

OHIO SEA GRANT COLLEGE PROGRAM

2014–2018 STRATEGIC PLAN

INTRODUCTION

Ohio Sea Grant College Program

The Ohio Sea Grant College Program at The Ohio State University, including Stone Laboratory, the Center for Lake Erie Area Research (CLEAR), and the Great Lakes Aquatic Ecosystem Research Consortium (GLAERC), is a statewide program aimed at improving the environmental health and economic vitality of this country's Great Lakes resources with an emphasis on Lake Erie and its watershed. Ohio Sea Grant is a partnership among academia, government, and the private sector, and uses a combination of research, education, and outreach to focus on the 3 Es: the economy, the environment, and education.

The Ohio Sea Grant Program is one of 33 state programs in the National Oceanic and Atmospheric Administration (NOAA), US Department of Commerce. The NOAA Sea Grant College Program is focused on sustaining our nation's ocean, coastal, and Great Lakes resources and is a matching program. For every dollar Ohio Sea Grant receives from NOAA Sea Grant, Ohio Sea Grant must provide a minimum of \$0.50 of matching support from non-federal sources. Therefore, seeking partnerships to leverage resources for maximum impacts is a key strategy in attaining the program's goals and fulfilling its mission. Ohio Sea Grant receives support from many of its partners, including the State of Ohio, The Ohio State University (e.g. Ohio State University Extension, Office of Research, College of Food, Agricultural, and Environmental Sciences), collaborating universities, state agencies, private businesses, and concerned citizens.

With its unique combination of research, education, and outreach, Ohio Sea Grant is sought-after for its unbiased and science-based approach toward addressing pressing environmental and economic issues, often in collaboration with other federal, state, and local entities, as well as nonprofit organizations at all levels. At its core, Ohio Sea Grant aims to be a good leader and a good partner. Using the National Sea Grant Network, local collaborations, and a strong relationship with the community, Ohio Sea Grant is a program of action, investigating Lake Erie issues and sharing solutions with those likely to shape the region's future.

Ohio Sea Grant celebrated its 34th anniversary in 2012. Over that span, Ohio Sea Grant has supported more than 500 projects, with 287 principal investigators from over 20 colleges and universities, and more than 500 graduate and undergraduate students, all from its base NOAA budget. The program's annual research component supports approximately 20 research projects each year, providing the necessary science to address the lake's emerging issues. Over the same time span, using support from The Ohio State University and private sector donors, Ohio Sea Grant has provided scholarships, fellowships, employment opportunities, and research experiences to over 1500 graduate and undergraduate students at Stone Laboratory, Ohio State University's island campus. The program has six extension/outreach specialists from Toledo to Conneaut (two

additional positions are currently open), eight seasonal and part-time science education instructors, approximately 20 part-time faculty members teaching at Stone Lab, six visiting research supervisors at Stone Lab, and a central administrative and communications office based at Ohio State University in Columbus. Dr. Jeff Reutter is the Ohio Sea Grant College Program Director. Dr. Christopher Winslow is the Assistant Director for Research and Administration, Jill Jentes Banicki is the Assistant Director for Communications, Bryan Ford is the Business Manager, Matt Thomas is Stone Laboratory's Manager, Dr. Kristin Stanford is the Education and Outreach Coordinator at Stone Laboratory, Justin Chaffin is the Research Coordinator at Stone Lab, and Frank Lichtkoppler is the Extension Program Leader. The program also has a strong base of volunteers, from its private sector Sea Grant Advisory Committees to its active alumni and volunteer organization called "the Friends of Stone Laboratory."

Core Strategies and Tools

Research

Annually, Ohio Sea Grant supports the work of scientists from a dozen universities throughout Ohio as they work to solve the most pressing problems facing Lake Erie—from addressing solutions to harmful algae blooms in the western basin to uncovering the economic value of a cleaner environment. Many of these scientists take advantage of facilities at Ohio State University's Stone Laboratory, a fully equipped freshwater research laboratory and island campus.

Typically, one third to one half of Ohio Sea Grant's core budget from NOAA is dedicated to competitively funded projects. Proposals for small grants (requesting up to \$10,000) from the program's development fund can be submitted at any time. Proposals for larger research grants (up to \$60,000 per year for up to two years) are requested through a biennial request for proposals (RFP). Submissions are welcome from anyone, and the RFP is disseminated to every college and university in Ohio. The most recent RFP is publicly accessible through the research pages on www.ohioseagrant.osu.edu/research.

Pre-proposals submitted to the RFP cycle are subject to review by a panel of experts consisting of both Ohio Sea Grant employees and external professionals. Based upon that panel's review, full proposals are either invited or discouraged; however, no proposal is rejected based upon pre-proposal evaluations.

Full proposals submitted to the RFP cycle are all subject to external written peer review. Investigators are also permitted to draft written responses to blinded peer reviews before proposals and written peer reviews are evaluated by an external panel of experts from agencies, academia, industry, and other stakeholders. A representative from the NOAA Sea Grant Program in Washington, DC, attends the panel meeting to ensure fairness and the absence of conflicts of interest. The Director of Ohio Sea Grant takes the recommendations of the panel into consideration when selecting and submitting full proposals to the NOAA Sea Grant Program with Ohio Sea Grant's biennial omnibus proposal submission.

Education

The Franz Theodore Stone Laboratory serves as the main educational facility for Ohio Sea Grant, offering approximately 25 college-credit courses each summer to undergraduate and graduate students, advanced high school students, educators, and professionals. Stone Laboratory also offers non-college credit workshops and conferences to educate and train future Great Lakes stewards. In addition to those taking college-level classes and workshops, as many as 8,000 students in grades 4-12 and other groups take part in Stone Laboratory's Lake Erie Science Field Trip Program, annually.

Training educators to better address coastal issues is also a key component of Ohio Sea Grant's strategy. Educator workshops provide hands-on experiences conducting water sampling and monitoring, while curricula development takes a Great Lakes focus on addressing climate change and other key topics.

In 2010, Lake Erie Literacy Principles were developed by Ohio Sea Grant and its partners to build upon the NOAA Ocean principles, yet with a regional focus. These literacy principles were later used as models for the development of Great Lakes Literacy Principles, coordinated by COSEE Great Lakes (i.e. Centers for Ocean Sciences Education Excellence). The Lake Erie principles are now being used in both formal and informal educational settings to ensure consistent messaging and lifelong learning.

Outreach

Lake Erie is Ohio's most valuable natural aquatic resource and is regarded by many as the most important lake in the world. As a result, the lake is used for multiple, and sometimes conflicting, purposes. Therefore, Ohio Sea Grant and its partners must circulate the best information available to lake managers, decision-makers, elected officials, and stakeholders in order to encourage sustainability and stewardship of Lake Erie resources. Informed clientele make better decisions regarding the wise use and protection of Lake Erie, which requires the services of an active Sea Grant Outreach and Extension Program.

