



LAKE GUARDIAN

Research Vessel *Lake Guardian* 2018 Annual Report

Prepared by:
United States Environmental Protection Agency
Great Lakes National Program Office
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THE GREAT LAKES

About the Great Lakes

The North American Great Lakes are an important ecological, cultural, and economic resource for the United States and Canada. The Great Lakes contain one-fifth of the world's surface freshwater and the ecosystem is one of the most biologically diverse in North America. The health of the Great Lakes is an important binational priority, and the US and Canadian governments have several programs in place to monitor the health of the Great Lakes. The US Environmental Protection Agency's (EPA) Great Lakes National Program Office (GLNPO) uses the Research Vessel (R/V) *Lake Guardian* to monitor water quality, contaminants, and the food web across the Great Lakes. R/V *Lake Guardian* surveys help EPA meet requirements and commitments under the Clean Water Act, Great Lakes Water Quality Agreement (GLWQA), and the Great Lakes Restoration Initiative (GLRI).



What is the GLWQA?

The Great Lakes Water Quality Agreement (GLWQA), originally signed in 1972, is a commitment between the United States and Canada to restore and protect the Great Lakes ecosystem. The GLWQA provides a framework for identifying and implementing binational priorities for improving water quality and ecosystem health. In 2012, the GLWQA was amended to better address current threats to Great Lakes. The US EPA Great Lakes National Program Office coordinates the US implementation of the GLWQA.

What is the GLRI?

The Great Lakes Restoration Initiative (GLRI) was launched in 2010 to accelerate US efforts to protect and restore the Great Lakes ecosystem. With oversight by US EPA GLNPO, the GLRI provides critical resources to 16 federal organizations and numerous non-federal partners working together to achieve long-term restoration and protection goals. Through FY 2018, GLRI has funded over 4,700 projects that focus on the most important Great Lakes environmental issues. The five focus areas of the GLRI are:

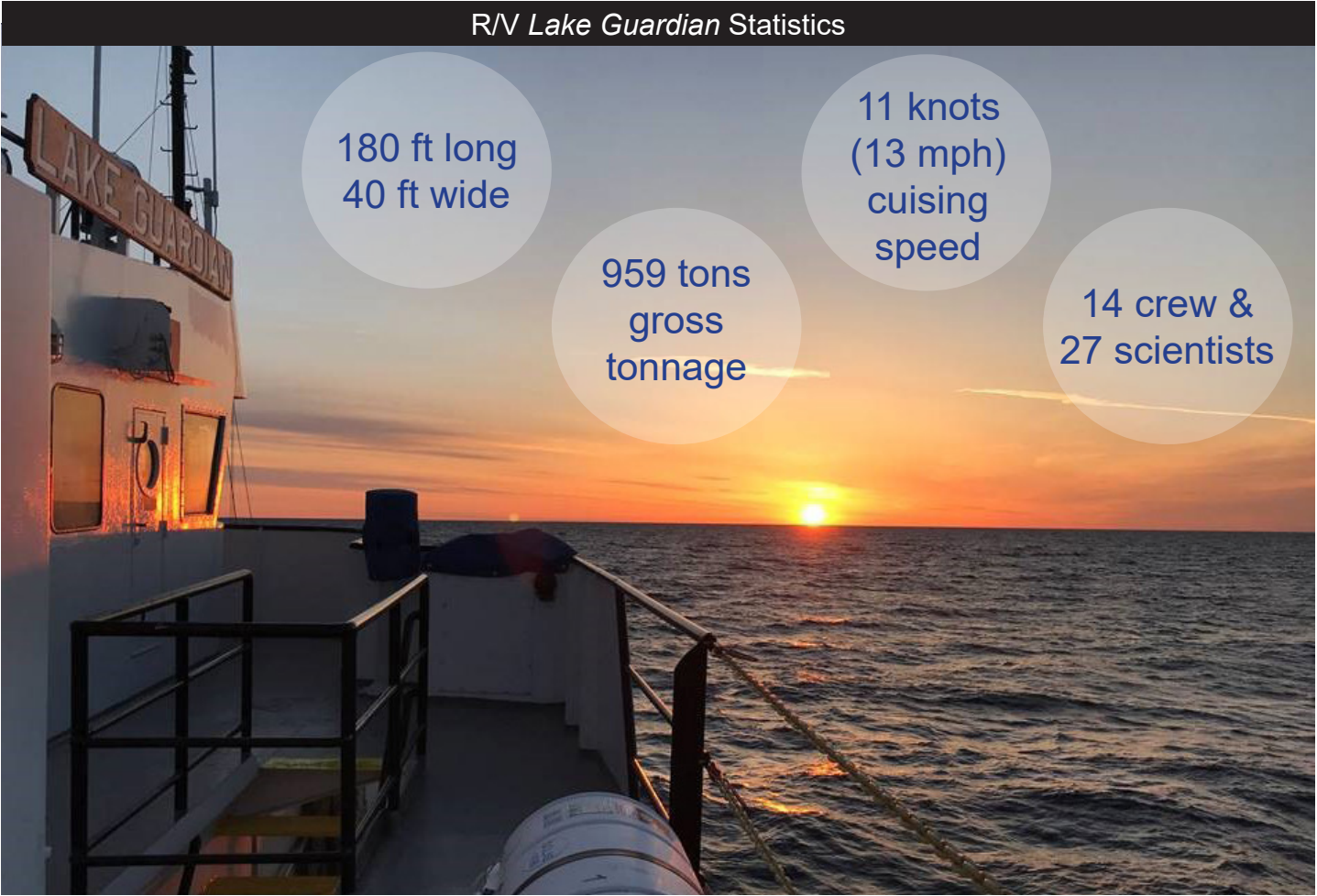
- Toxic substances and Areas of Concern
- Invasive species
- Non-point source pollution impacts on nearshore health
- Habitats and species
- Foundations for future restoration actions

