U.S. EPA Great Lakes National Program Office's Research Vessel *Lake Guardian*

2016 Annual Report

Monitoring and Protecting the Health of the Great Lakes

EPA 905-R-17-002

R/V LAKE GUARDIAN

United States Environmental Protection Agency Great Lakes National Program Office January 2017

The Great Lakes

The North American Great Lakes are an international resource. With more than 40 million American and Canadian people depending on the lakes for drinking water and recreational opportunities, the health of the lakes is a top priority. United States and Canadian governments have recognized the importance of the lakes and put efforts into monitoring their health. The U.S. Environmental Protection Agency (EPA) relies on the research vessel the R/V *Lake Guardian* to help carry out this monitoring.

R/V *Lake Guardian*

The R/V *Lake Guardian* is the largest research vessel in the U.S EPA fleet, and is currently the largest research vessel on the Great Lakes. The R/V *Lake Guardian* is owned and operated by EPA's Great Lakes National Program Office (GLNPO). The purpose of this report is to provide a brief overview of the research, monitoring and education activities conducted onboard the R/V *Lake Guardian* during the 2016 field season.

GLNPO will provide annual updates on the work supported by the R/V *Lake Guardian*. Annual reports detailing the latest data and trends for many of the long-term programs covered in this report will also be available soon.

In This Report

The R/V *Lake Guardian* helps U.S. EPA and other partners monitor the health of the Great Lakes (Image Credit: Michael Milligan)

Lake Huron sunset from aboard R/V *Lake Guardian* during the Summer Survey 2016.

Mission of the R/V *Lake Guardian*

U.S. EPA GLNPO is responsible for restoring and protecting the health of the Great Lakes under the Great Lakes Water Quality Agreement (GLWQA) and the Great Lakes Restoration Initiative (GLRI). GLNPO is also responsible for monitoring and reporting on the status and trends of the Great Lakes ecosystem. The R/V *Lake Guardian* operates on all five lakes (Superior, Michigan, Huron, Erie and Ontario) to conduct monitoring and research and provide educational opportunities.

What is the GLRI?

The Great Lakes Restoration Initiative, or the GLRI, was launched in 2010 to accelerate efforts to protect and restore the largest system of fresh surface water in the world, the Great Lakes. The GLRI is critical to address the most persistent and challenging environmental problems facing this important ecosystem.