Getting timely and relevant information to the public is key to Ohio Sea Grant's outreach endeavors. The program's Extension/Outreach Specialists, with offices spread across Ohio's Lake Erie counties, interact with Ohio citizens to help them solve problems related to Lake Erie and help them identify opportunities including: sustainable economic development, fisheries, boating, beaches, birding, shipping, water use, ecosystem rehabilitation, sustainability, and tourism. Activities vary depending on the need being addressed; however, many of these tasks involve facilitating community discussions and planning retreats, providing one-on-one consultations with elected officials and other decision makers, and linking research efforts to emerging needs to solve problems. Also, the Ohio Sea Grant Communication Network supports web-based initiatives, including webinars, to increase information dissemination.

Ohio Sea Grant Extension is a partnership among academia, government, and the private sector that combines the use of current and emerging technology and a network of personal relationships to identify coastal issues and potential solutions. Ohio Sea Grant Extension is fully engaged within coastal communities and they have

earned credibility by helping residents and visitors make informed decisions and implement solutions based on good science and clientele-driven educational programs. The program helps people use science-based information to make informed decisions about real-world problems, issues, and opportunities.

Ohio Sea Grant Facilities and Collaborative Program

Franz Theodore Stone Laboratory

The mission of the Franz Theodore Stone Laboratory is to serve Ohio State University, the Ohio Sea Grant College Program, the State of Ohio, and the people of Ohio as their research, education, and outreach facility on Lake Erie. Established in 1895, Stone Laboratory is the oldest freshwater biological field station in the country and the center of Ohio State University's teaching and research on Lake Erie. Annually, the Lab serves as the base for more than 65 researchers from over a dozen agencies and academic institutions, all working to explore the origins and solutions for Great Lakes challenges. Currently, the research facilities and the grounds are undergoing extensive renovations in order to continue providing advanced, cutting-edge research opportunities and to incorporate green infrastructure (e.g. solar panels and solar thermal heating) to minimize its ecological footprint.

Stone Laboratory's place-based educational programming is intended to address the needs of the following audiences: students in grades 4-12, college undergraduate and graduate students, K-12 teachers, research scientists, decision-makers and elected officials, technical staff in state and federal agencies, and the general public.

Stone Laboratory strives to:

- Improve the quality of science education in Ohio by creating high-quality, hands-on science education opportunities for students in grades 4-12 and adults;
- Provide undergraduate and graduate research training;
- Create special educational opportunities for teachers;
- Forge strong community partnerships that help enhance and sustain the local coastal economy;
- Help decision-makers and elected officials make more informed decisions through education and training programs; and
- Encourage and support research on critical issues and problems facing Lake Erie, the Great Lakes, and the environment, to foster more informed management decisions.

Additionally, Ohio Sea Grant and Stone Laboratory entered into an exciting collaboration with the Ohio Department of Natural Resources to offer outreach programming at the historic Put-In-Bay Hatchery and Aquatic Visitors Center on South Bass Island. Debuted in 2009, this interactive education facility is a unique addition to Ohio Sea Grant outreach and education and attracts more than 13,000 people annually.

Center for Lake Erie Research (CLEAR)

Ohio State University created CLEAR in 1970 after the burning of the Cuyahoga River to focus the expertise of Ohio State's faculty on Lake Erie problems and issues. CLEAR is part of the Ohio Sea Grant College Program. Ohio Sea Grant, CLEAR, and Stone Lab led and served as the base for much of the research and outreach that brought about the rebirth of Lake Erie in the 1970s and 80s and moved the Lake from its "dead lake" image to the "Walleye Capital of the World."

Great Lakes Aquatic Ecosystem Research Consortium (GLAERC)

Ohio Sea Grant formed GLAERC in 1992 to bring together aquatic scientists from 12 colleges and universities across Ohio, including Bowling Green State University, Case Western Reserve University, Cleveland State University, Heidelberg College, John Carroll University, Kent State University, Miami University, Mount Union College, Ohio State University, Ohio University, University of Toledo, and Wright State University. The mission of GLAERC is to enhance collaboration, cooperation, and communication, and to aid in sharing of equipment and facilities. This collaborative approach makes Ohio's top scientists more effective and competitive for federal funding, improving their ability to address the critical issues and problems affecting Ohio's surface waters. Stone Laboratory serves as the Consortium's shared research facility.

OHIO SEA GRANT VISION AND MISSION

The mission of the Ohio Sea Grant College Program is to increase the public's understanding and improve development and conservation of our Great Lakes and ocean resources, with particular emphasis on Lake Erie. Within this mission, the program has several overarching goals:

- Promote sustainable economic development on the Lake Erie coast and watershed by applying scientific knowledge to solve resource problems;
- Develop the critical knowledge and technology to help coastal industries in Ohio as they work to enhance their bottom line;
- Identify, protect, and conserve valuable coastal habitats and strive to improve environmental conditions in the Lake Erie and Great Lakes ecosystems;
- Enable coastal and Great Lakes communities to successfully adapt to changing climate, social, and economic conditions; and
- Improve the quality of marine and aquatic education in Ohio to foster a more informed citizenry with a higher quality of life.

OHIO SEA GRANT COLLEGE PROGRAM RELATIONSHIPS AND REPORTING STRUCTURE

Dr. Jeffrey M. Reutter is Director of the Ohio Sea Grant College Program at The Ohio State University which includes Stone Laboratory, the Center for Lake Erie Area Research (CLEAR), and the Great Lakes Aquatic Ecosystem Research Consortium (GLAERC). Dr. Reutter reports to two vice presidents at OSU: Dr. Caroline Whitacre, Vice President for Research, and Dr. Bruce McPheron, Vice President for Agricultural Administration. Stone Laboratory is the shared research facility for GLAERC and the base for many of Ohio Sea Grant's research, education, and outreach programs.

PLANNING PROCESS AND STRATEGIC APPROACH

Alignment with the National Sea Grant College Program Strategic Plan

A majority of the 2014 – 2018 Ohio Sea Grant Strategic Plan contains wording consistent with the national plan in an effort to instill a national focus to the Sea Grant College Program. All modifications of the national plan were done in an effort to align the plan with Lake Erie coastal and watershed issues, as well as the needs and requests of Ohio Sea Grant's constituents.

Self-Evaluation Activities and Strategies to Receive External Input

In addition to focusing on priorities and actions for the future, Ohio Sea Grant has a regular planning process that includes a number of self-evaluation activities designed to improve the operation and effectiveness of the program. These activities include:

- Meetings with external Sea Grant Extension Advisory Committees, the Friends of Stone Laboratory, and the Ohio State University Vice Presidents for Research and Agriculture (and their administrative staffs) to review efforts and priorities;
- One-on-one meetings between the director and each staff member to discuss his or her position and ideas; and
- Quarterly/monthly meetings of the Sea Grant Administration, Extension and Communication staff.

These activities provide dedicated time to reflect on the past, plan for the future, and modify goals. As a result, this strategic plan reflects an ongoing planning and self-reflection process and is a living document that is reviewed and modified throughout the year as needs and opportunities change. This is essential for Ohio Sea Grant to remain a program of action addressing emerging issues, challenges, and opportunities, as well as allowing the program to respond to constituency needs based on an ever-changing economic and ecological environment.