R/V LAKE GUARDIAN

About the R/V *Lake Guardian*

The R/V *Lake Guardian* is currently the largest research vessel operating in the Great Lakes. US EPA uses the R/V *Lake Guardian* to conduct monitoring and research activities on all five Great Lakes. EPA's R/V *Lake Guardian* surveys meet requirements under the Clean Water Act to establish a system-wide surveillance network to monitor Great Lakes water quality. They also satisfy EPA's obligations under the GLWQA to "undertake monitoring and surveillance to anticipate the need for further science activities and to address emerging environmental concerns." Further, R/V *Lake Guardian* surveys meet Great Lakes Restoration Initiative commitments to "assess the overall health of the Great Lakes." In addition to research and monitoring, the ship also provides numerous public outreach and educational opportunities around the Great Lakes basin. The purpose of this report is to provide a brief overview of the research, monitoring, and outreach activities conducted onboard the R/V *Lake Guardian* during the 2018 field season.

R/V *Lake Guardian* Statistics



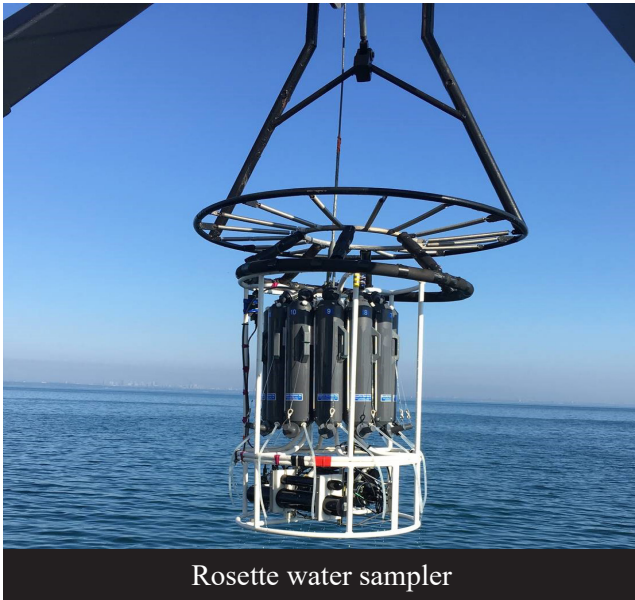
180 ft long
40 ft wide

959 tons
gross
tonnage

11 knots
(13 mph)
cruising
speed

14 crew &
27 scientists

Onboard Research Facilities and Equipment



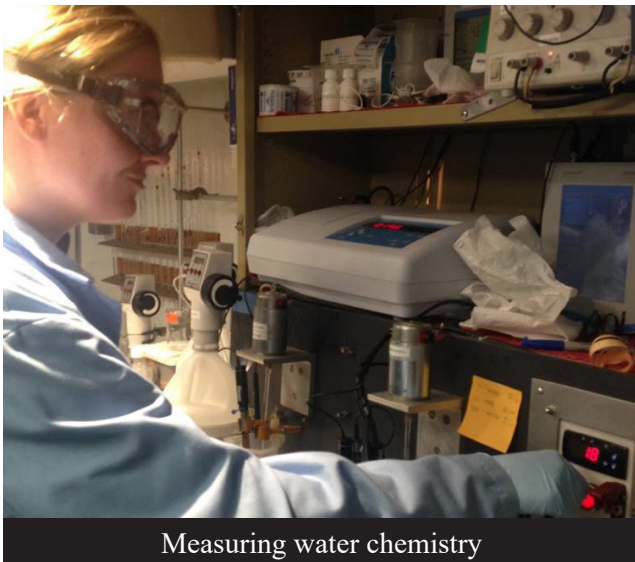
Rosette water sampler



Filtering water for nutrient analyses

