigan, operating as part of the National Oceanic and Atmospheric Administration (NOAA) Office of Oceanic and Atmospheric Research (OAR). GLERL’s Ann Arbor facility houses experimental and marine instrumentation laboratories furnished with state-of-the-art equipment and technology to support GLERL’s scientific research. Integral to GLERL’s operation is the Lake Michigan Field Station (LMFS), strategically located on the eastern shore of Lake Michigan in Muskegon, Michigan. The LMFS serves as the home base for field operations, research, and GLERL vessel operations—critical assets in providing physical access to the Great Lakes and advancing NOAA’s mission in the region.

GLERL’s research capacity is further strengthened by its in-house and regional partnerships. These include participating universities, municipalities, State, Federal, and international agencies, non-governmental institutions, and many others. These partnerships foster mutually beneficial research and collaboration, promote efficient information exchange and dissemination, and help identify and take advantage of shared resources and expertise.

GLERL serves as the financial management center for the distribution of funds throughout NOAA via the interagency Great Lakes Restoration Initiative. GLERL also provides regional small boat infrastructure and services to all NOAA line offices in the Great Lakes, producing operational efficiencies and cost savings to the government. The Ann Arbor facility serves informally as a regional operating center, providing access to NOAA’s NMFS Habitat Restoration, National Marine Sanctuaries Regional Coordination, NMFS Office of Enforcement, National Geodetic Survey, Great Lakes Observing System, the NOAA Great Lakes Regional Collaboration Team, and the Cooperative Institute for Great Lakes Research.
GLERL Science Branches

Observing Systems and Advance Technology (OSAT) - OSAT conducts scientific and engineering research and development, identifies emerging observational infrastructure needs, and provides environmental observations and data throughout the Great Lakes.

Ecosystem Dynamics (EcoDyn) - EcoDyn strives to monitor, analyze, understand, and predict changes in Great Lakes and coastal ecosystems to strengthen capacity for managing water quality, fisheries, invasive species, and ecosystem health.

Integrated Physical and Ecological Modeling and Forecasting (IPEMF) - IPEMF conducts innovative research and development of numerical models to predict the physical, chemical, biological, and ecological response of the Great Lakes due to weather, climate, and human-induced changes.

Information Services (IS) - IS coordinates and supports information flow internally among NOAA staff, and externally with stakeholders and the general public to advance science, service, and stewardship of the Great Lakes and coastal ecosystems.
**NOAA Great Lakes Regional Partnerships**

**NOAA Cooperative Institutes** - NOAA Cooperative Institutes are academic and non-profit research institutions that demonstrate the highest level of performance in the conduct of research, supporting NOAA’s mission goals and strategic plan. The Cooperative Institute for Great Lakes Research (CIGLR) is sponsored by the NOAA Great Lakes Environmental Research Laboratory (GLERL) and hosted by the University of Michigan. CIGLR and GLERL staff work side-by-side on exciting new research, training the next generation of scientists, and turning research into action for safe and healthy Great Lakes communities.

**NOAA Great Lakes Regional Collaboration Team (GLRCT)** - The GLRCT serves to unify and integrate NOAA initiatives in the Great Lakes region by providing services that meet the evolving needs of stakeholders. The GLERL Director also serves as NOAA's Regional Team Lead for the Great Lakes, facilitating collaboration of more than 800 NOAA employees and partners representing the agency’s diverse capabilities. The GLRCT Regional Coordinator is co-located at GLERL.

**Great Lakes Sea Grant Network** - Through its network of extension educators and its use of engaging communication and education techniques, the Great Lakes Sea Grant Network plays a central role in supplying the region and the nation with usable solutions to pressing problems and providing information needed to better manage Great Lakes resources for present and future generations of Americans. Located at GLERL, the Regional Sea Grant Specialist position facilitates information exchange between GLERL and Sea Grant regarding Great Lakes-related research, extension, education, and other programs.
Great Lakes Observing System (GLOS) - GLOS is one of 11 regional associations of the Integrated Ocean Observing System (IOOS), working to enhance the ability to collect, deliver, and use ocean and Great Lakes information. A bi-national nonprofit, GLOS provides end-to-end data services that support science, policy, management, and industry in the Great Lakes. GLOS is co-located with GLERL and coordinates on support for critical observing needs and data delivery to stakeholders.

Great Lakes Integrated Sciences and Assessments (GLISA) - As one of 11 NOAA Regional Integrated Sciences and Assessments (RISA) teams, GLISA serves as a collaboration between the University of Michigan and Michigan State University. GLISA’s team of social and physical scientists work at the boundary between climate science and decision makers, striving to enhance Great Lakes communities' capacity to understand, plan for, and respond to climate impacts now and in the future. GLERL collaborates with GLISA on the Annual Climate Summary for the Great Lakes Basin, climate modeling workshops, lake ice forecasting, and climate communications.

National Marine Sanctuaries Program - NOAA’s Office of National Marine Sanctuaries serves as the trustee for a network of underwater parks encompassing more than 600,000 square miles of marine and Great Lakes waters. The Thunder Bay National Marine Sanctuary (TBNMS), based in Alpena, Michigan and encompassing 4,300 square miles of northwestern Lake Huron, is jointly managed by NOAA and the State of Michigan to discover, document, interpret, and protect a nationally significant collection of historic shipwrecks. TBNMS works in partnership with GLERL to facilitate additional research in sanctuary waters including biology, geology, and climate change studies, and relies on GLERL vessel and other technological support.