Lake Guardian Ship Facts

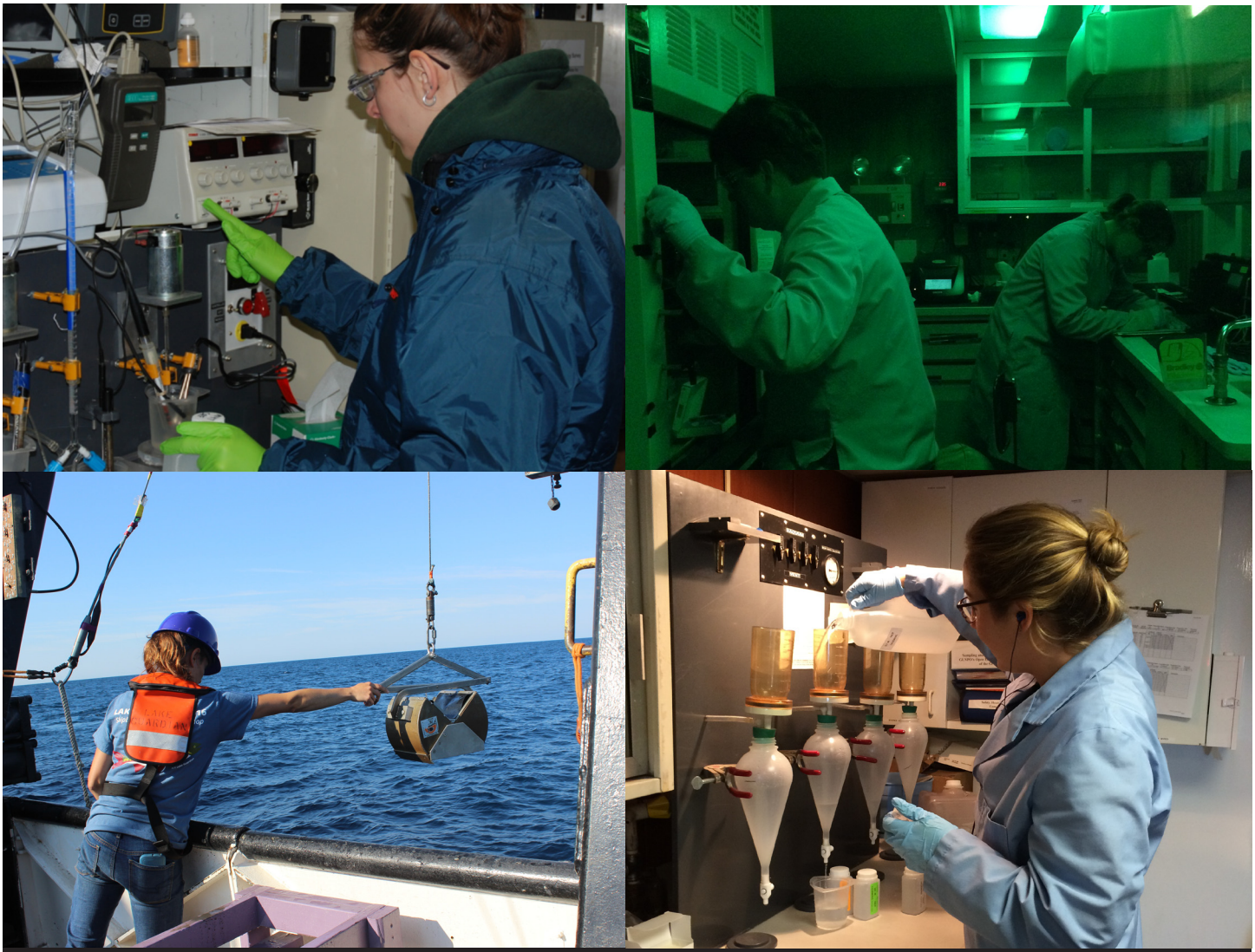
Length	Gross Tonnage	Cruising Speed	Berthing Capacity
180 feet	959 tons	11 knots	41 people - 14 crew members - 27 visiting scientists

Onboard Research Facilities and Equipment

R/V *Lake Guardian* has three dedicated laboratories: a general purpose or “wet” laboratory, chemistry laboratory, and biology laboratory. The wet lab, serving as the main collection space, is where all samples are first brought onboard. Raw water samples are processed and filtered in the wet lab; while other samples pass through to the chemistry lab for nutrient analysis, or the biology lab for zooplankton, phytoplankton, and chlorophyll-a processing and analysis.

The ship is equipped with state-of-the-art sampling equipment to aid in monitoring the health of the lakes. The Rosette water sampler, outfitted with a Sea-Bird multi-parameter profiler (conductivity, temperature and depth) and other probes, serves as the main device for water sample collection. The Rosette collects water column data and raw water samples at designated depths at each sampling station.

Samples are collected from lake sediment using a PONAR sampler, a box corer or a multicorer. A benthic sled can also be deployed for video analysis of the lake bottom and collection of lake benthos in large quantities. Zooplankton and *Mysis* samples are collected by pulling nets up through the water.



(Clockwise from upper left) Scientist measuring pH, conductivity and alkalinity of water samples in the wet lab; Scientists measuring chlorophyll-a in the biology lab; Scientist filtering samples in the wet lab; R/V *Lake Guardian* technician deploying a PONAR off the aft deck.