The R/V *Lake Guardian* is equipped with state-of-the-art sampling equipment to monitor the health of the Great Lakes. A Rosette water sampler is outfitted with a multi-parameter CTD (conductivity, temperature, depth) profiler, fluoroprobe, 12 Niskin bottles, and several other instruments to collect water column data and water samples at specific depths. The ship also deploys other technical instruments, including laser optical plankton counters, fisheries acoustics, and underwater imaging devices.

Scientists on the R/V *Lake Guardian* sample lake sediment and benthic organisms using Ponar grab samplers, a box corer, and multicorer. Several nets of various lengths, diameters, and mesh sizes are used to collect zooplankton, *Mysis*, and larval fish samples. Following field collection, water and biological samples are processed in three on-board laboratories: the general purpose or “wet” laboratory, the chemistry laboratory, and the biology laboratory.



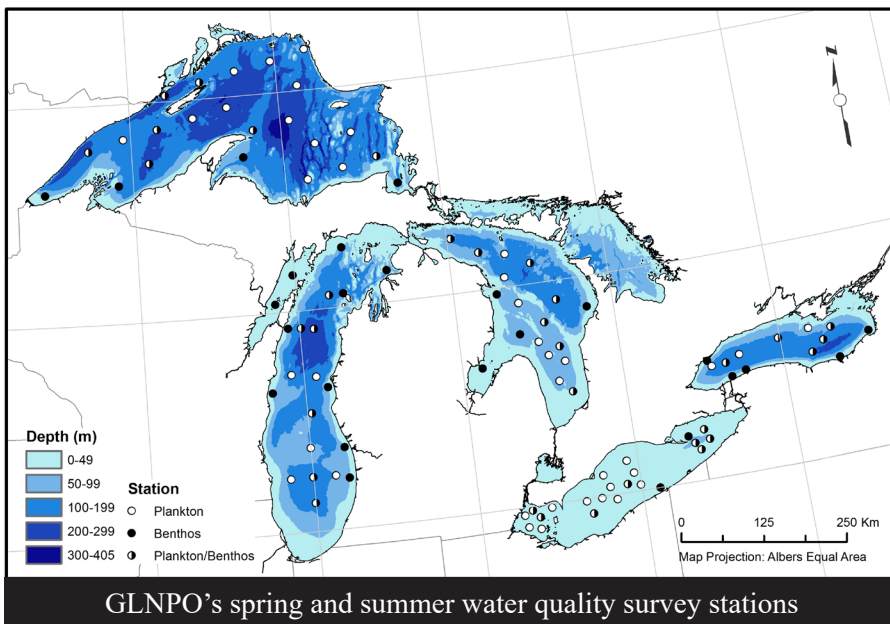
Measuring water chemistry



Ponar grab

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

Since 1983, US EPA GLNPO has monitored the offshore waters of the Great Lakes to determine ecosystem trends and identify emerging problems. The Great Lakes Water Quality Monitoring Program measures several physical and chemical parameters across the Great Lakes, and the Biology Monitoring Program monitors the plants and animals of the lower food web. The long-term data collected by these GLNPO monitoring programs are highly valuable to ecosystem managers and scientific researchers seeking to understand the complex Great Lakes ecosystem.