FOCUS AREAS AND STRATEGIC PLAN STRUCTURE

To help the nation understand, manage and use its coastal resources wisely, NOAA Sea Grant identified four focus areas central to what the Sea Grant College Program does. The focus areas are:

1. Healthy Coastal Ecosystems
2. Sustainable Fisheries and Aquaculture
3. Resilient Communities and Economies
4. Environmental Literacy and Workforce Development

These focus areas evolved from the NOAA Sea Grant College Program's 2009-2013 Strategic Plan and reflect America's most urgent needs along our coasts, as well as NOAA goals and Sea Grant's strengths and core values. The focus areas also reflect the integration of Sea Grant's research and engagement programs. These functional areas provide the foundation for implementing a successful four-year plan, and Ohio Sea Grant has adopted these focus areas due to their relevancy and importance to its constituents.

Each focus area has goals, outcomes and performance measures. The goals describe the desired long-term direction for each focus area. The outcomes are benchmarks from which Ohio Sea Grant can track progress toward achieving each goal. Performance measures are quantitative ways of measuring outcomes with targets.

Outcomes are commonly categorized as short-, medium-, and long-term. In this plan, learning, action, and consequence outcomes are synonymous to short-, medium-, and long-term outcomes and have been chosen to more easily identify the transition across outcome categories. For example, progress toward a goal starts with an achievable and measurable learning outcome and is followed by a series of "what happens next" questions until the goal is met (action and consequence). Using this approach, it is easier to demonstrate in a linear process how goals are achieved.

- Learning (short-term) outcomes lead to increased awareness, knowledge, skills, changes in attitudes, opinions, aspirations or motivations through research and/or constituent engagement.
- Action (medium-term) outcomes lead to behavior change, social action, adoption of information, changes in practices, improved decision-making or changes in policies.
- Consequence (long-term) outcomes are long-term, and in most cases, require focused efforts over multiple strategic planning cycles. Consequence outcomes in a four-year strategic plan serve as reference points toward reaching focus area goals between the current and future strategic plans.

There are two types of performance measures identified in this plan. Performance measures that are most closely linked to a single focus area are listed at the end of each focus area section. Cross-cutting performance measures - broad measures of progress toward goals for all focus areas - are listed following the Education and Workforce Development Focus area.

Collectively, the four focus areas include 11 goals, 93 outcomes and 13 performance measures. This plan directly aligns to NOAA's goals and objectives as articulated in NOAA's Next Generation Strategic Plan: climate adaptation and mitigation, weather-ready nation, healthy oceans, and resilient coastal communities and economies. The 2014-2018 Ohio Sea Grant Strategic Plan capitalizes on the program's unique capacities and strengths and provides the program with the flexibility and creativity required to adapt to emerging needs.

Focus Area: Healthy Coastal Ecosystems (HCE)

Lake Erie offers countless coastal resources to the 12 million residents within its watershed and the millions of visitors who spend more than \$11 billion in local businesses each year. Therefore, protecting the health of the coastal ecosystem is of utmost concern, from cultural, environmental, and economic viewpoints. As one of the world's most productive freshwater fisheries, Lake Erie must maintain a healthy and consistent aquatic food web to ensure economic vitality for coastal communities, many of which support businesses and jobs that rely on the fishery industry. Beyond sport fish, the lake provides crucial habitat to a myriad of living creatures; the Lake Erie coastline is a major pathway on the migratory bird route and provides shelter for a variety of reptiles, amphibians, and mammals. Furthermore, the beauty of the shoreline has enticed many residents and businesses; nearly 11 million people depend on Lake Erie for drinking water alone. Therefore, a healthy coastal ecosystem provides the foundation for life both within and surrounding Lake Erie.

However, Lake Erie faces a number of threats to coastal health, which Ohio Sea Grant and its partners are working to address. Ohio Sea Grant has identified the following key challenges to coastal health: sedimentation and dredging, nutrient loading and phosphorus, harmful algal blooms, the Dead Zone, aquatic invasive species, climate change, toxic substance and pharmaceutical pollution, and coastal community and economic development (See Appendix A for details on each challenge). Although these issues jeopardize coastal health and functioning, the Ohio Sea Grant network has experience restoring vital coastal resources. The network was instrumental in identifying eutrophication as the cause of poor ecosystem health in the 1960s and 1970s. This research was conducted by experts still in the network today and has since led to modified policy, a change in public behavior, and the restoration of shoreline health. Based on this experience and a wealth of new knowledge, Ohio Sea Grant is well positioned to address current threats.

The Ohio Sea Grant network prioritizes regional approaches and understands the need to be both a leader *and* a partner in overcoming observed and emerging threats to coastal ecosystem health. Therefore, Ohio Sea Grant's continuing goal is to understand how changes on land impact coastal and water resources. To do this, it is essential for Ohio Sea Grant and its partners to educate the public and decision-makers about ecosystem-based management – an integrated approach to management that considers the entire ecosystem, including humans, and the cumulative impacts of different sectors¹. By implementing this management strategy across the Great Lakes, Ohio Sea Grant can better protect the health of this vital coastal ecosystem.

¹ NOAA National Sea Grant College Program 2014 – 2017 Strategic Plan

1. **Goal: Lake Erie and Great Lakes ecosystem services are improved by enhanced health, diversity and abundance of the Lake Erie's fish, wildlife and plants.**

Strategy

Ohio Sea Grant intends to support research, education, and outreach focused on habitat protection and restoration. It will do this by encouraging a reduction of nutrient loading from the watershed, increased sustainable land-use planning, and lake-wide monitoring efforts used to evaluate and improve the Lake Erie ecosystem, its fisheries, and water regulations. Ohio Sea Grant will also continue to support promising research focused on ecosystem health. Additionally, the program will facilitate research, education, and outreach on emerging issues that may threaten Lake Erie ecosystem services.

Learning Outcomes

- 1.1. Develop and calibrate new standards, measures, and indicators of Great Lakes coastal and ecosystem health and sustainability.
- 1.2. Identify critical uncertainties that impede progress toward achieving sustainability of Great Lakes' ecosystems and the goods and services they provide.

Action Outcomes

- 1.3. Resource managers, policy-, and decision-makers use standards and indicators to support Great Lakes and Lake Erie watershed ecosystem-based management.

Consequence Outcomes

- 1.4. Dynamic ecological systems continue to provide a wide range of ecological, economic and societal services for the Lake Erie coast and watershed, and are more resilient to change.
- 1.5. Greater public stewardship leads to participatory decision-making and collaborative ecosystem-based management decisions.

2. **Goal: Ecosystem-based approaches are used to manage Lake Erie's land, water and living resources.**

Strategy

Ohio Sea Grant will continue supporting research, education and outreach programs geared toward the agricultural community throughout the Lake Erie watershed in an effort to change behavior and thereby reduce nutrient and sediment loading to Lake Erie. Ohio Sea Grant will also continue targeting special programs for other nutrient sources including CSOs, failing septic tanks, water treatment plants, and lawn fertilizer. The program has renovated its research facilities at Stone Lab and entered into partnerships with Ohio EPA and the Lake Erie Charter Boat Association to allow it to monitor nutrient levels, toxin levels, and algal concentrations in order to evaluate the effectiveness of its ecosystem based management efforts.