2016 Annual Spring Survey Quick Facts*

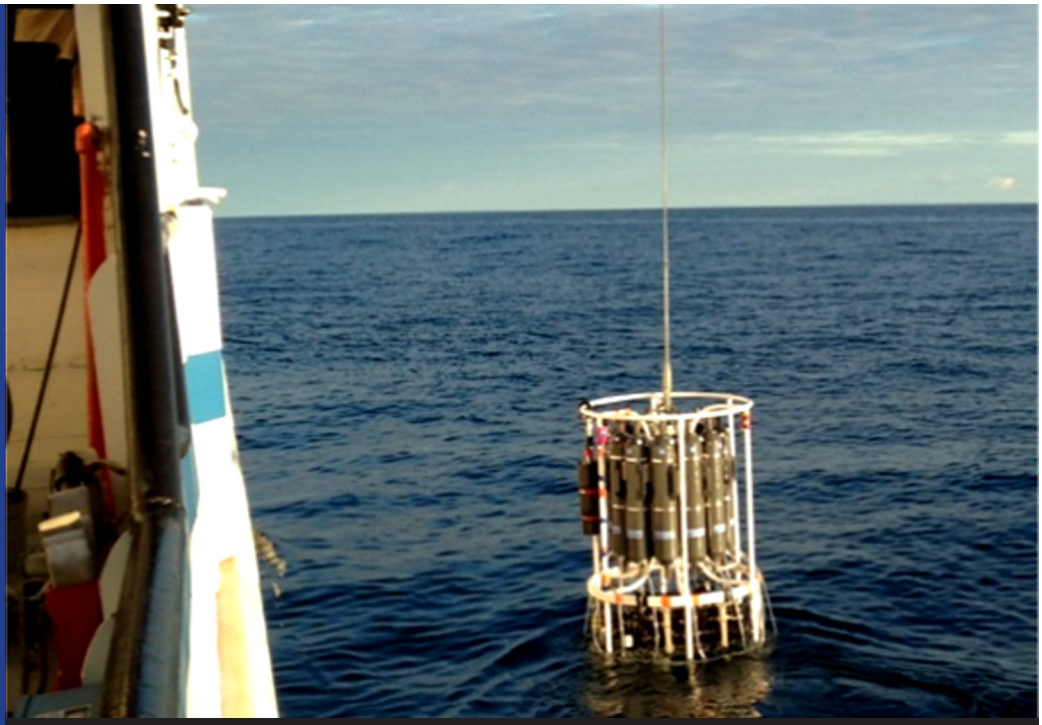
360
Sampling Locations

10,000
Nautical Miles Traveled

700
Zooplankton Net Tows

650
PONAR Grabs

*Approximate values



The Rosette water sampler is lowered off of the starboard side of the R/V *Lake Guardian* into Lake Superior to collect water samples at different depths for chemical and biological analyses.

GLNPO's Long-term Water Quality and Biology Annual Surveys

GLNPO is responsible for monitoring the offshore water quality of the Great Lakes to evaluate trends and identify emerging problems from chemicals entering the lakes. GLNPO also established a long-term biology program to monitor phytoplankton, zooplankton, *Mysis*, benthic communities and chlorophyll-a across the lakes. The biology program tracks the ecological health of the lakes, specifically the lower food web. Understanding the link between the lower food web and fish survival and growth aids in managing the fisheries and fishery stocking programs. GLNPO provides the long-term data necessary for that understanding. Both the long-term water quality and biology programs began in 1983.

The following chemical, physical and biological properties are assessed during the water quality survey in all five Great Lakes:

Chemical/Nutrient Parameters: phosphorus (total phosphorus, total dissolved phosphorus, dissolved reactive phosphorus, particulate phosphorus), nitrogen (nitrate, nitrite, total nitrogen, particulate nitrogen), particulate organic carbon, reactive silica and chloride

Physical and Water Quality Parameters: water temperature, conductivity, total suspended solids, dissolved oxygen, pH, alkalinity, transmissivity, incident light, secchi depth, air temperature, wind speed, wave height and barometric pressure

Biological Parameters: phytoplankton, zooplankton, *Mysis*, benthic invertebrates and chlorophyll-a

A map of GLNPO's annual spring and summer survey sampling site locations on the Great Lakes.