Physical Parameters: Water temperature, air temperature, wind speed, wave height, surface and underwater photosynthetically active radiation (PAR), Secchi depth, turbidity, sediment grain size

Chemical Parameters: Dissolved and particulate phosphorus and nitrogen, particulate and total organic carbon, cations, reactive silica, metals, chloride, sediment carbon/nitrogen/phosphorus, conductivity, total suspended solids, dissolved oxygen, pH, alkalinity, total hardness

Biological Parameters: chlorophyll-a, phytoplankton, zooplankton, *Mysis*, benthic invertebrates, *Diporeia*, dreissenid mussels

Who assists with water quality & biology monitoring?

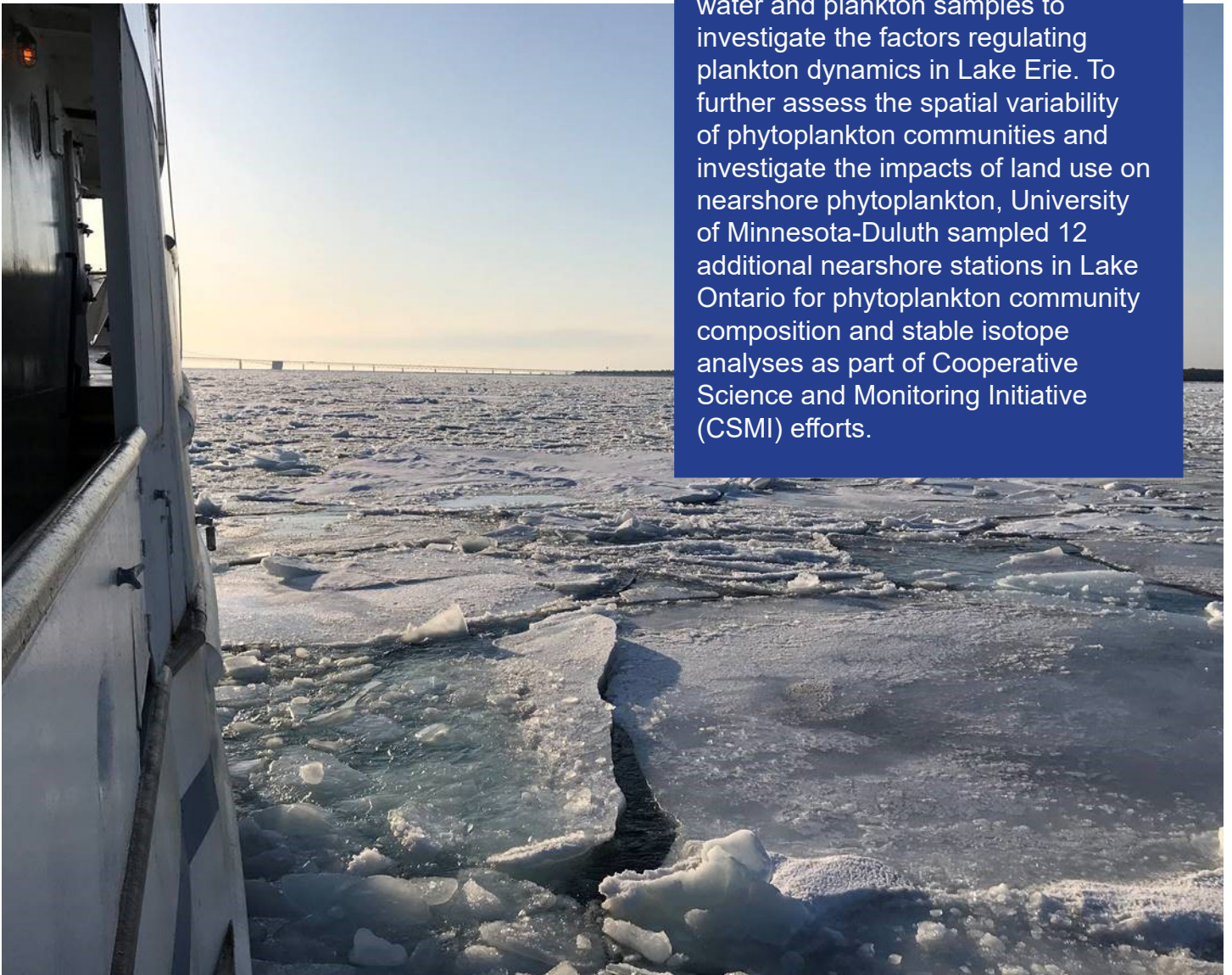
The ship is operated by a crew from Cetacean Marine. Many EPA scientists and Oak Ridge Institute for Science and Education (ORISE) research participants collect water and biological samples. In 2018, GLNPO had cooperative agreements with University of Minnesota-Duluth, Cornell University, and Buffalo State College to collect and analyze the samples that support the Biology Monitoring Program. The Federal Occupational Health (FOH) lab analyzed GLNPO's water samples for several nutrient parameters. General Dynamics Information Technology (GDIT), a GLNPO contractor, performs data review and validation for many GLNPO monitoring programs.