Using its education expertise, the program will provide the information and training necessary to implement ecosystem-based management. Through its outreach program Ohio Sea Grant will continue to alert Ohio communities of any improved practices, resources, or policies regarding watershed-based management approaches. The program will provide information and resources through the Ohio Sea Grant website, social media outlets, and the formal and informal education opportunities at Stone Laboratory, the Aquatic Visitors Center, and throughout the Ohio Sea Grant network. Ohio Sea Grant will continue facilitating workshops, consultations, and field trips that bring together residents, resource managers, businesses, and industries, educating these sectors on the most up-to-date information regarding ecosystem-based management.

Learning Outcomes

- 2.1. Farmers learn best management practices to reduce nutrient runoff and erosion.
- 2.2. Coastal communities learn their roles in both causing and preventing harmful algal blooms.
- 2.3. Stakeholders have access to data, models, policy information and training that support Great Lakes ecosystem-based planning, decision-making and management approaches.
- 2.4. Baseline data, standards, methodologies and indicators are developed to assess the health of Lake Erie ecosystems and watersheds.
- 2.5. Residents, resource managers, businesses and industries understand the effects of human activities and environmental changes on Lake Erie fisheries, water quality, and Great Lakes' coastal resources.
- 2.6. Resource managers have an understanding of the policies that apply to coastal protected species, such as the Lake Erie water snake.

Action Outcomes

- 2.7. Methodologies are developed and used to evaluate a range of practical ecosystem-based management approaches for planning and are adaptable to future management needs.
- 2.8. Resource managers apply ecosystem-based management principles when making decisions about Lake Erie and its watershed.
- 2.9. Resource managers incorporate laws and policies to facilitate and implement ecosystem-based management throughout Lake Erie and its watershed.
- 2.10. Residents, resource managers, and businesses integrate social, natural, and physical science when managing resources and work with all sectors in the decision-making process.

Consequence Outcomes

- 2.11. Land, water, and living resources are managed using ecosystem-based approaches.
- 2.12. Based on Ohio Sea Grant research and monitoring efforts, managers are able to use adaptive management to modify ecosystem-based management approaches to reach desired outcomes.

3. Goal: Lake Erie and Great Lakes ecosystems and their habitats are protected², enhanced, or restored.

Strategy

Ohio Sea Grant intends to engage residents, resource managers, and businesses through informal education opportunities, public presentations, workshops, trainings, and web-based media, to share why Lake Erie is important and what they can do to enhance their coast. It will continue to expand the Clean Marinas and Clean Boaters programs, and the program will support sustainable coastal community and economic development in order to define, build value, protect and highlight non-degraded systems. Ohio Sea Grant will also help residents, resource managers, and businesses understand emerging threats to help Ohio communities remain aware and prepared. Additionally, the program will continue wetlands restoration programs, develop collaborations with groups involved in restoration and conservation, and support research proposals seeking to restore or enhance coastal ecosystems.

Learning Outcomes

- 3.1. Residents, resource managers and businesses understand the importance of the benefits provided by preserving non-degraded ecosystems throughout the Great Lakes.
- 3.2. Residents, resource managers and businesses understand the threats to Lake Erie and the consequences of degraded ecosystems.
- 3.3. Scientists develop technologies and approaches to restore degraded ecosystems within the Lake Erie watershed.

Action Outcomes

- 3.4. Decision-makers, resource managers, and businesses set realistic and prioritized goals to protect, enhance and restore habitats throughout the Lake Erie watershed by incorporating scientific information and public input.
- 3.5. Resource managers, businesses, and residents adopt innovative approaches and technologies to maintain or improve the function of ecosystems throughout the Lake Erie watershed.

Consequence Outcomes

- 3.6. Great Lakes habitats are protected, enhanced, or restored.
- 3.7. Degraded ecosystem function and productivity are restored throughout the Lake Erie watershed and the Great Lakes.

Healthy Coastal Ecosystems Performance Measures

1. By 2018, 200 Ohio Sea Grant tools, technologies, and information services will have been used by our partners/customers to improve ecosystem-based management.
2. By 2018, 12 ecosystem-based approaches will be used to manage land, water, and living resources in coastal areas as a result of Ohio Sea Grant activities.

² In the context of this goal, protected areas are those places in some form of conservation management program.

3. By 2018, 40 acres of coastal habitat will be protected, enhanced, or restored as a result of Ohio Sea Grant activities.

Focus Area: Sustainable Fisheries and Aquaculture (SFA) ³

Lake Erie's fishery is part of the economic and cultural identity of many coastal communities. The Lake Erie sport fishery is known for its extensive smallmouth bass, steelhead, yellow perch, and walleye populations and the commercial fishery is the most valuable freshwater commercial fishery in the world. Furthermore, Lake Erie often produces more fish for human consumption than the other four Great Lakes combined, explaining why the Ohio portion of the Lake hosts more than 40% of Great Lakes' charter boats and supports one of the world's largest charter boat industries.

Although valuable, the Lake Erie fishery is finite. In the past few decades, an uptick in the number of threats that could jeopardize a sustainable fishery has caught the attention of the public and media and underscored the need to remain vigilant on protecting fishery and ecosystem resources. Specifically, aquatic invasive species like the zebra/quagga mussels and round goby have altered food web dynamics in the lake. Asian carps (Bighead and silver) have the potential to disrupt the system further if they establish in Lake Erie, compromising sport-fish populations and changing the entire fish community composition. These impending threats may lead to catastrophic consequences, which is why focused research, management, and public awareness are essential to protect this freshwater community.

It is imperative to strike a balance between demand and sustainability of the fishery. Ohio Sea Grant recognizes the need to understand how changes in the ecosystem impact these resources and to identify how to help the fishing industry and public understand these impacts. Understanding the genetic makeup of the fishery has been the focus of recent years, leading to a better understanding of spawning rituals and prioritized habitats. By supporting ongoing research, educating the public, and maintaining open communication with the fishing community, Ohio Sea Grant works toward a more sustainable future for fisheries in Lake Erie.

4. Goal: A safe, secure, and sustainable Lake Erie fishery to meet public demand.

Strategies

Ohio Sea Grant will continue to provide up-to-date information to fishery managers, anglers, and the public regarding changes in policy and regulations, new research findings, and responsible fishing

³ Ohio Sea Grant uses a working definition of "fishery sustainability" that is based on the NOAA Fishwatch concept. Sustainability involves "meeting today's needs without compromising the ability of future generations to meet their needs. In terms of fish, this means catching or farming fish responsibly, with consideration for the long-term health of the environment and the livelihoods of the people who depend upon the environment."

techniques and tools through presentations, training workshops, and informal and formal education opportunities at Stone Laboratory, the Aquatic Visitors Center, and throughout the Ohio Sea Grant network. Ohio Sea Grant will continue the annual Ohio Charter Captain's Conference, a source of information and updates on good fishery management for more than 30 years, which has a proven track record of increasing attendee profits and economic resiliency. Additionally, the program will support research focused on wild fish population studies, the food web, sustainable fishing techniques, innovations in aquaculture, and the economic impact of the Ohio charter fishing industry.