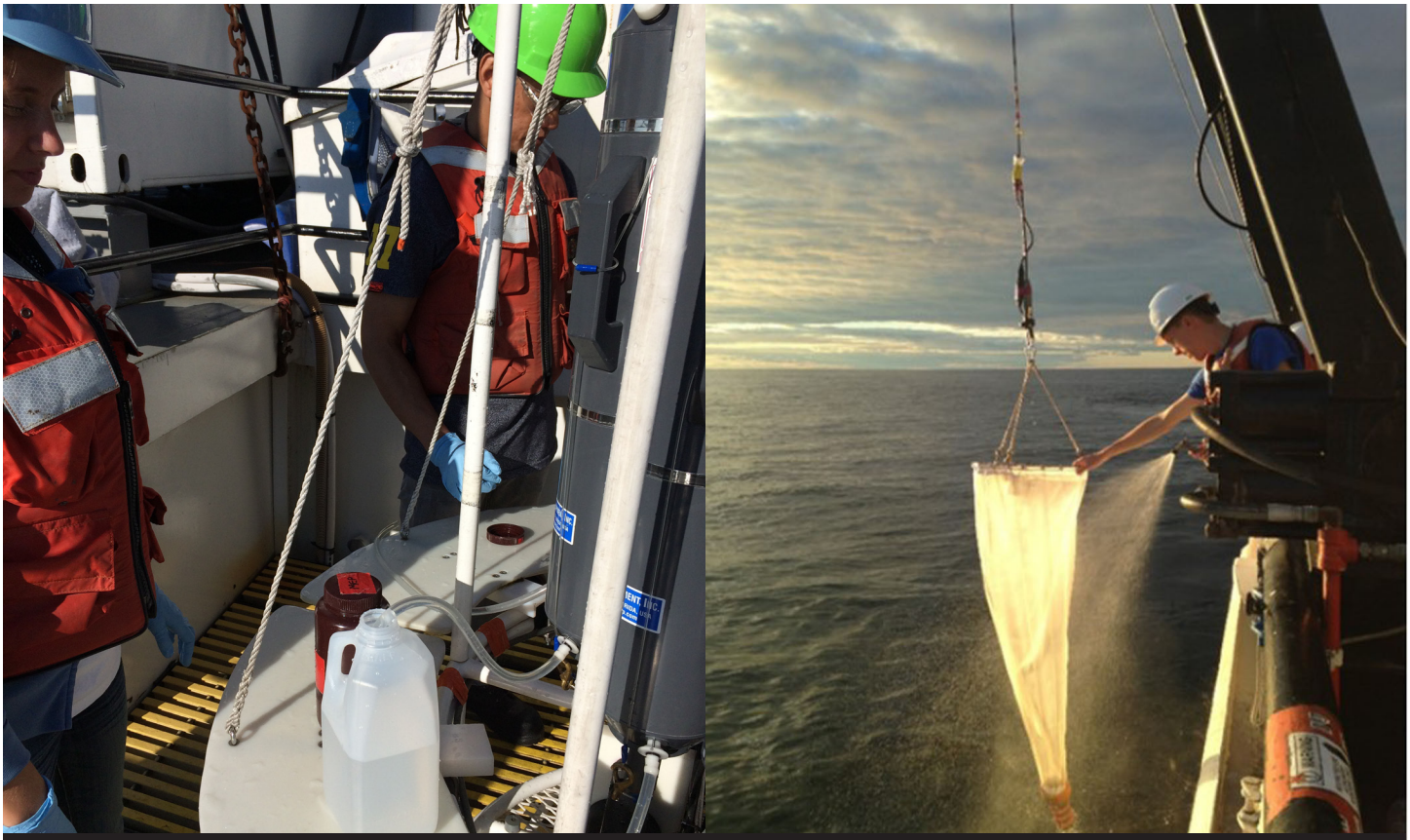
Spring Survey

Depending on the timing of ice break-up in the lakes, Spring Survey begins in late-March when the lakes are isothermal with low biological activity. The spring survey focuses on water quality, zooplankton, and *Mysis*. GLNPO has cooperative agreements with University of Minnesota-Duluth (UMD) and Cornell University to analyze the biological samples that support the long-term biology monitoring program.

Spring Survey 2016

In 2016, the spring survey began March 25 and finished on April 22. Over the course of the spring survey, eight EPA scientists and research fellows were onboard to collect, preserve and analyze water samples for nutrients and other water quality parameters. Ten additional researchers, technicians and students from UMD and Cornell were onboard the R/V *Lake Guardian*. UMD collected and preserved samples for phytoplankton analysis as part of the long-term biology monitoring program. Additional samples were collected in nearshore locations of Lake Superior to look at the variability of phytoplankton communities and the impact of local sources of nutrients entering the lake. The changing phytoplankton community has indicated water quality changes in the lakes, as well as changes due to global climate change. Some samples will also be analyzed for stable isotopes, which indicate where nutrients originate and how they pass through the food web, helping to evaluate changes in lake food web structure. Cornell collected zooplankton and chlorophyll-a samples for the long-term monitoring program.

