An Illinois-Indiana Sea Grant Partner Report

Great Lakes Science

Connecting with Communities

IISG21-ADM-RLA-041

PURDUE UNIVERSITY Extension

Illinois Extension
UNIVERSITY OF ILLINOIS URBANA-CHAMPAIGN

Sea Grant
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NOAA

Funding is provided by the U.S. Department of Commerce, National Oceanic and Atmospheric Administration (NOAA Grant #COM NA18OAR4170082), Office of Sea Grant, University of Illinois at Urbana-Champaign and Purdue University, West Lafayette, Indiana. University of Illinois and Purdue University offer equal opportunities in programs and employment.

INTRODUCTION

Throughout the Great Lakes basin, community leaders face the challenge of making long-term management decisions that lead to substantial impacts on ecological integrity and community quality of life. For local decision makers with limited resources, understanding the implications of development and identifying optimal planning strategies to make their communities more resilient—economically, environmentally and socially—requires research, outreach, and monitoring at a larger, basin-wide scale, coupled with local pilot testing and adaptive management.

Regional Setting and Overarching Principles

In 2012, the U.S. and Canada updated the Great Lakes Water Quality Agreement, outlining binational cooperation to restore and maintain Great Lakes resources and commit the two countries to a series of goals and initiatives. These include restoring nearshore habitats, including drinking water sources; restoring or delisting Areas of Concern; identifying and mitigating emerging contaminants; updating nutrient targets; and working with communities to understand how climate change will impact water quality. The U.S. EPA Great Lake National Program Office (GLNPO) is charge with coordinating U.S. efforts.

In 2010, GLNPO adopted the Great Lakes Restoration Initiate (GLRI) Action Plan to catalyze protection and restoration in the region. The plan seeks to engage non-federal partners in research that advances Great Lakes Water Quality Agreement goals. GLRI Action Plan II continues and refines the efforts set forth in Plan I through 2019 and Action Plan III continues the work in 2020.

The Illinois-Indiana Sea Grant Partnership

Sea Grant programs specialize in science-based, unbiased outreach and extension programming. Located at Land Grant universities in coastal and Great Lakes states and U.S. territories, Sea Grant programs couple research with outreach and education expertise to inform decision making at all levels—from K-12 students to policy makers.

Illinois-Indiana Sea Grant (IISG) is co-administered at the University of Illinois and Purdue University and works on water issues in Lake Michigan locally, the Great Lakes regionally, and, as the two states are almost entirely hydrologically connected to the Mississippi River, the Gulf of Mexico nationally.

Starting in 2005, GLNPO established an interagency agreement with NOAA to fund IISG and the other Great Lakes Sea Grant programs to help the agency bring EPA science to local and regional decision makers. This initial 5-year agreement resulted in substantial progress and led to a second agreement. The results of this 2016–2020 award are detailed in this report.

Photo courtesy of Mike Milligan

MONITORING THE GREAT LAKES

The EPA Great Lakes National Program Office has supported extensive research on the status and health of the Great Lakes. These data, gathered over decades, can enrich and inform work done by fellow scientists in the region, helping them tell a more accurate and thorough story or create new measuring techniques and models. This resource is also useful in support of lake-wide management plans and in ongoing decisions faced by local resource managers and public officials.

Since 2002, IISG has been working with GLNPO to develop products, tools, and strategies to provide access to Great Lakes offshore water quality sampling. The program has also been engaged in initiatives that develop quantitative analyses for agencies to improve the effectiveness of monitoring programs, by developing ways to make Great Lakes data collection and analysis more efficient, dependable, and precise. Through new algorithms, huge datasets can be understood quickly, and sampling can happen with more consistent accuracy.

Sea Grant is also leading efforts to coordinate agency and university scientists as they come together to study the Great Lakes in a systematic and comprehensive fashion.