Learning Outcomes

- 4.1. Fishery managers and fishermen understand the dynamics and drivers of wild fish populations.
- 4.2. The charter boat and fishery industries⁴ are knowledgeable about innovative technologies, approaches and policies.
- 4.3. Lake Erie commercial and recreational fishers are knowledgeable about efficient and responsible fishing techniques and fishery sustainability.
- 4.4. Lake Erie commercial and recreational fishers are knowledgeable about fishing regulations and why they are important.
- 4.5. The fishery industry is knowledgeable about best practices to minimize aquatic invasive species.
- 4.6. Ohio consumers have an increased knowledge of the nutritional benefits and risks of local fish species, how to judge fish safety and quality, and appropriate fish preparation techniques.
- 4.7. The charter boat industry is aware of innovative and required business opportunities, fishing, and marketing strategies.

Action Outcomes

- 4.8. Lake Erie fishers employ efficient fishing techniques.
- 4.9. Lake Erie fishers apply techniques to reduce negative impacts on depleted, threatened or endangered species.
- 4.10. Recreational fishers fish sustainably.
- 4.11. The Lake Erie fishery sector adopts techniques and approaches to minimize its environmental impact.
- 4.12. Lake Erie watershed resource managers establish policies and regulations that achieve a better balance between economic benefit and conservation goals.
- 4.13. Natural and human threats to the long-term viability of Lake Erie's fish populations are minimized.

Consequence Outcomes

- 4.14. The seafood⁵ supply from Ohio waters is sustainable and safe.
- 4.15. There is an expansion of the sustainable Ohio fishing and aquaculture industries.

⁴ The seafood industry includes all sectors of the industry, including aquaculturists, commercial fishermen, haulers, bait dealers, retailers and supporting businesses.

⁵ Seafood includes product originating from all sectors of the fishing and aquaculture industries in Ohio waters.

5. **Goal: Informed consumers who understand the health benefits of fish consumption and how to evaluate the safety and sustainability of the fish they buy and catch.**

Ohio Sea Grant will continue to provide up-to-date information to the public regarding safe and sustainable seafood consumption through presentations, training workshops, and informal and formal education opportunities at Stone Laboratory, the Aquatic Visitors Center, and throughout the Ohio Sea Grant network. The program will also support research focused on determining contaminant levels in Lake Erie-based seafood.

Learning Outcomes

- 5.1. The Lake Erie fishery industry is aware of the standards for safe seafood.
- 5.2. Ohio seafood consumers have the knowledge to evaluate sustainable seafood choices.
- 5.3. Ohio seafood consumers have an increased knowledge of the nutritional benefits of seafood products and know how to judge seafood safety and quality.

Action Outcomes

- 5.4. Recreational fishers follow advice in consumption advisories and minimize contaminant uptake.

Consequence Outcomes

- 5.5. Consumers avoid excessive contaminant uptake.

Sustainable Fisheries and Aquaculture Performance Measures

4. By 2018, 300 fishers, seafood processors, and aquaculture industry personnel will have modified their practices using knowledge gained in fisheries sustainability and seafood safety as a result of Ohio Sea Grant activities.
5. By 2018, 100 seafood consumers will modify their practices using knowledge gained in fisheries sustainability, seafood safety, and health benefits of seafood as a result of Ohio Sea Grant activities.

Focus Area: Resilient Communities and Economies (RCE) ⁶

The coastline provides countless economic, social, and recreational opportunities for millions of Lake Erie residents and visitors. Tourism alone accounts for more than \$11 billion in revenue for the eight Ohio coastal counties. Sport fishing supports nearly 23,000 Ohio jobs and provides \$1 billion to the coastal economy⁷. In addition, 41% of Ohio's population lives in the Lake Erie basin. This concentration of residents and visitors puts additional strain on already finite coastal resources and leaves the population and its economic stability

⁶ Resilience is determined by the degree to which a community is capable of organizing itself to increase its capacity for learning from past economic, natural or technological disasters.

⁷ The Ohio Environmental Council, 2009: http://www.theoec.org/pdfs/factsheets/ohiowater_factsheet_9-09.pdf

vulnerable to natural hazards, such as climate change, flooding, erosion, and harmful algal blooms. To accommodate more people and activity while balancing demands on coastal resources, Ohio Sea Grant must support the development of innovative policies, institutional capacities, and management approaches to increase community resilience and coastal sustainability⁸.

Furthermore, Lake Erie is the southernmost, shallowest, and warmest of the Great Lakes. Due to the lake's physical characteristics, impacts of emerging issues often appear here first and with greater intensity. Lake Erie's watershed is also the most populated of the Great Lakes, meaning not only is there a greater dependency on the lake for local communities and economies, but increased media exposure and public awareness when things go wrong. Its watershed is also the least forested and the most urbanized and agricultural, increasing the chances of human-related impacts. Although this creates a greater demand for Ohio Sea Grant research, education, and outreach, the increased saliency creates additional opportunities to engage stakeholders in discussions about Lake Erie, its value, and stewardship.

It is Ohio Sea Grant's priority to change public behavior while maximizing economic benefits and minimizing losses, especially in the face of emerging coastal threats. Ohio Sea Grant recognizes the need to continue its work with the fisheries and birding communities, tourism, and other economic sectors to increase business resiliency, and increase awareness of and preparedness for impending hazards. Additionally, the program must maintain efforts to increase access to the coastline, support current coastal industries, and encourage sustainable coastal development. By increasing awareness and providing hazard preparedness training, as well as building resiliency and value of ecosystem-dependent businesses and communities, Ohio Sea Grant can help the coastal community function within the limits of the ecosystem.

6. Goal: Development of vibrant and resilient Lake Erie coastal economies.

Strategy

To strengthen Lake Erie-based economies, Ohio Sea Grant will continue supporting the sustainable use of coastal resources and educate elected officials, community leaders, and the public on why this is important and how to gain value from such efforts. The program will continue developing an aquatic invasive species rapid response plan and other hazard trainings. Also, to educate the public on Lake Erie's economic value, Ohio Sea Grant will continue to partner with the tourism sector, produce webinars, informational sessions, and factsheets that discuss sustainable tourism issues, and support economic valuation of coastal resources through social science research. Through partnerships with other state and federal agencies, Ohio Sea Grant will continue building upon the successes of the Ohio Coastal Training program to reach decision-makers. The program will also continue to use its unique array of education and outreach programs, such as Stone Laboratory and Aquatic Visitors Center tours and workshops, Clean Marinas and Clean Boater programs, resource-based tourism product development activities, elected officials trainings, Ohio Sea Grant Extension network presentations, and informal education opportunities

⁸ NOAA National Sea Grant College Program 2014 – 2017 Strategic Plan

to make communities aware of the balance between the health of the economy and the health of Lake Erie's natural and cultural systems.

Learning Outcomes

- 6.1. Ohio communities⁹ are aware of the interdependence between the health of the economy and the health of Great Lakes natural and cultural systems.
- 6.2. Ohio communities have access to information needed to understand the value of waterfront and tourism-related economic activities.
- 6.3. Ohio communities understand the strengths and weaknesses of alternative development scenarios on resource consumption and local economies.
- 6.4. Ohio communities are aware of regulatory regimes affecting economic sustainability.
- 6.5. Ohio communities are knowledgeable about economic costs and benefits from energy planning and conservation.

