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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)**

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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 formal<sup>11</sup> 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, 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.

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<sup>11</sup> Formal is defined as training or education that is done for a credit or certification

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 and Lake Erie 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 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*: 5,000 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.<sup>12</sup> 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.

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