NOAA GLERL partnerships foster mutually beneficial research and collaboration, promote efficient information exchange and dissemination, and help identify and take advantage of shared resources and expertise. Photo credits: Researchers in NOAA GLERL laboratory by Daryl Marshke/Michigan Photography; R/V Storm in Thunder Bay National Marine Sanctuary by David J. Ruck/Great Lakes Outreach Media.
FORECASTING RESEARCH IN TIMES OF UNCERTAINTY

GLERL is committed to addressing the needs of the Great Lakes and coastal communities as we strategize our research priorities for the future. By almost any measure, the Great Lakes region is one of the world’s most important economic and population centers, with a population of 107 million, a GDP of $6 trillion USD and 1.5 million Great Lakes-related jobs. Nearly one-third of U.S. and Canadian economic activity is centered in the Great Lakes region and they contain 95% of our nation's fresh surface water. The future strength of the Great Lakes Blue Economy and regional prosperity depends on society’s ability to maintain their water quality, biological productivity, healthy coastal ecosystems, recreational and commercial access to the lakes and a safe navigation system.

The changing political and economic landscape adds layers of complexity that all environmental research communities encounter. As is true throughout NOAA, the operating landscape for the Great Lakes environmental science community is changing and this presents challenges and opportunities for GLERL. To help shape the strategic direction for research, NOAA laboratories, and programs, the NOAA 2020-
NOAA GLERL and CIGLR deployed and maintained a network of buoys and meteorological stations while following safety protocols during the COVID-19 pandemic. These instruments are an essential source of Great Lakes data, providing measurements like wind speed, water and air temperature, and wave height.

**2026 Oceanic and Atmospheric Research Strategy** identifies the following six factors that will impact our future operating environment and our capacity to remain leaders in environmental research:

- Society’s perception of the natural environment.
- Shifts in funding.
- Technology is lowering barriers to entry.
- Integrated approaches and skill sets.
- On-demand culture.
- Increased competition for STEM talent.

For GLERL, these factors are informing our strategic approach for the coming years. In order to remain relevant and continue to provide global scientific leadership in ecosystem research, GLERL is programming for flexibility and placing a renewed emphasis on the importance of innovative partnerships and collaborations. We are acknowledging and embracing uncertainty as we set forth on new strategic directions, goals, and priorities for the future.
An inter-agency team of public and private sector partners are addressing drinking water safety near Cleveland. The experimental hypoxia forecast model developed at GLERL (see inset above) can predict when low oxygen (hypoxic) water may be in the vicinity of drinking water intake pipes. Advance notice of hypoxic conditions allows water managers to change their treatment strategies to ensure the health and safety of drinking water. *Photo credit: Ed Verhamme, Limnotech*
STRATEGIC APPROACH

GLERL’s approach to scientific research—integrated around physical, chemical and biological interactions—serves as a framework to address the complex environmental challenges posed by a large-lake system in a state of flux as well as to serve as a model for other freshwater and coastal ecosystems. This integrated approach builds upon long-term observations, data collection, experimentation, modeling, prediction, and forecasting. The integration of research focuses scientific questions to strengthen understanding of the Great Lakes and toward solving environmental problems posing risks to the vitality and resiliency of the Great Lakes.

While the operating landscape for the environmental science community is changing, we are guided by the following five strategies developed by the NOAA Oceanic and Atmospheric Research. GLERL will continue to conduct and deliver world-class science dedicated to the NOAA mission of science, service and stewardship.

1. Deliver world-class science together

GLERL will operate as an integrated, connected, and aligned organization with a shared vision to deliver world-class products. Recognizing that GLERL cannot succeed alone, GLERL will collaborate with other NOAA Line Offices, government, academia, nonprofit, industry, and international partners.

2. Develop the next-generation workforce

GLERL will grow the leaders of tomorrow. With a focus on diversity and inclusion, GLERL will broaden its talent pool to reflect multidisciplinary skill sets.

3. Prioritize mission-relevant research

GLERL will continue to contribute to fulfilling NOAA’s vision of resilient ecosystems, communities, and economies. GLERL will anticipate future scientific and operational needs, while delivering on current expectations.

4. Strengthen internal and external collaboration

GLERL will leverage the breadth of expertise across GLERL, NOAA Line Offices, and external domestic and international communities to improve mission effectiveness.

5. Leverage new technology and advance computing capability

GLERL will engage the external community to maintain awareness of new technology and explore innovative ways to acquire and use it.
Eddy covariance stations (see inset above), such as that on the White Shoal lighthouse in Lake Michigan, provide key information for researchers to build models that more accurately reproduce lake conditions, allowing for better forecasts of water levels and lake-effect snow.
GOALS AND STRATEGIC OBJECTIVES

Four goals reflect what OAR desires to achieve, where to focus activities, and, ultimately, how to improve the organization’s ability to deliver NOAA’s future. The objectives, nested under each goal, are the areas of focus needed, and where GLERL is aligning to help OAR achieve its goals.

1. Explore the Marine Environment
   Increase knowledge of the Great Lakes and the regional water budget to support resource management and public awareness.

2. Detect Changes in the Great Lakes Ecosystem
   Produce, analyze, and interpret observation records to understand the Earth system with a regional focus of the Great Lakes and inform the public.

3. Make Forecasts Better
   Improve accuracy, precision, and efficiency of forecasts and predictions to save lives and property and support a vibrant economy.

4. Drive Innovative Science
   Cultivate and deliver mission-relevant research to lead the environmental science community.

“GLERL’s mission is to conduct research to understand and predict the Great Lakes and coastal ecosystems; develop technology to improve NOAA science, service, and stewardship; and transition the results so they are useful to society.”
**Goal 1: Explore the Marine Environment**

Increase knowledge of the Great Lakes and the regional water budget to support resource management and public awareness.