Action Outcomes

- 6.6. Ohio citizens are actively engaged in management and regulatory decisions concerning Lake Erie and the surrounding watershed.
- 6.7. Ohio communities engage in economic development initiatives that capitalize on the value of their natural and cultural resources while balancing Lake Erie watershed resource conservation and economic growth.

Consequence Outcomes

- 6.8. Great Lakes communities have diverse, healthy economies and industries without displacing traditional working waterfronts¹⁰.

7. Goal: Communities use comprehensive planning to make informed strategic decisions.

Strategy

Ohio Sea Grant will support sustainable community development by providing unbiased, science-based resources and expertise to local businesses, decision-makers and the public, highlighting the methods and benefits of effective planning. Ohio Sea Grant will continue to offer leadership training for elected and appointed officials and emerging community leaders, which includes sessions about community planning and sustainable development, and the program will maintain relationships and open communication with land-use planners along the coast. Additionally, the program will educate coastal communities about hazard rapid response plans. Ohio Sea Grant will also identify barriers to sustainable development and determine key issues facing policymakers to guide future work in this area.

⁹ Communities are defined broadly to include governments, businesses, residents, visitors and non-governmental organizations.

¹⁰ Working waterfront is a term broadly used in this plan to include water-dependent and water-related industries, such as energy production, tourism, ports and harbors, marine transportation, shipyards, marinas, commercial fishing, recreational fishing, aquaculture, fishing piers and public access.

Learning Outcomes

- 7.1. Ohio coastal communities understand the connection between planning and natural resource management issues and make management decisions that minimize conflicts, improve resource conservation efforts and identify potential opportunities.

Action Outcomes

- 7.2. Ohio communities make use of tools and information to explore the different patterns of coastal development, including community visioning exercises, resource inventories and coastal planning.
- 7.3. Ohio communities adopt and implement coastal plans that include sustainable development principles.
- 7.4. The public, leaders and businesses within the Lake Erie watershed work together to implement plans for the future that include sustainable development principles and to balance multiple uses of coastal areas.

Consequence Outcomes

- 7.5. Quality of life in Great Lakes communities, as measured by economic and social well-being, improves without adversely affecting environmental conditions.

8. Goal: Improvements in Lake Erie and Great Lakes coastal water resources sustain human health and ecosystem services.

Strategy

Ohio Sea Grant intends to support research exploring the human impact on and value of Lake Erie water resources. Using a variety of outlets, such as the program's magazine, *Twine Line*, web-based media, and presentations, Ohio Sea Grant will share results with Lake Erie stakeholders. Stone Laboratory, the Aquatic Visitors Center, and the Ohio Sea Grant Extension Network will disseminate the most up-to-date information about water laws, policies, and research findings, and explore and communicate how community actions can improve or hinder water resource quality and quantity. The program intends to expand the Clean Marinas and Clean Boater programs as well as enhance the reach and visibility of extension educators to provide resources to a wider audience, all in an effort to spread the value of Lake Erie stewardship. By communicating the value of water to the Lake Erie public, Ohio Sea Grant hopes to encourage sustainable practices with water resources and improvements in ecosystem services.

Learning Outcomes

- 8.1. Ohio communities are aware of the impact of human activities on water quality and supply.
- 8.2. Ohio communities understand the value of clean water, adequate supplies and healthy watersheds.
- 8.3. Ohio communities within the Lake Erie watershed understand water laws and policies affecting the use and allocation of water resources.

Action Outcomes

- 8.4. Ohio communities engage in planning efforts to protect water supplies and improve water quality.
- 8.5. Ohio communities adopt mitigation measures, best management practices and improved site designs in local policies, ordinances, and other measures to address water supplies and water quality.

Consequence Outcomes

- 8.6. Lake Erie and Great Lakes water supplies are sustained.
- 8.7. Lake Erie and Great Lakes water quality improves.

9. **Goal: Resilient Lake Erie and Great Lakes coastal communities adapt to the impacts of hazards and climate change.**

Strategy

Ohio Sea Grant intends to inform the public about adaptation strategies and best management practices for impending threats through research, education, and outreach. Through developing printed material, presentations, formal and informal education at Stone Laboratory and the Aquatic Visitors Center, sector-specific training sessions and conferences, and cutting-edge use of technology, Ohio Sea Grant will integrate communication techniques to deliver these messages to the widest audience possible, while still being able to tailor messages for specific user groups. Ohio Sea Grant will also continue developing rapid response plans in conjunction with local, state, and federal partners, and it will support research exploring the potential impacts of emerging threats and climate change.

Learning Outcomes

- 9.1. Great Lakes residents and decision-makers are aware of and understand the processes that produce climate change and other hazards and the implications of those processes for them and their communities.
- 9.2. Great Lakes decision-makers are aware of existing and available hazard- and climate-related data and resources and have access to information and skills to assess local risk vulnerability.
- 9.3. Great Lakes communities have access to data and innovative and adaptive tools and techniques to minimize the potential negative impact from hazards.
- 9.4. Ohio and Great Lakes decision-makers understand the legal and regulatory regimes affecting adaptation to climate change and other impending hazards, like harmful algal blooms or aquatic invasive species.

Action Outcomes

- 9.5. Ohio communities apply best-available hazards and climate change information, tools, and technologies in the planning process.
- 9.6. Great Lakes decision-makers apply data, guidance, policies, and regulations to hazard planning and recovery efforts.

- 9.7. Ohio communities develop and adopt comprehensive hazard mitigation and adaptation strategies suited to local needs.
- 9.8. Ohio residents take action to reduce the impact of coastal hazards on their life and property.
- 9.9. Ohio communities adopt a comprehensive risk communications strategy for hazardous events.

Consequence Outcomes

- 9.10. Great Lakes communities effectively prepare for hazardous events and climate change.
- 9.11. Great Lakes communities are resilient and experience minimum disruption to life and their economies following hazard events.

Resilient Communities and Economies Performance Measures

6. By 2018, 12 communities will have implemented sustainable economic and environmental development practices and policies (e.g., land-use planning, working waterfronts, energy efficiency, business retention and expansion, climate change planning, smart growth measures, green infrastructure) as a result of Ohio Sea Grant activities.
7. By 2018, 80 communities will have implemented hazard resiliency practices to prepare for, respond to or minimize coastal hazardous events as a result of Sea Grant activities.

Focus Area: Environmental Literacy and Workforce Development (ELWD)

An engaged, environmentally literate public is the most effective tool to address the environmental challenges facing the Great Lakes. Furthermore, a workforce skilled in science, technology, engineering, math (the STEM disciplines), and communication is a powerful weapon in the innovation needed to preserve vital coastal resources and to combat future coastal hazards. Overall, a skilled and engaged citizenry can more effectively develop the tools, technologies, and strategies necessary to protect and enhance the Great Lakes.