With these resources and opportunities in hand, scientists can apply them to some of the Great Lakes' most pressing problems, including hypoxia, invasive species, and the threat of climate change. In these and other efforts, IISG specialists work with community leaders, natural resource professionals, and Great Lakes residents to monitor, improve, and protect the quality of the Great Lakes overall and in critical locations.

Focused Great Lakes Research

To better answer critical Great Lakes research questions, it's important to set priorities that address research gaps and to pool knowledge and expertise. The Cooperative Science Monitoring Initiative (CSMI) can focus research efforts to address issues that pose concerns in each of the Great Lakes.

CSMI is a binational research program organized through GLNPO and Environment Canada.

Every year, multiple federal, state agency and university scientists gather on one of the Great Lakes to take part in coordinated research. CSMI provides an opportunity for scientists to work with resource managers to set research priorities and then find synergies and paint the big picture of the status of each lake.

Paris Collingsworth, IISG Great Lakes ecosystem specialist, along with other IISG staffers and Great Lakes Sea Grant specialists, and in collaboration with EPA scientists, has provided leadership, facilitating the process, defining critical questions, and coordinating research efforts of various agencies

for large-scale studies. He is a member of the Great Lakes Water Quality Agreement Annex 10 CSMI task group and has participated in numerous research cruises.

Each year, the CSMI process rotates around the lakes—when it is the field season in one lake, in the other four lakes it is time for data analysis, report writing, setting priorities, or planning for the next field season. Below are some priorities and findings from the last round of CSMI sampling and monitoring for each lake.

One key finding from the 2015 CSMI Lake Michigan field season was that even though the overall quagga population decreased between 2010 and 2015, the overall biomass increased during this time. This means that quaggas are bigger than they were in 2010 and may be having more impact on the ecosystem despite being fewer in number.

IISG is making a concerted effort to get these and other research results from 2015—the most recent Lake Michigan field year—out to a broader audience. With input from CSMI scientists, IISG has developed products, including an executive summary and whitepaper, that share the story of the lake's changing food web and related research results. To reach a broader audience, IISG's Kristin TePas and Allison Neubauer developed an ESRI Story Map called Lake Michigan Health: A Deeper Dive that provides historical context and recent research results about Lake Michigan's lower food web, prey fish, and contaminant levels. In addition to leading the process to set research priorities, Collingsworth is coordinating outreach efforts among other Great Lakes Sea Grant programs.

The 2016 Lake Superior CSMI report has good news. A benthic survey of the lake suggests that populations of Diporeia, an important food source for many fish, are in good condition, with little evidence to suggest that the severe population declines that have been found in other Great Lakes are occurring in Lake Superior.

The Lake Huron field season in 2017 proved to be an opportunity to pilot new technology for capturing remote imagery, which could

improve spatial estimates of Great Lakes biological communities. For example, videography and autonomous underwater vehicles are promising new approaches to estimating round goby abundance in rocky habitats, which are difficult to sample using traditional methods.

In 2018, a binational survey of lake whitefish egg and larvae was completed across Lake Ontario in an effort to describe the spatial extent of white fish spawning habitat and quantify drivers of spawning success.

Researchers from the U.S. and Canada, representing numerous agencies, took part in a project in 2019 to examine the effects of multiple stressors, such as harmful algal blooms (HABs) and hypoxia, on the food webs of Lake Erie. In addition to HABs, in recent years, Lake Erie has seen the growth of hypoxic zones. These areas of low oxygen, often caused by an excess of nutrients, can be very debilitating for aquatic life. They also are challenging for water treatment facilities—hypoxia can change the water's pH and can cause discoloration. Facilities can adjust their treatment to account for the impact of hypoxia in drinking water treatment, but a warning system could provide the necessary time.