**STRATEGIC OBJECTIVES**

<table>
<thead>
<tr>
<th>1.1 Spatially characterize and map the Great Lakes.</th>
<th>o Coordinate and partner with others using a variety of characterization methods and techniques to acquire data for environmental, physical, and biological parameters.</th>
</tr>
</thead>
</table>
| 1.2 Determine how climate change impacts the Great Lakes physical and ecological system and coastal communities. | o Improve and expand the capacity to forecast effects of climate change on the Great Lakes and its ecosystem to reduce risk and improve resilience.  
| | o Integrate physical measurements, physical processes and observations to improve predictions of Great Lakes water levels, water budget and ice cover and expand the knowledge base of Great Lakes extreme events.  
| | o Conduct assessments of ecosystem health and trends relative to climate.  |
| 1.3 Communicate the value of the Great Lakes. | o Provide Great Lakes environmental data for services and tools that inform decisions, policies, and resource management.  
| | o Communicate value to stakeholders by leveraging established networks and creating new collaborations.  
| | o Engage the public to increase citizen participation in observations, exploration, and stewardship; and enhance Great Lakes literacy in the U.S.  |
Goal 2: Detect Changes in the Great Lakes Ecosystem

Produce, analyze, and interpret observation records to understand the Great Lakes ecosystem and inform the public.

STRATEGIC OBJECTIVES

2.1 Sustain and advance Great Lakes observational capacity.
- Advance the Great Lakes research observational capacity using shipboard operations, monitoring infrastructure and uncrewed systems; expand use and application of technology to enhance remote sensing capacity to assess ecosystem impacts and for use in modeling and forecast development.

2.2 Identify and address gaps in Great Lakes observations needed to understand causes of freshwater ecosystem and regional variability and change.
- Expand the current suite of Great Lakes observations and sampling to identify gaps and prioritize needs. Improve Great Lakes understanding, forecasts, applied knowledge, and predictions for high-impact events.
- Test and develop observation technologies, experimental tools and capabilities through partnerships and/or research efforts to better address these needs in the coming decade.

2.3 Increase the accessibility, use and synthesis of Great Lakes data.
- Leverage technologies, field and lab experimentation and modeling approaches to gather and share relevant information with Great Lakes stakeholders and partners, OAR, across NOAA, and throughout the external community to heighten understanding of the Great Lakes system, the management of its resources, and the effects on society.
- Engage with stakeholders early and regularly throughout research and development to understand user requirements, needs, and expectations.
- Deliver informational products that inform decision making.
Goal 3: Make Forecasts Better

Improve accuracy, precision, and efficiency of forecasts and predictions to save lives and property and support a vibrant economy.

### STRATEGIC OBJECTIVES

| 3.1 Develop Great Lakes components of an Earth System Model. |  
| --- | --- |
| - Develop a coordinated Great Lakes modeling system to improve forecast capability of lake hydrodynamics, lake ice, hydrological response, ecological processes, water quality, and climatic variability and trends across spatial and temporal scales. |  
| - Establish protocols for routine model skill assessment and explore approaches to probabilistically quantify model uncertainty. |  

| 3.2 Design tools and applications to forecast high-impact Great Lakes weather, water, climate, and ecosystem events. |  
| --- | --- |
| - Invest in the development of tools, technologies, experimental methods, and processes to advance models and increase the relevancy of forecasts. |  
| - Improve the capability to understand observation and forecast uncertainty and better communicate the uncertainty. |  

| 3.3 Transition science that meets users’ current and future needs. |  
| --- | --- |
| - Research to Operations (R2O): Research-based models are transitioned to operations through collaboration with NOAA partners. |  
| - Research to Applications (R2A): Research-based models are transitioned to applications through collaboration with important stakeholders or other government agencies. |
Goal 4: Drive Innovate Science

Cultivate and deliver mission-relevant research to lead the environmental science community.

**STRATEGIC OBJECTIVES**

| 4.1 Reinforce a culture of innovation and adaptability. | - Strengthen processes, governance, and structures that cultivate innovation and the behaviors of innovation. Establish processes for risk acceptance and management across the organization.  
- Create a culture of resilience by fostering an appreciation for risk and creating a structure that is adaptive and flexible.  
- Recruit and attract a diverse, highly-capable workforce.  
- Create an inclusive culture that connects all staff to GLERL and encourages communication, flexibility, and fairness. |
| 4.2 Invest in high-risk, high-reward science. | - Identify and conduct new and innovative science and assess the impacts, risks, and opportunities.  
- Lead research on identified high-risk, high-reward areas to advance NOAA’s mission and guide the environmental community. |
| 4.3 Accelerate the delivery of mission-ready, next-generation science. | - Expedite the delivery of mission-ready science, services, and technologies.  
- Prioritize mission-driven science and research agendas, addressing NOAA’s most pressing requirements in a relevant, timely manner. |
NOAA GLERL researchers conduct particle trajectory simulations (top) that illustrate how flow affects the potential transport of a substance (e.g., oil, sediment, or nutrients). To validate the model, drifter buoys are periodically released (bottom) into the lakes. The drifter buoys float with the currents and their tracks are compared to modeled results. These simulations illustrate the complex physical conditions in the lakes and the importance of ongoing research to improve models that provide information for management and decision-making efforts.
APPENDIX A
Congressional Mandates

Legal Authorities for NOAA OAR Great Lakes Environmental Research Laboratory:

**Title 15: Commerce and Trade**

- § 313c: Authorized activities of the National Oceanic and Atmospheric Administration
  - 1) Improve the capability to accurately forecast inland flooding (including inland flooding influenced by coastal and ocean storms) through research and modeling
  - 5) Assess, through research and analysis of previous trends, among other activities—
    (A) the long-term trends in frequency and severity of inland flooding; and (B) how shifts in climate, development, and erosion patterns might make certain regions vulnerable to more continual or escalating flood damage in the future.