Ohio Sea Grant prides itself in its efforts toward guiding an environmentally literate public. The program works closely with state agencies and local non-governmental organizations, such as the Department of Natural Resources Division of Wildlife and The Nature Conservancy, to offer formal¹¹ and informal training to the public. Ohio Sea Grant Extension Educators organize a variety of conferences and training sessions to keep the coastal workforce up-to-date on the newest strategies, technologies, and policies in their sectors. Also, Ohio Sea Grant's Stone Laboratory research facility and the Aquatic Visitors Center provide informal and formal education to more than 13,000 visitors annually, ranging in age from elementary to adult learners. Stone Laboratory organizes and facilitates field trips, workshops, conferences, and lecture series that allow EPA managers to work side-by-side with water treatment operators, and high schoolers to learn next to decision-makers. Furthermore, a portion of the Stone Laboratory summer curriculum is devoted to educators, giving them the skills and tools necessary to further public environmental literacy. By organizing collaborative,

¹¹ Formal is defined as training or education that is done for a credit or certification

focused educational and training opportunities, Ohio Sea Grant sets the stage for the creativity and passion needed to defend Lake Erie's coastal health.

Ohio Sea Grant and its partners (The Ohio Lake Erie Commission, the Ohio Department of Natural Resources (ODNR) Office of Coastal Management, and ODNR Division of Wildlife - Old Woman Creek National Estuarine Research Reserve) were the first on the Great Lakes to develop literacy principles tailored to regional education standards and information needs. Linked to the NOAA Ocean Literacy Principles, the Lake Erie Literacy Principles will be used to continue to support lifelong learning. Place-based educational venues, such as museums, nature centers, and aquaria, reach thousands of residents and visitors each year. Through the use of the Literacy Principles, accurate and important messages about Lake Erie will be linked to formal education messaging and instruction, creating a path of learning beyond the classroom.

Ohio Sea Grant recognizes the need to continue providing education and skills training to the Lake Erie coastal community to develop workforce capacity and promote superior resource management. By expanding formal and informal education both within and beyond traditional classrooms, Ohio Sea Grant will continue to encourage active Great Lakes stewardship.

10. Goal: An environmentally literate public supported and informed by a continuum of lifelong formal and informal engagement opportunities.

Strategy

Ohio Sea Grant intends to continue its pursuit of this goal with the programming, courses, field trips, workshops, tours, and seminars offered at Stone Laboratory, the Aquatic Visitors Center, and throughout the state. Through continued collaboration with informal science education centers, as well as providing formal courses, seminars, and various programs geared toward formal and informal educators, the program's reach will be magnified by training the trainers. Additionally, Ohio Sea Grant will continue encouraging the adoption of Great Lakes literacy principles throughout Great Lakes' classrooms and informal education centers.

Learning Outcomes

- 10.1. Formal and informal educators are knowledgeable of the best available science on the effectiveness of environmental science education.
- 10.2. Formal and informal educators understand Great Lakes environmental literacy principles and they understand how best to apply them in the classroom or informal settings.
- 10.3. Lifelong learners know where to engage in Great Lakes informal science education opportunities focused on coastal topics.
- 10.4. Students from grades 4 to adults participate in Sea Grant courses, field trips, workshops, and conferences and gain information and experiential learning that impacts their attitudes and decisions about coastal, ocean, and Great Lakes issues.

Action Outcomes

- 10.5. Formal and informal educators use Great Lakes environmental literacy principles in their teaching activities.
- 10.6. Formal and informal curricula are developed and refined using the best available research on the effectiveness of environmental and science education.
- 10.7. Formal and informal education programs take advantage of the knowledge of Ohio Sea Grant-supported scientists and engagement professionals.
- 10.8. Formal and informal educators, students and/or the public collect and use Great Lakes coastal weather data in inquiry and evidence-based activities.
- 10.9. Lifelong learners make choices and decisions based on information they learned through informal Great Lakes science education opportunities.
- 10.10. Educators work cooperatively to leverage federal, state and local investments in Great Lakes coastal environmental education.

Consequence Outcomes

- 10.11. Members of the public incorporate broad understandings of their actions on the environment into personal decisions.

11. Goal: A future workforce reflecting the diversity of Ohio Sea Grant programs, skilled in science, technology, engineering, mathematics and other disciplines critical to local, regional and national needs.

Strategy

Ohio Sea Grant intends to continue offering and improving upon science, technology, engineering, and mathematics (STEM) programming at Stone Laboratory and the Aquatic Visitors Center. Stone Laboratory will continue providing formal and informal STEM education opportunities, such as tours, courses, field trips, and workshops, geared toward K – gray (adult) students. The program will also highlight the benefits of STEM skillsets and make students aware of potential career paths involving STEM topics. Additionally, Ohio Sea Grant will provide presentations throughout Ohio on STEM education opportunities offered through the program. Ohio Sea Grant will support STEM curriculum development for educators and continue training educators on Great Lakes-oriented STEM education techniques.

Learning Outcomes

- 11.1. Ohio students and teachers are aware of opportunities to participate in Ohio Sea Grant science, technology, engineering, mathematics and active stewardship programs.

Action Outcomes

- 11.2. A diverse and qualified pool of applicants pursues professional opportunities for career development in natural, physical and social sciences and engineering.
- 11.3. Graduate and undergraduate students are trained in research and engagement methodologies.

- 11.4. Research projects support undergraduate and graduate training in fields related to understanding and managing our coastal resources.
- 11.5. Private sector donations to Ohio Sea Grant and Stone Lab allow students to receive scholarships, fellowships, and employment opportunities from the program.
- 11.6. Volunteers enhance the quality of the program and assist in training participants.

Consequence Outcomes

- 11.7. A diverse workforce trained in science, technology, engineering, mathematics, law, policy or other related fields is employed and has high job satisfaction.

Environmental Literacy and Workforce Development Performance Measures

- 8. By 2018, 50 Ohio Sea Grant facilitated curricula will have been adopted by formal and informal educators.
- 9. By 2018, 160,000 people will have been engaged in Ohio Sea Grant supported informal education programs.
- 10. By 2018, 16 Sea Grant-supported graduates will be employed in a career related to their degree within two years of graduation.
- 11. *State Performance Measure*: 5000 professionals will have received continuing education and/or training from Ohio Sea Grant that helps them keep their jobs or advance professionally in their career.

CROSS-CUTTING PERFORMANCE MEASURES

- 12. Economic (market and non-market; jobs and businesses created or retained) benefits derived from Sea Grant activities.
 - a. By 2018, \$10 million total economic (market and non-market) benefits will be derived from Sea Grant activities. (\$2.5 million per year)
 - b. 1 business will be created annually as a result of Ohio Sea Grant activities.
 - c. 3 businesses will be retained annually as a result of Ohio Sea Grant activities.
 - d. 2 jobs will be created annually as a result of Ohio Sea Grant activities.
 - e. By 2018, 40 jobs will be retained as a result of Ohio Sea Grant activities.
 - f. 0 patents will be derived annually as a result of Sea Grant activities.
 - g. By 2018, 60 peer reviewed publications will result from Ohio Sea Grant work.
- 13. By 2018, 60 peer-reviewed publications will be produced by the Sea Grant network, and TBD citations will accrue for all peer-reviewed publications from the previous four years.