Access to Data

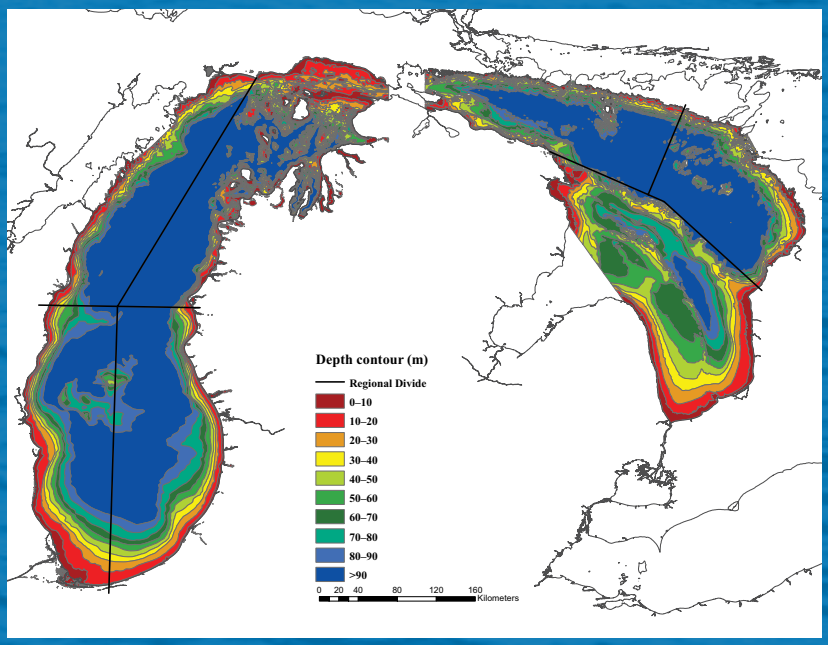
GLNPO's years of monitoring data can be a valuable tool for scientists and resource managers to see trends and shifts over time. As scientists connect historical data with their own, they can tell a more accurate story of the health of the Great Lakes or create new measuring techniques and models.

IISG and the National Center for Supercomputing Applications (NCSA) at the University of Illinois developed greatlakesmonitoring.org, a one-stop shop for information. The website makes it easy to view and analyze decades of nutrient, contaminant, and other water characteristic data. Great Lakes Monitoring routinely checks the EPA water quality archive and uploads new, quality-controlled datasets.

When GLNPO's rich data resource informs the development of new algorithms, new data can be analyzed more quickly and consistently. The historical data can also be key to developing new technology to address old and new Great Lakes concerns.

For example, Collingsworth worked with engineers at NCSA to develop ways to consistently pinpoint fluctuating lake elements that are critical to understanding the health of the lakes, such as the thermocline and the deep chlorophyll layer, and to highlight anomalies in sensor data.

They developed algorithms that can read thousands of lines of data in near real time from Triaxus and Seabird sensors, filling in missing information and flagging unexpected results as they go—spikes in water temperature, drops in oxygen levels, or a pocket of zooplankton-rich water. These algorithms serve to make monitoring and data management far more efficient. In their absence, monitoring programs can collect a great deal of unusable data.



Applied Research

With the ability to tap into years of monitoring data and new algorithms, research on pressing topics such as hypoxia, harmful algal blooms, and climate change has stepped up. These findings are informing forecast models and providing new insights that can inform municipal and natural resource management decision making.

Harmful algal blooms and hypoxia

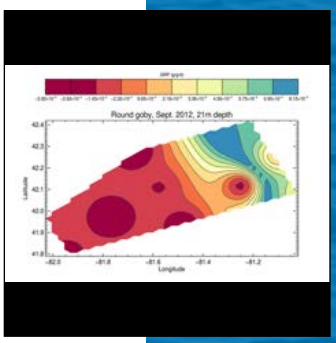
Collingsworth's participation in designing and executing the 2019 Lake Erie CSMI survey to study the combined stressors of hypoxia and HABs illustrates how his work in data access, including developing algorithms, applied research, and the coordinated approach of CSMI, helps make the most of Great Lakes research opportunities.