- § 1511: Bureaus in Department
  - Reorganization of the Department of Commerce (1970), establishing and authorizing NOAA for the conception, planning, and conduct of basic research and development in the fields of water motion, water characteristics, water quantity, and ice and snow

- § 2904: National Climate Program (components relevant to NOAA GLERL research)
  - Assessments of the effect of climate on the natural environment, land and water resources, and basic and applied research to improve understanding of climate processes
  - Basic and applied research to improve the understanding of climate processes, natural and man induced
  - Methods for improving climate forecasts on a monthly, seasonal, yearly, and longer basis

- § 8531: NOAA satellite and data management
  - Integrate additional coastal and ocean observations, and other data and research, from the Integrated Ocean Observing System (IOOS) into regional weather forecasts to improve weather forecasts and forecasting decision support systems;
  - Support the development of real-time data sharing products and forecast products
  - Support increasing use of autonomous, mobile surface, sub-surface, and submarine vehicle ocean and freshwater sensor systems and the infrastructure necessary to share and analyze these data in real-time and feed them into predictive early warning systems.

**Title 16: Conservation**

- § 1447b. Regional Marine Research Boards
  - The Great Lakes Research Office authorized under § 1268(d) of title 33 shall be responsible for research in the Great Lakes region

- § 4722: Aquatic Nuisance Species Program
ANS prevention, monitoring, control, education, research

§ 4730: Great Lakes and Lake Champlain Invasive Species Program

(A) IN GENERAL.—The Administrator shall establish within the Great Lakes National Program Office a program, to be known as the “Great Lakes and Lake Champlain Invasive Species Program”—

(i) in collaboration with—

(I) the Director of the United States Fish and Wildlife Service;

(II) the Administrator of the National Oceanic and Atmospheric Administration;

(III) the Director of the United States Geological Survey; and (IV) the Secretary of the department in which the Coast Guard is operating; and

(ii) in consultation with—

(I) the head of Great Lakes Aquatic Nonindigenous Species Information System of the National Oceanic and Atmospheric Administration; and

(II) the head of Great Lakes Environmental Research Laboratory of the National Oceanic and Atmospheric Administration.

(B) PURPOSES.—The purposes of the Program shall be—

(i) to monitor for the introduction and spread of aquatic nuisance species into or within the Great Lakes and Lake Champlain Systems;

(ii) to detect newly introduced aquatic nuisance species prior to the establishment of the aquatic nuisance species in the Great Lakes and Lake Champlain Systems;

(iii) to inform, and assist with, management and response actions to prevent or stop the establishment or spread of an aquatic nuisance species;

(iv) to establish a watch list of candidate aquatic nuisance species that may be introduced or spread, and that may survive and establish, within the Great Lakes and Lake Champlain Systems;

(v) to monitor vectors likely to be contributing to the introduction or spread of aquatic nuisance species, including ballast water operations;

(vi) to work collaboratively with the Federal, State, local, and Tribal agencies to develop criteria for prioritizing and distributing monitoring efforts;

(vii) to develop, achieve type approval for, and pilot shipboard or land-based ballast water management systems installed on, or available for use by, commercial vessels operating solely within the Great Lakes and Lake Champlain Systems to prevent the spread of aquatic nuisance species populations within the Great Lakes and Lake Champlain Systems; and
(viii) to facilitate meaningful Federal and State implementation of the regulatory framework in this subsection, including monitoring, shipboard education, inspection, and compliance conducted by States.

Executive Order 13112 Invasive Species

- Each federal agency whose actions may affect the status of invasive species shall, to the extent practicable and permitted by law: "...conduct research on invasive species to prevent introduction and provide environmentally sound control invasive species..."

Boundary Waters Treaty of 1909 (between the United States and Great Britain/Canada)

- The Boundary Waters Treaty was signed in 1909 to prevent and resolve disputes over the use of the waters shared by Canada and the United States and to settle other transboundary issues. The treaty established the International Joint Commission (IJC) to help the two countries carry out its provisions.

Title 22: Foreign Relations and Intercourse

- § 267b International Joint Commission; invitation to establish; personnel; duties
  - The President of the United States is requested to invite the Government of Great Britain to join in the formation of an international commission, to be composed of three members from the United States and three who shall represent the interests of the Dominion of Canada, whose duty it shall be to investigate and report upon the conditions and uses of the waters adjacent to the boundary lines between the United States and Canada, including all of the waters of the lakes and rivers whose natural outlet is by the River Saint Lawrence to the Atlantic Ocean; also upon the maintenance and regulation of suitable levels; and also upon the effect upon the shores of these waters and the structures thereon, and upon the interests of navigation, by reason of the diversion of these waters from or change in their natural flow; and, further, to report upon the necessary measures to regulate such diversion, and to make such recommendations for improvements and regulations as shall best subserve the interests of navigation in said waters.

- § 268 International Joint Commission; salaries; powers
  - The salaries of the members on the part of the United States of the International Joint Commission, established under the treaty of January 11, 1909, between the United States and Great Britain, relating to boundary waters between the United States and Canada, shall be fixed by the President

Title 33: Navigation and Navigable Waters

- § 891b: Fleet replacement and modernization plan
  - Proposed acquisition of modern scientific instrumentation for the NOAA fleet, including acoustic systems, data transmission positioning and communication systems, physical, chemical, and meteorological oceanographic systems, and data acquisition and processing systems

- §893: Ocean and Atmospheric Research and Development Program
- Identify emerging and innovative R&D supporting U.S. competitiveness and new economic opportunities based on NOAA research, observations, monitoring, modeling, and predictions that sustain economic services.

- Advance ocean, coastal, Great Lakes, and atmospheric research and development, including potentially transformational research, in collaboration with other relevant Federal agencies, academic institutions, the private sector, and nongovernmental programs, consistent with NOAA’s mission to understand, observe, and model the Earth’s atmosphere and biosphere, including the oceans, in an integrated manner.