Spring Survey

The annual Spring Water Quality Survey of all five lakes begins after most of the winter lake ice has thawed. On the 2018 Spring Survey, EPA scientists and ORISE research participants were onboard the R/V *Lake Guardian* to collect, preserve, and analyze water samples for nutrients and other water quality parameters at 75 long-term stations. Ten researchers, technicians, and students from Cornell University and University of Minnesota-Duluth also participated in the Spring Survey to collect the phytoplankton, chlorophyll, *Mysis*, benthos, and zooplankton samples supporting the Biology Monitoring Program.

Additional Science and Monitoring on the Spring Survey

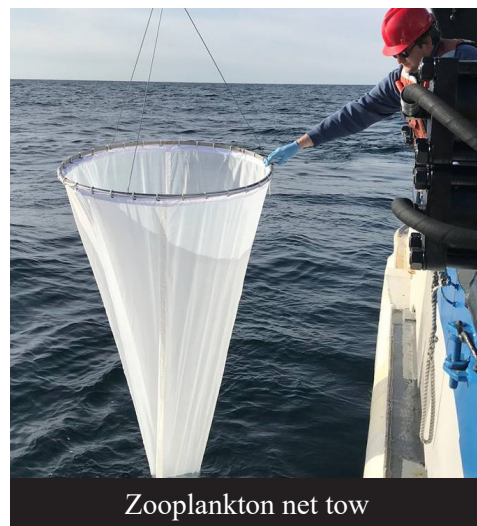
Additional researchers from the University of Chicago collected water samples for DNA and RNA analysis to determine the microbial community composition across all five lakes. A researcher from Bowling Green State University also collected water and plankton samples to investigate the factors regulating plankton dynamics in Lake Erie. To further assess the spatial variability of phytoplankton communities and investigate the impacts of land use on nearshore phytoplankton, University of Minnesota-Duluth sampled 12 additional nearshore stations in Lake Ontario for phytoplankton community composition and stable isotope analyses as part of Cooperative Science and Monitoring Initiative (CSMI) efforts.



Summer Survey

The annual Summer Water Quality Survey occurs in August when the lakes are near peak biological activity. Over the course of 2018 Summer Survey, numerous scientists and students from many organizations were onboard to collect, preserve and analyze the water, phytoplankton, chlorophyll, zooplankton, *Mysis*, and benthos samples at 97 long-term stations for GLNPO monitoring programs.

Buffalo State also collected additional Ponar samples for the genetic analysis of benthic organisms. At a selection of sites, Buffalo State towed a benthic sled outfitted with high-quality cameras along 500 meter transects to capture videos of the bottom of Lakes Michigan, Huron, Erie, and Ontario. These video transects help determine the spatial extent of invasive quagga and zebra mussels.



Additional Science and Monitoring on the Summer Survey

Similar to the Spring Survey, University of Minnesota-Duluth sampled 12 additional nearshore stations in Lake Ontario for phytoplankton community composition and stable isotope analyses. Additional *Mysis* samples were also collected by a Cetacean Marine Technician in all five lakes except Erie to assess the effectiveness of horizontal tows for collecting *Mysis* samples. This technique can allow researchers to obtain greater *Mysis* biomass for contaminant and biological analyses than standard net tows.

Additional researchers from the University of Chicago were onboard to collect water samples for microbial community composition analyses. Researchers from the US Geological Survey (USGS) also participated in the Summer Survey to collect water and plankton samples for mercury analyses. Mercury is a toxic substance that can bioaccumulate in the Great Lakes food web, leading to fish consumption advisories.