The resulting data and trends from Spring Survey 2016 will be shared in separate annual reports in 2018.



(LEFT) Scientists collect water samples from the Rosette water sampler after a cast in Lake Superior; (RIGHT) After a tow, a scientist rinses a zooplankton net to wash the catch into the collection bottle.

Summer Survey

Summer Survey begins in August when the lakes are at their peak biological activity, so benthos samples are collected in addition to water quality, phytoplankton, zooplankton and *Mysis*. Collectively, these samples help determine the status and trends of water quality and the lower food web in the Great Lakes, which is important information used by lake and fisheries managers. Under a sub-agreement with Cornell, Buffalo State University also participates in the implementation of the benthos component of GLNPO's long-term biology monitoring program.

Summer Survey 2016

In 2016, the summer survey began August 1 and finished on August 27. Over the course of Summer Survey, twelve EPA scientists and research fellows were onboard to collect, preserve and analyze water samples for nutrients and other water quality parameters. Twelve additional researchers, technicians and students from Buffalo State, Cornell, and UMD were onboard the R/V *Lake Guardian* to collect and preserve samples for zooplankton, *Mysis*, phytoplankton, benthic invertebrate communities and chlorophyll-a.

UMD collected additional water and sediment samples in Lake Superior as part of their ongoing study to track phytoplankton dynamics in response to natural and human influences in the Great Lakes. The results will be used to look at historical changes in the lower food web, which cannot be detected through regular water sampling.

Buffalo State collected additional benthos samples to help identify and prioritize future sampling locations. Additional PONAR samples were also collected to characterize benthic meiofauna (benthic invertebrates smaller than macrofauna but larger than microfauna) as part of Buffalo State's research collaboration with Texas A&M University at Galveston. The benthic meiofauna data will be used to better understand the lower food web structure of the lakes, filling in a part of the food web about which very little is known.

The resulting data and trends from Summer Survey 2016 will be shared in separate annual reports in 2018.

Cooperative Science & Monitoring Initiative (CSMI)

What is CSMI?

The Cooperative Science and Monitoring Initiative (CSMI) is a joint United States and Canadian effort to provide environmental managers with needed information on each Great Lake.

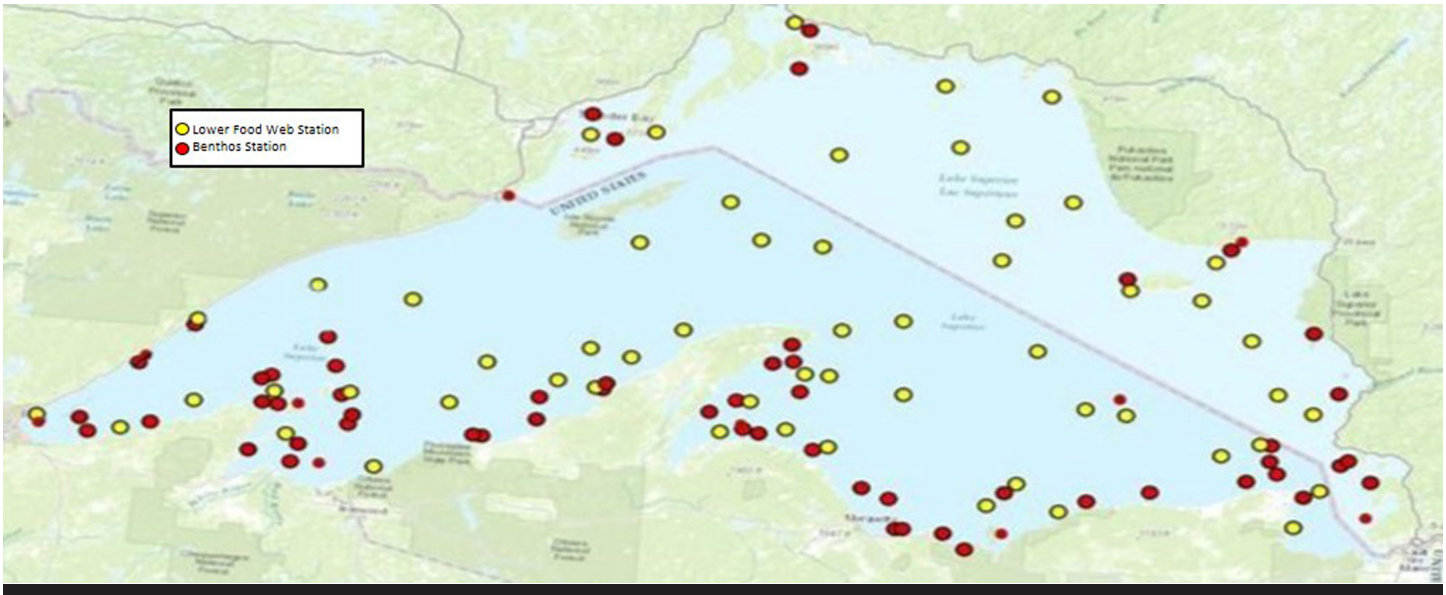
In addition to the annual spring and summer sampling surveys, one lake is revisited each year in a five-year rotation. In 2016, CSMI was focused on Lake Superior. In subsequent years, CSMI will focus on Lake Huron (2017), Lake Ontario (2018), Lake Erie (2019) and Lake Michigan (2020).