- § 1121: Congressional declaration of policy
  - The National Oceanic and Atmospheric Administration, through the national sea grant college program, offers the most suitable locus and means for such commitment and engagement through the promotion of activities that will result in greater such understanding, assessment, development, management, [1] utilization, and conservation of ocean, coastal, and Great Lakes resources. The most cost-effective way to promote such activities is through continued and increased Federal support of the establishment, development, management, and operation of programs and projects by sea grant colleges, sea grant institutes, and other institutions, including strong collaborations between Administration scientists and research and outreach personnel at academic institutions.

- §1268: Great Lakes
  - Establish within NOAA a Great Lakes research office to “conduct, through the Great Lakes Environmental Research Laboratory, National Sea Grant College program, other Federal laboratories, and the private sector, appropriate research and monitoring activities which address priority issues and current needs relating to the Great Lakes.”
  - d) Great Lakes Research
    1. Establishment of Research Office
      
      There is established within the National Oceanic and Atmospheric Administration the Great Lakes Research Office.
    
    2. Identification of issues
      
      The Research Office shall identify issues relating to the Great Lakes resources on which research is needed. The Research Office shall submit a report to Congress on such issues before the end of each fiscal year which shall identify any changes in the Great Lakes system [3] with respect to such issues.
    
    3. Inventory
      
      The Research Office shall identify and inventory Federal, State, university, and tribal environmental research programs (and, to the extent feasible, those of private organizations and other nations) relating to the Great Lakes system, and shall update that inventory every four years.
4. **Research exchange**

The *Research Office* shall establish a *Great Lakes* research exchange for the purpose of facilitating the rapid identification, acquisition, retrieval, dissemination, and use of information concerning research projects which are ongoing or completed and which affect the *Great Lakes System*.

5. **Research Program**

The *Research Office* shall develop, in cooperation with the Coordination Office, a comprehensive environmental research program and data base for the *Great Lakes system*. The data base shall include, but not be limited to, data relating to water quality, fisheries, and biota.

6. **Monitoring**

The *Research Office* shall conduct, through the *Great Lakes* Environmental Research Laboratory, the National Sea Grant College program, other Federal laboratories, and the private sector, appropriate research and monitoring activities which address priority issues and current needs relating to the *Great Lakes*.

7. **Location**

The *Research Office* shall be located in a *Great Lakes* State.

- **§ 3424: Research, exploration, education, and technology programs**

(Note: 33 U.S. Code SUBCHAPTER II—NOAA UNDERSEA RESEARCH PROGRAM)

  - Development, testing, and transition of advanced undersea technology associated with ocean observatories, submersibles, advanced diving technologies, remotely operated vehicles, autonomous underwater vehicles, and new sampling and sensing technologies

- **§ 3601: Integrated Coastal and Ocean Observation System**

  - Enable advances in scientific understanding to support the sustainable use, conservation, management, and understanding of healthy *ocean, coastal, and Great Lakes resources*

  - Improve the Nation’s capability to measure, track, explain, and predict events related directly and indirectly to weather and climate change, natural climate variability, and interactions between the oceanic and atmospheric environments, including the *Great Lakes*

  - authorize activities to promote basic and applied research to develop, test, and deploy innovations and improvements in coastal and ocean observation technologies, modeling *systems*, and other scientific and technological capabilities to improve our conceptual understanding of weather and climate, ocean-atmosphere dynamics, global climate change, physical, chemical, and biological dynamics of the ocean, coastal and *Great Lakes environments*, and to conserve healthy and restore degraded coastal ecosystems.
 § 4005: Great Lakes hypoxia and harmful algal blooms (established under the Harmful Algal Bloom and Hypoxia Research and Control Act (HABHARCA) of 1988 to prevent, reduce, management, mitigate, and control HABs and hypoxia)

  o Develop for Congress and the President an integrated assessment to address the causes, consequences, and approaches to reduce hypoxia and harmful algal blooms in the Great Lakes, including the status of and gaps within current research, monitoring, management, prevention, response, and control activities.
APPENDIX B
Great Lakes Environmental Research Laboratory Charter

Great Lakes Environmental Research Laboratory (GLERL)

4840 S. State Rd. Ann Arbor, MI 48108
734-741-2235
www.glerl.noaa.gov

Vision:
A trusted scientific enterprise to advance observation, modeling, understanding, and prediction of the Great Lakes and coasts to sustain resilient ecosystems, communities, and economies.

Mission:
Research, Develop, Transition

Conduct research to understand and predict the Great Lakes and coastal ecosystems; develop technology to improve NOAA science, service, and stewardship; and transition the results so they are useful to society.

Core Competencies:
- Harmful Algal Blooms Research
- Hypoxia Research
- Great Lakes Long-term Ecological Research
- Invasive Species Research
- Great Lakes Water Level Forecasting and Lake Hydrology
- Great Lakes Real-Time Environmental Coastal Observing Network
- Great Lakes Coastal Forecasting System
- Great Lakes CoastWatch
- Ice Research, Monitoring and Forecasting
- Great Lakes Regional Climate Modeling and Forecasting
- Great Lakes Physical Observations
- Great Lakes Regional Fleet
- Communications and Outreach

Statutory Authority and/or Charge Under NOAA Strategic Plan:
1. 33 U.S.C. § 1268 Establishment of Great Lakes research office
2. 16 U.S.C. § 1447b—Regional Marine Research Programs
3. 15 U.S.C. § 1511 COMMERCE AND TRADE
4. 16 U.S.C. § 4741--CONSERVATION
5. 16 U.S.C. § 4722. AQUATIC NUISANCE SPECIES PROGRAM
6. 16 U.S.C. § 760e – STUDY OF MIGRATORY GAME FISH; WATERS; RESEARCH PURPOSE
8. 15 U.S.C. §§ 1525, 1540—COOPERATIVE AGREEMENTS/REIMBURSEMENT TO FURTHER NOAA’S MISSION
11. 33 U.S.C. § 1268--NAVIGATION AND NAVIGABLE WATERS--WATER POLLUTION PREVENTION AND CONTROL--RESEARCH AND RELATED PROGRAMS
12. 33 U.S.C. §2326b-NAVIGATION AND NAVIGABLE WATERS--WATER RESOURCES DEVELOPMENT