Cooperative Science & Monitoring Initiative (CSMI)

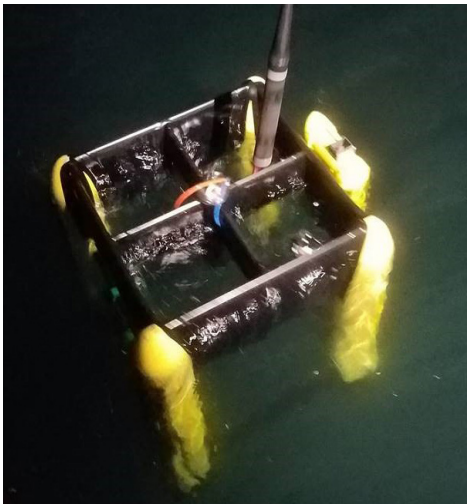
What is CSMI?

The Cooperative Science and Monitoring Initiative (CSMI) is a joint US and Canadian effort to bring an extra focus on one of the five Great Lakes each year. US EPA GLNPO is responsible for coordinating CSMI research and monitoring efforts among the US federal, state, tribal, and academic partners. Lake Ontario was the focus of the 2018 CSMI field year. In subsequent years, the CSMI field year will rotate to Lake Erie (2019), Lake Michigan (2020), Lake Superior (2021), then Lake Huron (2022).

Lake Ontario 2018

The GLWQA Lake Ontario Partnership identified six overarching science priorities for the 2018 CSMI:

- Nutrient concentrations and loadings
- Nearshore nutrient-related problems (*Cladophora*)
- Aquatic food web status
- Fish dynamics
- Critical and emerging pollutants
- Coastal wetland status



Triaxus instrument package



Viewing live feed of Triaxus acoustics data

Lake Ontario CSMI Lower Aquatic Food Web (LOLA) Surveys

The R/V *Lake Guardian* served as the platform for many studies investigating the health of the aquatic food web in Lake Ontario. The Lake Ontario Lower Aquatic Food Web (LOLA) surveys were conducted in May, June, and September 2018 to characterize spatial and seasonal trends of Lake Ontario's lower food web. Hundreds of water quality, nutrient, microbial, phytoplankton, zooplankton, *Mysis*, and larval fish samples were collected at 24 stations across Lake Ontario by scientists from US EPA GLNPO, US EPA's Office of Research and Development (ORD) Mid-Continent Ecology Division (MED), Cornell University, NY State Department of Environmental Conservation, Department of Fisheries and Oceans Canada, Environment and Climate Change Canada (ECCC), and Ontario Ministry of the Environment, Conservation and Parks. In addition to discrete samples, the Triaxus instrument package with a laser optical plankton counter was deployed to explore the patchiness and spatial distribution of several lower food web components. Altogether, the results from these seasonal surveys provide insight into the current status of Lake Ontario's lower food web.

Lake Ontario CSMI Benthos Survey

In September 2018, US EPA GLNPO, US EPA ORD Gulf Breeze and MED, Buffalo State College, NOAA's Great Lakes Environmental Research Laboratory, and the University of Michigan Cooperative Institute of Great Lakes Research conducted an intensive lake-wide survey of the benthic community in Lake Ontario. Ninety-nine stations were sampled for benthic community composition, sediment grain size, and sediment nutrients. At 61 of the 99 stations, a benthic sled with video cameras was deployed to map the spatial distribution and abundance of invasive quagga mussels. A drop-down camera was also used to capture images of the lake bottom. A sediment profile imaging (SPI) camera was also deployed to investigate sediment characteristics and develop a benthic community health index for freshwater systems. The results from this survey provide a lake-wide synopsis of the status of Lake Ontario's benthic lower food web. Because benthic invertebrates are water and sediment quality indicators, results from 2018 will be compared with past and future Lake Ontario CSMI surveys to determine ecosystem changes over time.



Deploying the SPI camera



Counting and sorting invasive dreissenid mussels



Processing Ponar samples



Deploying the drop-down camera



Collecting water samples using the dip method



Dreissenid mussels collected for chemical analysis

Lake Ontario CSMI Contaminants in the Food Web Survey

US EPA GLNPO's Great Lakes Fish Monitoring and Surveillance Program (GLFMSP) tracks long-term trends of chemicals in Great Lakes top predator fish, such as lake trout, and several other associated ecosystem components, including water, sediment, benthic invertebrates, and plankton.

In June 2018, a CSMI survey by US EPA GLNPO, Clarkson University, SUNY Fredonia, SUNY Oswego, ECCC, USGS, and NOAA's Mussel Watch Program collected water, phytoplankton, zooplankton, benthos, and sediment samples for toxic chemical analysis at one site in Lake Ontario. Samples were analyzed for a suite of persistent and bioaccumulative chemicals and also for stable isotopes to better identify energy and contaminant transfer through the food web.