APPENDIX A

Sedimentation and Dredging

When storms rage across the Lake Erie region in the spring and summer months, new sediment is washed from the landscape. Sediment that had previously settled to the bottom of its tributaries is stirred up and flushed downstream to Lake Erie. The Maumee River, in Lake Erie's western basin, contributes more sediment to the lake than Lake Superior receives from all of its tributaries combined. At times the sediment is visible, creating a murky and muddy plume that not only reduces property values by creating a less-than-enticing view, but also creates the perfect incubator for the growth of *Microcystis*—a common species of cyanobacteria that can produce toxins harmful to animals and people. Over time, the build-up of sediment reduces the depth of harbors, making it necessary to dredge and remove the excess sediment to restore safe boat passage. With dredging comes an additional risk of spreading nutrients and other pollutants like mercury and PCBs, which often rest at the bottom of these harbors attached to sediment particles. Communities must carefully assess the risks involved with any dredging project, taking care to properly dispose of contaminated sediment—often in specialized landfills or confined disposal facilities in the lake. However, an even better solution would be to prevent the sediment from leaving agricultural fields or collect it during dredging activities and reuse it on land in beneficial ways.

Nutrient Loading and Phosphorus

Nutrients provide the foundation of Lake Erie's food web. Phosphorus and nitrogen are essential nutrients for algae, which are then eaten by tiny zooplankton. Larval fish feed on zooplankton, and those young fish are often devoured by the bigger fish that people love to catch and/or eat. In Lake Erie, the right balance of nutrients is an essential part of maintaining safe drinking water as well as the lake's role as a world-class fishery. But when the levels of nutrients become too high, there are often consequences. Phosphorus, a key ingredient in many fertilizers, animal waste, and weed killers, finds its way to Lake Erie from many sources, including sewage treatment plants and combined sewage overflows (CSO). When water runs off agricultural fields and treated lawns, it takes phosphorus with it. Most living things need phosphorus to survive, but in Lake Erie, it's possible to have too much of a good thing. Nuisance and harmful algae will grow until their supply of phosphorus runs out (phosphorus is often the limiting nutrient in freshwater—the nutrient that is in the shortest supply), causing the blooms that make Lake Erie look like pea soup and contribute to the Dead Zone.

Harmful Algal Blooms

In Lake Erie, the most common type of harmful algae is the cyanobacteria *Microcystis*, which thrives in the warm, phosphorus-laden water of the western basin and sometimes produces a toxin called microcystin that can cause illness and death to people and animals. Aside from these health effects, harmful algal blooms can also cause taste and odor problems in drinking water, pollute beaches, and reduce oxygen levels for fish and

other animals that live in Lake Erie. Zebra and quagga mussels are also thought to add to the problem by selectively filtering only beneficial algae from the water, leaving behind cyanobacteria and by concentrating nutrients in the nearshore zone. Though the blooms often originate in the Maumee and Sandusky bays in Lake Erie's western basin, currents cause them to drift out to the central basin where they die and sink to the lake bottom. Oxygen near the lake floor is then used up in the decomposition process, resulting in a Dead Zone. Decreasing the amount of phosphorus that enters Lake Erie could go a long way toward reducing the size of these blooms.

The Dead Zone

Lake Erie is the shallowest of the Great Lakes, with an average depth of 24 feet in the western basin, 60 feet in the central basin, and 80 feet in the eastern basin. The water stratifies each summer in May or June, forming a warm top layer and a cold bottom layer with a transitional line between called the thermocline. Since this split generally forms about 50 feet below the surface, the central basin is left with only 10 feet of water below the thermocline where sunlight and the mixing action of wind cannot penetrate to replenish the supply of oxygen. The Dead Zone forms when the oxygen is completely consumed and remains in the central basin until the water mixes again in the fall. Any animals trapped in the area die, sometimes washing onto the Lake Erie shore in large numbers, as in a fish kill. Although there is evidence that areas of low oxygen have existed in Lake Erie for centuries, the problem is exacerbated by the increasing levels of cyanobacteria that form harmful algal blooms. Since animals like zebra and quagga mussels will not eat cyanobacteria, much of it dies and falls to the lake bottom, where it consumes large amounts of oxygen as it is decomposed. Solving the problem of harmful algal blooms may lead to a decrease in the Dead Zone.

Aquatic Invasive Species

More than 185 aquatic invasive species can be found in the Great Lakes, with about 75% of these arriving since the St. Lawrence Seaway opened in 1959, pointing to ballast water in cargo ships as one major cause. As the shallowest, warmest, and biologically most productive of the lakes, Lake Erie is often the most hospitable to these foreign invaders. It's a fact that has undeniably changed its ecosystem in the last 50 years, pushing out native species and circulating toxins like mercury in the environment that otherwise would have settled into the sediment. The first zebra mussel in Lake Erie was found on October 15, 1988, at Stone Laboratory. The population of this filter-feeding, clam-like creature exploded, reaching 30,000 per square meter within a year and causing millions of dollars of damage to water treatment facilities all along the Lake Erie shore. More recently, round gobies have entered the landscape, competing with bottom-dwelling native fish and creating a new path for contaminants like mercury and PCBs to be passed up the food web and into the fish humans like to eat. At this moment, two species of Asian carp are threatening the Great Lakes with new invasions from the Chicago area. Only improved management programs and public education will keep additional species from reaching the Great Lakes in the future.

Climate Change

The details may still be debated but most scientists agree: climate change is occurring, and human activity has contributed to the problem. As the earth's atmosphere continues to warm, many of the above problems will worsen. Storms will intensify and become more frequent, increasing the amount of sediment and nutrients in Lake Erie. These additional nutrients, as well as warmer water temperatures, will benefit harmful algal blooms and exacerbate the Dead Zone. Milder winters could usher in new invasive species that may not have survived in colder temperatures, and native species populations may decrease without benefit of ice cover. In its research, education, and outreach efforts, Ohio Sea Grant is working to better understand these critical issues and developing strategies to improve the forecast for Lake Erie for future generations.

Coastal Community and Economic Development

A key element of Ohio Sea Grant's past success has always been its focus on coastal community and economic development efforts. A strong local economy built upon a healthy ecosystem will value stewardship of its natural world. In addition, a weaker economy diverts funding away from ecological projects when attention is focused on emergency needs. Diversifying local community economies becomes a way to protect tax revenues and personal income during downturns in particular niche markets, and it can build awareness and increased protection of local resources if new diversifications are based on the resources themselves. Ohio Sea Grant will continue to emphasize projects that foster economic development, solve societal problems, enhance the value of Lake Erie to the state and region, and address important societal issues.

Toxic Substances and Pharmaceutical Pollution

Pharmaceuticals and toxin pollution in the region's waterways pose a serious threat to the Lake Erie foodweb and public. Prescription and over-the-counter drugs enter waterways when medicines are disposed of incorrectly or excreted after use and introduced to surface waters through effluent from treatment plants, septic systems, industrial discharges, and commercial animal feeding operations.¹² Once in the environment, pharmaceuticals normally have no immediate impact. However, long-term exposure can disrupt organ and body systems, like reproductive organs, in wildlife and humans. Toxins have a more immediate impact on wildlife and human welfare, explaining why many were banned in the 1970s. Regardless, Lake Erie had been a dumping ground for centuries and restoration efforts have not eradicated toxin pollution. Ohio Sea Grant is working to better understand short- and long-term effects of these pollutants on wildlife and human health and what can be done to prevent future exposure.

¹² "Protecting the Great Lakes from Pharmaceutical Pollution." Alliance for the Great Lakes. 2010. <http://www.greatlakes.org/Document.Doc?id=810>