Lake Superior 2016

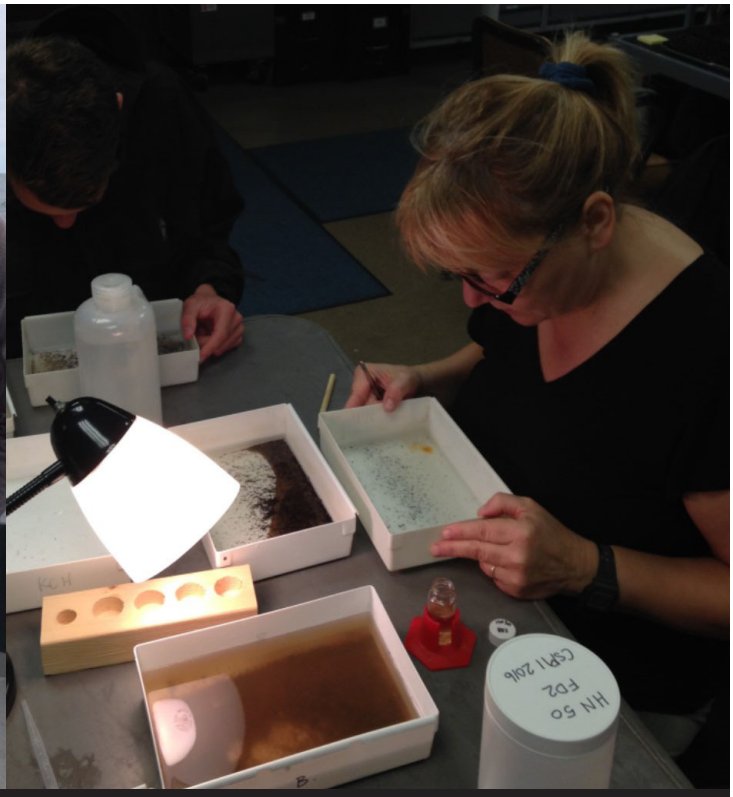
Focusing on Lake Superior, the 2016 CSMI Survey took place following Summer Survey at the end of August. The Lake Superior Binational Program Partnership identified lower-trophic food web health and energy transfer as one of their priorities for the 2016 CSMI in order to better understand the food web structure as it relates to fisheries management and overall lake health.

In response to this priority, an intensive assessment of the lower food web in the nearshore and offshore zones of Lake Superior was conducted to supplement the long-term annual monitoring programs. U.S. EPA's Office of Research and Development (ORD) and Buffalo State University sampled for water chemistry, phytoplankton, zooplankton, *Mysis*, sediment and benthic invertebrates. An important focus of the 2016 CSMI Survey was *Diporeia* - small, shrimp-like crustaceans that are a major food web component in the Great Lakes. *Diporeia* populations have declined dramatically since the 1990s in every Great Lake except for Lake Superior, so monitoring their populations in Lake Superior is important for understanding lake health.

The results from this survey will provide lakewide estimates of the status and condition of Lake Superior's lower food web. These results will be compared with similar Lake Superior CSMI surveys conducted in 2005-2006 and 2011 to provide a baseline of ecosystem changes observed over the past decade in the nearshore and offshore zones of the lake.