Collecting benthic invertebrates for chemical analyses

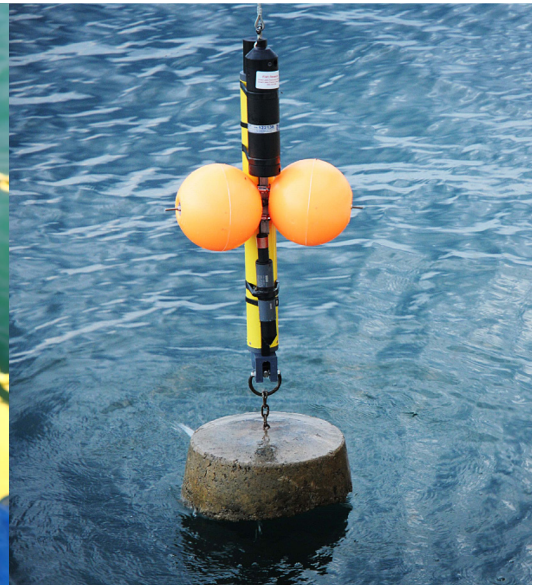
Lake Erie Dissolved Oxygen Monitoring

During the warm summer months, the central basin of Lake Erie experiences hypoxia, or low oxygen levels, near the bottom of the lake. Hypoxia has negative implications for both biological communities and drinking water management. GLNPO has been monitoring dissolved oxygen (DO) levels in the central basin of Lake Erie since 1983 to assess the status and trends of hypoxia and inform management decisions. The data collected by the Lake Erie DO Monitoring Program supports hypoxia and ecosystem modeling efforts and may ultimately support management efforts under the Nutrients Annex of the GLWQA.

GLNPO's Lake Erie DO Monitoring Program measures DO on numerous ship surveys each year. From May to October 2018, six R/V *Lake Guardian* surveys and two USGS R/V *Muskie* surveys measured DO at 10 long-term sites in the central basin of Lake Erie. In addition, continuous monitoring with *in situ* DO and temperature sensors is used to assess hypoxia in between surveys.



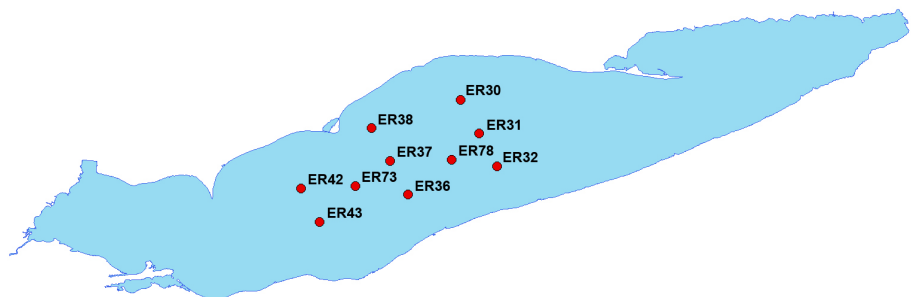
Collecting water samples for DO analysis



DO sensor deployment

Dissolved Oxygen Sensors

To supplement ship surveys, two buoys with DO and temperature sensors were deployed until September 2018. The *in situ* sensors provide more detailed data on the day-to-day variability of DO concentrations at their given location than can be obtained by discrete surveys.



Central basin Lake Erie stations sampled on DO surveys

2018 Lake Ontario

In July 2018, 14 educators participated in a week-long immersive workshop with EPA, University of Buffalo, and SUNY College of Environmental Science and Forestry (ESF) scientists. On Lake Ontario, the educators collected water, plankton, benthic invertebrates, and sediment samples for toxic chemical analyses to support the GLFMSP. Educators also collected water samples to investigate nearshore and offshore differences in phytoplankton productivity and microbial and eukaryotic communities.

Post-workshop surveys indicated that all 14 participants gained new knowledge and the confidence to explain Great Lakes concepts to students and all plan to integrate these concepts into lesson back in the classroom.