**Science Themes and Research Areas:**
GLERL’s approach to scientific research—integrated around physical, chemical and biological interactions—serves as a framework to address the complex environmental challenges posed by a large-lake system in a state of flux as well as to serve as a model for other freshwater and coastal ecosystems of the world. GLERL is uniquely organized to maintain its integrated scientific research program. GLERL’s organizational structure is built upon the following four branches that drive GLERL’s research agenda:

**Observing Systems and Advanced Technology**
Through the development of cutting-edge instrumentation, observing, and remote sensing technologies, the OSAT branch team members acquire the data and develop information products needed to improve understanding of the Great Lakes and coastal ecosystems and support decision-making for resource managers and other stakeholders.

**Ecosystem Dynamics (EcoDyn)**
The EcoDyn branch strives to anticipate, monitor, analyze, understand, and forecast changes in the Great Lakes and coastal ecosystems to strengthen capacity for managing water quality, fisheries, and ecosystem and human health.

**Integrated Physical and Ecological Modeling and Forecasting (IPEMF)**
The IPEMF branch conducts innovative research and develops numerical models to predict the physical, chemical, biological, and ecological response in the Great Lakes due to weather, climate, and human-induced changes. The forecast models and quantitative tools developed at GLERL allow scientists, coastal resource managers, policy makers, and the public to make informed decisions for optimal management of the Great Lakes.

**Information Services (IS)**
The IS branch coordinates and supports information flow internally among NOAA staff, and externally with stakeholders and the general public to advance science, service, and stewardship of the Great Lakes and coastal ecosystems.

**Products and Results:**
GLERL supports NOAA’s goals to understand and predict changes in climate, weather, oceans and coasts; and to share that knowledge and information with others. GLERL research programs, guided by NOAA priorities, deliver products to a broad suite of stakeholders. GLERL’s experimental forecasting capabilities, e.g., the Great Lakes Forecasting System, experimental harmful algal bloom, hypoxia, and lake level forecasts, are the foundation for ecosystem approaches to management. GLERL is also home to NOAA’s CoastWatch program for the Great Lakes that produces a number of real-time and retrospective satellite data products. The stakeholders of
GLERL's research and development products, services, and information include federal, public, private, and academic organizations who apply the research outcomes to make better operational decisions supporting various societal and economic sectors.

Lead the world in earth system observation and prediction to enhance the nation’s Blue Economy.
- Real-time Coastal Observation Network (ReCON) collecting high bandwidth data about ecosystems
- Harmful algal bloom and hypoxia forecasting
- Hydrology: water levels, ice prediction, and lake management
- Satellite Color-Producing Agent Algorithm
- Radar Satellite Ice-type Algorithm
- Hyperspectral imagery – phytoplankton functional types algorithm

Minimize the impacts of severe weather.
- Understanding hydrodynamic input to lake effect snow
- Understanding and forecasting Great Lakes ice dynamics
- Meteotsunami research

Customers:
GLERL collaborates across NOAA and with the Cooperative Institute for Great Lakes Research, Great Lakes Sea Grant, and a wide range of academic partners to pursue research that leads to an ecosystem approach to management. GLERL also serves as the DOC’s representative on the Great Lakes Interagency Task Force, as outlined by a Presidential Executive Order (No. 13340), to restore and protect the Great Lakes. This task force brings together eleven Agency and Cabinet-level departments at the Secretary level. GLERL is a partner in the interagency Great Lakes Restoration Initiative and administers the program for NOAA. Since 2010, NOAA has received $272.3 million and GLERL has received $43.2 million. GLERL constituents include the Great Lakes and coastal science communities, state and federal government agencies, state, national and international commissions, K-12 and higher educational institutions, professional scientific organizations, other non-government organizations, and the general public.

Future Expectations:
Going forward, GLERL will continue to be a leader in large lakes of the world research. GLERL is aligning with NOAA’s new strategies in key science and technology focus areas including uncrewed systems, artificial intelligence, data, and ‘omics to guide transformative advancements in the quality and timeliness of NOAA science, products and services. By implementing our GLERL Strategic Plan we will continue to solve tough problems and set the course to strengthen NOAA’s freshwater environmental S&T leadership for the coming decades.
APPENDIX C
**Implementation Plan**

The following contains additional details toward the implementation of the NOAA GLERL Strategic Plan 2021-2025.

**Goal 1: Explore the Marine Environment**

Increase knowledge of the Great Lakes and the regional water budget to support resource management and public awareness.

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<tr>
<th>STRATEGIC OBJECTIVES</th>
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<tr>
<td><strong>Objective 1.1 - Spatially characterize and map the Great Lakes.</strong></td>
<td>o Advance the use of physical and ecological observations and modeling in the Great Lakes to improve scientific information for managing Great Lakes resources.</td>
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<td>Coordinate and partner with others using a variety of characterization methods and techniques to acquire data for environmental, physical, and biological parameters.</td>
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| **Objective 1.2 - Determine how climate change impacts the Great Lakes physical and ecological system and coastal communities.** | o Develop and improve physical, biogeochemical and ecosystem models of the Great Lakes. o Define and understand spatial interactions of nutrients and food-web components from microbes to fishes in the Great Lakes. o Identify what Great Lakes species may be most vulnerable to climate change. o Track the trends in the Great Lakes ecosystem and it’s living marine resources related to climate change. o Continue Long-Term Research program on critical food web variables in nearshore and offshore Lake Michigan to meet management and forecasting needs. o Expand direct measurements and remote sensing work on monitoring water quality parameters, specifically focusing on key climate parameters such as temperature and dissolved inorganic carbon chemistry. |
| Improve and expand the capacity to forecast effects of climate change on the Great Lakes and its ecosystem to reduce risk and improve resilience. |
Integrate physical measurements, physical processes and observations to improve predictions of Great Lakes water levels, water budget and ice cover and expand the knowledge base of Great Lakes extreme events.