A map of the 2016 CSMI Survey sampling stations on Lake Superior.



(LEFT) Scientists rinse and strain Lake Superior sediment from a PONAR grab; (RIGHT) Scientists count the benthic invertebrates from a processed PONAR sediment sample.

Contaminants in the Food Web Survey

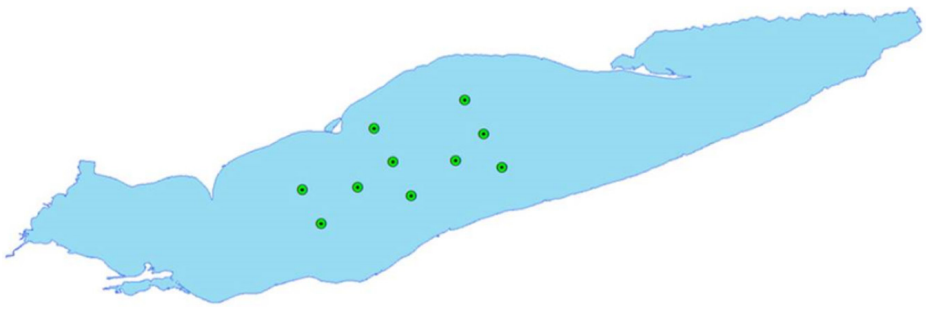
Lake Superior 2016

The core objective of the long-term Great Lakes Fish Monitoring and Surveillance Program (GLFMSP) is to assess and track trends of chemicals in Great Lakes top predator fish.

In 2016, to supplement this long-term monitoring program, researchers and students from Clarkson University, SUNY Fredonia, and SUNY Oswego collected water, phytoplankton, zooplankton, benthos and sediment samples from the R/V *Lake Guardian* at two locations in Lake Superior. These two locations, offshore of the Apostle Islands and Keweenaw Peninsula, are where lake trout are collected as part of the GLFMSP. The samples will be analyzed for a suite of persistent and bioaccumulative chemicals. The samples will also be analyzed for omega-3 fatty acids and stable isotopes to better identify energy transfer through the food web.

The resulting data and trends will be shared in a GLFMSP annual report in 2018.

Sample, collected from a benthic sled tow, full of *Diporeia* and larval fish.



Lake Erie Dissolved Oxygen Survey sampling stations in Lake Erie's central basin.

Lake Erie Dissolved Oxygen Survey

GLNPO has been monitoring hypoxia in the central basin of Lake Erie since 1983. This long-term program measures dissolved oxygen (DO) and temperature profiles at ten locations in the central basin of Lake Erie throughout the summer season when the lake is stratified. The program assesses the status and trends of hypoxic conditions to inform management decisions, including those being made under the Nutrients Annex of the GLWQA.

In 2016, six separate surveys were done to support the long-term DO program. The R/V *Lake Guardian* collected data and samples for four of these surveys in early-June, July, August and late-September. The U.S. Geological Survey (USGS), a partner agency, collected data in late-June and early-September using the R/V *Muskie* when the R/V *Lake Guardian* was supporting other survey work.

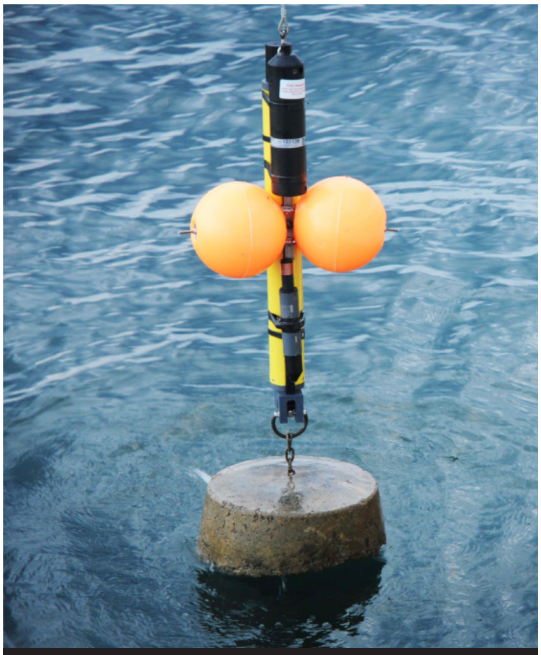
The resulting data and trends from the Lake Erie DO Survey will be shared in a separate annual report in 2018.