Center for Great Lakes Literacy Shipboard Science Workshop

Through a collaboration between US EPA GLNPO and the Great Lakes Sea Grant Network, the R/V *Lake Guardian* serves as a floating classroom every summer for the Center for Great Lakes Literacy (CGLL) Shipboard Science Workshops. In these workshops, educators from around the Great Lakes basin set sail on the R/V *Lake Guardian*, working side-by-side with scientists, conducting Great Lakes research and gaining valuable hands-on experience collecting and processing samples. After the week-long survey, the educators share their new Great Lakes science knowledge back in their classrooms with students from grades 4 through 12.



Great Lakes educators learning how to process Ponar grabs on the back deck of the R/V *Lake Guardian*

Public Outreach

There are opportunities each sampling season for the public and school groups around the Great Lakes basin to engage first-hand with the R/V *Lake Guardian*. In 2018, EPA scientists and the R/V *Lake Guardian* crew provided public tours of the ship in Rochester, Detroit, Sault Saint Marie, and Chicago. Public groups visited the back deck, Rosette deck, laboratories, pilot house, and sleeping quarters to get a glimpse into the life of R/V *Lake Guardian* scientists and learn about EPA's mission to monitor and protect the Great Lakes.

“Lake Guardian Live” Video Chats to Classrooms

In 2018, Illinois-Indiana Sea Grant coordinated 10 video chats between R/V *Lake Guardian* scientists and students across the Great Lakes basin, reaching a total of 350 students. Scientists explained their survey objectives and research to students and many fielded questions from the classrooms.

Shrinking Cups

Illinois-Indiana Sea Grant collected 246 Polystyrene cups from 772 students representing 28 classrooms from across the Great Lakes basin for the Incredible Shrinking Cup Experiment (<https://iiseagrant.org/water-boyles-over-for-teachers-on-lake-guardian>). Measured and decorated cups were attached to the Rosette water sampler and deployed to the bottom of the deepest Lake Superior station (SU08). This experiment helps teach the concepts of Boyle's Law by illustrating how the cups change in size due to high pressure at the bottom of the lakes.



Public tours in Sault St. Marie, MI



Polystyrene cups were crushed under pressure at the bottom of Lake Superior

2018 R/V *Lake Guardian* Schedule

March	Training & survey preparation Spring Survey begins
April	Spring Survey continued Chicago, IL public tours
May	Lake Ontario CSMI LOLA survey I
June	2 Lake Erie DO surveys Lake Ontario CSMI LOLA Survey II Lake Ontario CSMI contaminants survey Rochester, NY public tours
July	Lake Erie DO survey Lake Ontario CGLL Shipboard Science Workshop
August	Summer Survey Detroit, MI public tours Sault St. Marie, MI public tours
September	Lake Erie DO survey Lake Ontario CSMI benthos survey Lake Ontario CSMI LOLA survey III
October	Lake Erie DO survey
Nov. - Feb. 2019	Ship & equipment maintenance 2019 survey preparation

2018 R/V *Lake Guardian* Surveys in Numbers



To learn more about the R/V *Lake Guardian*, visit <https://www.epa.gov/great-lakes-monitoring/lake-guardian>. Additional information about GLNPO's Great Lakes monitoring programs is available at <https://www.epa.gov/great-lakes-monitoring>. Data from the limnology, biology, and contaminant monitoring programs can be accessed through the Great Lakes Environmental Database (GLENDa) at <https://cdx.epa.gov/>.

ACKNOWLEDGEMENTS

We gratefully acknowledge the support of all GLNPO monitoring program cooperators. GLNPO has cooperative agreements with Cornell University (Department of Natural Resources) and Buffalo State College under Agreement Award GL-00E01184 “Great Lakes Long-term Biological Monitoring of Zooplankton, Benthos, and Chlorophyll-a” and with Regents of the University of Minnesota under Agreement Awards GL-00E23101-2 and GL-00E01980 “Great Lakes Biological Monitoring: Phytoplankton.” GLNPO also has a cooperative agreement with Clarkson University under Agreement Award GL-00E01505 “The Great Lakes Fish Monitoring and Surveillance Program.” General Dynamics Information Technology supports monitoring programs under EPA Contract No. EPC-15-012: “Technical, Analytical, and Regulatory Mission Support for the Water Security Division.” GLNPO and the Department of Health and Human Services Federal Occupational Health Lab have an interagency agreement under DW075959351 “Analysis, Interpretation, and Data Management of Great Lakes Water for Inorganic Chemicals.” We are also thankful for the hard work and dedication of the ship’s crew from Cetacean Marine.

Cover photo credit: Michael Milligan, SUNY Fredonia

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