- Extend spatial and temporal observational capacity to include winter ecosystem and lake evaporation observations.
- Continue and develop the Great Lakes 'Omics program.
- Define and understand the impact of global-scale air masses, or teleconnection patterns, impacts on the Great Lakes.
- Coordinate with the NOAA Coastal Inundation Program, the Great Lakes Observing System and partners to develop and improve coastal flooding forecasting and inundation models.
- Improve Great Lakes physical models and forecasts.
- Provide Great Lakes expertise and input to the National Water model.
- Integrate observations, experiments and modeling to improve understanding of Great Lakes climate impacts.

Objective 1.3 - Communicate the value of the Great Lakes.

Provide Great Lakes environmental data for services and tools that inform decisions, policies, and resource management.

- Provide data, models and scientific analysis to Great Lakes Restoration Initiative partners and the Great Lakes Water Quality Agreement Annex teams in collaboration with the International Joint Commission and Canadian Federal and Provincial Agencies.
- Expand access to data on the GLERL website.
- Assess and improve service delivery through structured interaction with stakeholders and application of social science methods.

Communicate value to stakeholders by leveraging established networks and creating new collaborations.

- Continue to actively seek and engage in research collaborations with other NOAA OAR Laboratories and Programs, NOAA Line Offices, Great Lakes Sea Grant programs, and national and international
research organizations, including other Federal agencies, universities, the private sector and NGOs.

- Create connections to both existing and new NOAA science and technology focus areas.
- Create connections with State and tribal entities.

Engage the public to increase citizen participation in observations, exploration, and stewardship; and enhance Great Lakes literacy in the U.S.

- Increase Great Lakes scientific literacy by engaging with the media, giving public talks, and making our science more accessible to the public. GLERL scientists are encouraged to serve as mentors for students of all levels and backgrounds.
**Goal 2: Detect Changes in the Great Lakes Ecosystem.**

Produce, analyze, and interpret observation records to understand the Great Lakes system and inform the public.

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| **Objective 2.1 - Sustain and advance Great Lakes observational capacity.** | o Develop advanced computer processing, communications, networking, artificial intelligence, and power system techniques.  
 o Develop advanced techniques and procedures to explore ‘Omics techniques and data.  
 o Develop and implement advanced uncrewed platform technology integration techniques.  
 o Pursue advanced marine vessel observational technology related to vessel designs and data acquisition systems.  
 o Maintain long term ecological research observational programs at key sentinel sites.  
 o Hire/ train personnel to support emerging technologies and programs. |
| **Objective 2.2 - Identify and address gaps in Great Lakes observations needed to understand causes of freshwater ecosystem and regional variability and change.** | o Extend Great Lakes Small Boat Program vessel capacity to improve spatial and temporal (all season) coverage.  
 o Expand satellite and airborne remote sensing capacity to include relevant observations at appropriate spectral, temporal and spatial scales.  
 o Expand observational capacity using uncrewed systems.  
 o Hire/ train personnel to support emerging technologies and programs. |
Test and develop observation technologies, experimental tools and capabilities through partnerships and/or research efforts to better address these needs in the coming decade.

- Develop and evolve an ecosystems research program for understanding HABs and food web interactions. (i.e. ‘Omics, invasives)
- Develop and evolve the Great Lakes emerging technology program (i.e. hyperspectral imaging, lidar, radar, etc.) for uncrewed systems.

**Objective 2.3 - Increase the accessibility, use and synthesis of Great Lakes data.**

Leverage technologies, field and lab experimentation and modeling approaches to gather and share relevant information with Great Lakes stakeholders and partners, OAR, across NOAA, and throughout the external community to heighten understanding of the Great Lakes system, the management of its resources, and the effects on society.

- Engage in data sharing through public data repositories such as the NOAA National Centers for Environmental Information (NCEI), the National Center for Biotechnology Information (NCBI), the World Ocean Database (WOD), Marine Biological Observation Network (MBON), Global Lake Ecological Observatory Network (GLEON), Global Earth Observing System of Systems (GEOSS), Long Term Ecological Research (LTER) and the US National Science Foundation National Ecological Observatory Network (NEON).
- Extend use of cloud computing, artificial intelligence (machine learning) to rapidly process large Great Lakes data sets.

Engage with stakeholders early and regularly throughout research and development to understand user requirements, needs, and expectations.

- Identify and meet information needs of constituent groups while promoting GLERL’s expertise products, and services.
- Extend internal stakeholder engagement within NOAA for Research to Operations (R2O) and external engagement for Research to Applications (R2A).

Deliver informational products that inform decision making.

- Extend stewardship of GLERL data in alignment with the NOAA Data Strategy and in compliance with NOAA’s plan for Public Access to Research Results (PARR).
- Maintain and expand the suite of science communications products for general audiences to promote GLERL research.
**Goal 3: Make Forecasts Better**

Improve accuracy, precision, and efficiency of forecasts and predictions to save lives and property and support a vibrant economy.