What is the GLWQA?

The Great Lakes Water Quality Agreement (GLWQA) is a commitment between the United States and Canada to restore and protect the waters of the Great Lakes.

The Agreement provides a framework for identifying binational priorities and implementing actions that improve water quality. U.S. EPA coordinates U.S. activities that fulfill the Agreement.

The Agreement was amended in 2012 to better address threats to Great Lakes water quality and strengthen measures to anticipate and prevent ecological harm.



A DO logger deployed in Lake Erie.

Dissolved Oxygen (DO) Data Loggers

Since 2014, GLNPO has partnered with USGS, Illinois-Indiana Sea Grant and Ohio Department of Natural Resources to supplement the long-term DO monitoring program with moored DO data loggers. The data loggers provide more detailed data on the day-to-day variability of DO concentrations at their given location. The data may ultimately help resource agencies assess the extent of hypoxia to support efforts under the Nutrients Annex of the GLWQA.

In 2016, GLNPO deployed 26 DO loggers (two at each of ten long-term GLNPO stations, plus duplicate sensors at three of the stations) in early-June. These loggers were deployed 0.5 meter and 1.5 meters off the bottom of the lake to track changes in DO concentrations over the entire season. The loggers were retrieved in late-September. The data are currently being compared to the profile data collected from the research vessels.

The teachers and scientists during the 2016 Shipboard Science Workshop.

Center for Great Lakes Literacy Educator Cruise

The R/V *Lake Guardian* is also a floating classroom every summer for a group of educators from around the Great Lakes basin as part of the Center for Great Lakes Literacy (CGGL) Shipboard Science Workshop. Participants work side-by-side with scientists for a week doing real Great Lakes research and gaining valuable hands-on experience collecting and processing samples. The educators are expected to incorporate their new Great Lakes science knowledge back in their classrooms, and also share it with their colleagues. The cruise is a collaboration between the Great Lakes Sea Grant Network and GLNPO.

15 educators from across the Great Lakes states participated in this week-long immersive workshop with EPA and UMD scientists in 2016. While traversing Lake Superior, the educators collected and processed samples of water, zooplankton and benthos. At the end of the week, they analyzed the resulting data, which addressed different research questions, and presented their findings to the group.

A post-cruise evaluation indicated that all 15 participants gained new knowledge and the confidence to explain Great Lakes concepts, and all plan to integrate these concepts into lessons back in the classroom. An 8-month follow-up survey will be conducted in April to see how they incorporated their R/V *Lake Guardian* experience in their educational programming over the school year.

Shrinking Cup Experiment

The R/V *Lake Guardian* routinely engages with school groups from around the Great Lakes basin. Two programs for engaging students include classroom "Ask a Scientist" video chats with scientists onboard and the shrinking cup experiment.

In 2016, GLNPO partners from Illinois-Indiana Sea Grant collected over 300 Styrofoam cups from hundreds of students. The cups were attached to the Rosette water sampler as it was deployed to the bottom of the lakes. This experiment helped teach the concepts of Boyle's Law through observing how the cups change due to pressure at the bottom of the lakes.

Illinois-Indiana Sea Grant also coordinated video chats with scientists aboard the R/V *Lake Guardian* and school kids in classrooms across the Great Lakes basin. Four video chats were conducted this field season (during the CSMI surveys in August and September) with over 470 students participating.

Styrofoam cup size comparison.

2017 R/V *Lake Guardian* Schedule

March	Training and Survey Preparation; Spring Survey (All 5 Lakes)
April	Spring Survey (All 5 Lakes)
May	IAGLR Annual Meeting, Detroit, MI; Lake Huron CSMI Survey
June	Lake Erie DO Survey; Contaminants in the Food Web Survey (GLFMSP)
July	Lake Huron CGLL Educator Cruise; Lake Erie DO Survey; Lake Huron CSMI Survey
August	Summer Survey (All 5 Lakes)
September	Lake Erie DO Survey; Lake Huron CSMI Survey
October	Lake Erie DO Survey
November-February	Ship Maintenance and Preparation

U.S. EPA Great Lakes National Program Office
77 W Jackson Blvd
Chicago, IL 60604
312-353-2117
www.epa.gov/greatlakes