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<tr>
<td><strong>Objective 3.1 - Develop Great Lakes components of an Earth System Model.</strong></td>
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<tr>
<td>Develop a coordinated Great Lakes modeling system to improve forecast capability of lake hydrodynamics, lake ice, hydrological response, ecological processes, water quality, and climatic variability and trends across spatial and temporal scales.</td>
<td>- Improve GLERL’s modeling and forecasting capacity by development of improved models of earth system components (atmosphere, ocean/lake, land surface, biogeochemistry), coupling model components, and data assimilation.</td>
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<td>- Improve quantitative precipitation forecasts from the short-range time scale through seasonal prediction; improve Great Lakes precipitation, evaporation and runoff simulation and forecasting products.</td>
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<td>- Invest in Great Lakes integrated modeling system to create linkages to the NOAA Earth system modeling initiative and Unified Forecast System.</td>
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<td>- Extend observations needed to advance understanding of precipitation predictability (e.g. evaporation) to advance NOAA’s Precipitation Prediction Grand Challenge (Objective 4).</td>
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| Establish protocols for routine model skill assessment and explore approaches to probabilistically quantify model uncertainty. |  |
| | - Enhance GLERL’s ability to capture forecast uncertainty using probabilistic approaches. |
| | - Identify new sources of predictive skill and improve predictions of ecological and physical processes through observations, understanding and modeling of physical processes and phenomena of the Great Lakes components of an Earth system model. |
| | - Collect data to support rigorous model skill and uncertainty quantification. |
### Objective 3.2 - Design tools and applications to forecast high-impact Great Lakes weather, water, climate, and ecosystem events.

- Invest in the development of tools, technologies, experimental methods, and processes to advance models and increase the relevancy of forecasts.
- Improve the capability to understand observation and forecast uncertainty and better communicate the uncertainty.
- Improve physics in coupled Great Lakes models.
- Develop ecosystem models to provide scenario-based, nowcast, and forecast applications addressing Great Lakes ecosystem research and management questions.
- Develop understanding of drivers of Great Lakes Harmful Algal Bloom dynamics for development of tools to predict spatial distribution, extent, seasonal dynamics and toxicity.

### Objective 3.3 - Transition science that meets users’ current and future needs.

**Research to Operations (R2O):** Research-based models are transitioned to operations through collaboration with NOAA partners.
- Improve Great Lakes components of the National Water Model across short-to-long term time scales and across high- to-low lake level conditions to improve total water prediction.
- Transition a Great Lakes hypoxia forecast and HAB toxin forecast to operations.
- Collaborate to develop and demonstrate biogeochemical modeling of water quality and ecosystems functions for targeted Great Lakes watersheds.

**Research to Applications (R2A):** Research-based models are transitioned to applications through collaboration with important stakeholders or other government agencies.
- Develop scenario-based invasive species models for decision support with the Great Lakes management community.
- Develop community ecosystem model unstructured grid-based food web and nutrient dynamics for impacts of Great Lakes stressors.
Goal 4: Drive Innovate Science
Cultivate and deliver mission-relevant research to lead the environmental science community.

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<th>STRATEGIC OBJECTIVES</th>
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<td><strong>Objective 4.1 - Reinforce a culture of innovation and adaptability.</strong></td>
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<td>Strengthen processes, governance, and structures that cultivate innovation and the behaviors of innovation. Establish processes for risk acceptance and management across the organization.</td>
<td>o Create incentives that encourage curiosity driven research that can lead to a shift in research programs, and can impact the scientific questions that need to be answered to advance our understanding of the Great Lakes.</td>
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<td>Create a culture of resilience by fostering an appreciation for risk and creating a structure that is adaptive and flexible.</td>
<td>o Cultivate a culture that encourages curiosity driven research when addressing long-term, the societal and stakeholder needs, and adaptive and responsive research.</td>
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<td>Recruit and attract a diverse, highly-capable workforce.</td>
<td>o Recruit qualified individuals at all levels whose diverse backgrounds, experience, education and skills will advance GLERL’s mission.</td>
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<td>Create an inclusive culture that connects all staff to GLERL and encourages communication, flexibility, and fairness.</td>
<td>o Develop a Diversity, Equity and Inclusion Strategic Plan for GLERL.</td>
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<td><strong>Objective 4.2 - Invest in high-risk, high-reward science.</strong></td>
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<td>Identify new and innovative science and assess the impacts, risks, and opportunities.</td>
<td>o Dedicate a portion of base funds for exploratory research to support individual and cross-branch initiatives.</td>
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<td>Lead research on identified high-risk, high-reward areas to advance NOAA’s mission and guide the environmental community.</td>
<td>o Prepare proposals in new research areas. o Engage in NOAA and regional strategic workshops and planning initiatives to address emerging priorities.</td>
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<td>Objective 4.3 - Accelerate the delivery of mission-ready, next-generation science.</td>
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<tr>
<td>Expedite the delivery of mission-ready science, services, and technologies.</td>
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<tr>
<td>- Conduct research that addresses regional stakeholder needs and map NOAA Great Lakes research to NOAA and OAR goals, and Great Lakes bi-national policy.</td>
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<td>Prioritize mission-driven science and research agendas, addressing NOAA’s most pressing requirements in a relevant, timely manner.</td>
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<td>- Develop winter and under-ice ecosystem observational capacity and address Great Lakes winter limnology knowledge gaps.</td>
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<td>- Collaborate across NOAA CoastWatch on blended Synthetic Aperture Radar (SAR) products to improve ice classification mapping capability.</td>
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<td>- Research, develop, test, and support the meteotsunami detection and prediction system to the National Weather Service.</td>
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<td>- Develop the capability for drone-based surveillance of microcystin (MC) aerosols associated with toxic cyanobacterial blooms.</td>
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<td>- Working with partners, establish new standards and techniques for studying Great Lakes acidification, and incorporate data into biogeochemical models.</td>
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<td>- Conduct a cross-ecosystem comparison to assess and quantify food web and fisheries response to HABs, invasive species, hypoxia, and climate change.</td>
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<td>- Engage in on-going discussions with stakeholders to identify and meet mission needs of constituent groups.</td>
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