For this Lake Erie study, sampling up and down the food web took place over the course of the season aboard several large agency research ships, including Environment and Climate Change Canada's *Limnos*, and GLNPO's *Lake Guardian*. And the researchers used an innovative approach—each day they looked to new satellite images from the NOAA Experimental Lake Erie HAB Tracker to determine the presence of HABs and hypoxic zones (and ideally places where the two overlap) and adjust their course in real time, based on current conditions.

NOAA and the Great Lakes Environmental Research Lab have also developed a forecast model for hypoxia based on previous monitoring in Lake Erie. In 2015, Collingsworth led a team with GLNPO and

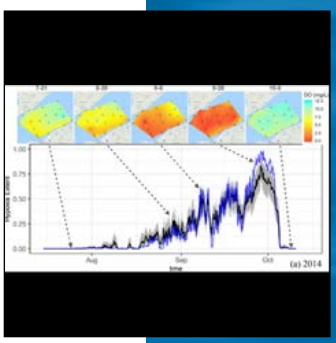
state and federal managers that deployed an array of dissolved oxygen sensors in the central basin of the lake. Extending the intensive monitoring to three years, the study produced a large dataset that revealed that hypoxia doesn't systematically spread out from the central basin of the lake as scientists have long believed. Pockets of low oxygen also continuously spring up at the edge of the basin, where they're sloshed around by internal waves.

With each of 22 sensors producing 25,000 data points each season, Collingsworth collaborated with a University of Illinois National Center for Supercomputer Applications graduate student to get a handle on so much information. They developed an algorithm that would summarize the data from each sensor into daily estimates and sync all the sensor data to a common time step.



NOAA combined this dissolved oxygen dataset with 7-day weather forecasts to provide a tool for researchers that also serves as an early warning device, alerting water suppliers when they may expect hypoxic water to intrude into coastal water intake cribs. The early warning system is run by NOAA Ecological Forecasting.

The Lake Erie hypoxia sensors and dataset have also been used in other applications with implications for resource management and commercial fishing. Researchers have studied the effects of a dynamic hypoxic zone on fisheries population assessments and its suppression of invasive species. Commercial fishers use the sensor data to set their course to where the fish likely are, based on the location of hypoxic zones.



To help in monitoring the lake's hypoxia extent and concentrations, as well as assessing the quality of its fish habitat, Collingsworth and Josh Tellier, a graduate student at Purdue University, used years of data to develop a 3-dimensional model that maps out low oxygen areas. The team tested how hypoxia and habitat quality affect three Lake Erie fish species—rainbow smelt, round goby, and yellow perch.

Climate change concerns

Because the lakes are stressed by various immediate factors, such as invasive species, hypoxia, and both too much and not enough

nutrients, long-term threats, like climate change, are often not prioritized by fisheries managers and decision makers. Collingsworth helped assess how climate change would interact with other stressors in the Great Lakes. The process included downscale modeling informed by GLNPO data; precipitation, temperature, and water levels; bioenergetics models; remote sensing data; and literature searches. The team compiled a comprehensive assessment of potential changes and impacts on fisheries and lake stressors.

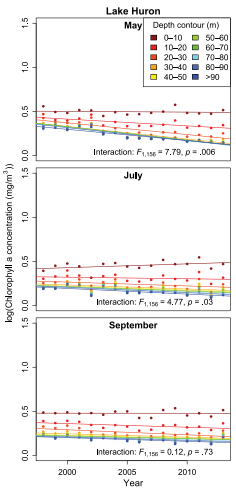
They concluded that resource managers should consider that current stressors, like hypoxia, have the potential to become worse with climate change. More frequent springtime storms could lead to higher nutrient levels in the lakes. Higher temperatures means longer periods of time when the water is stratified, consequently, longer periods of low productivity. And while the lakes have proven to be hospitable to many invasive species, for many non-native species, Great Lakes waters are just too cold for them to flourish. Warmer waters can change that.

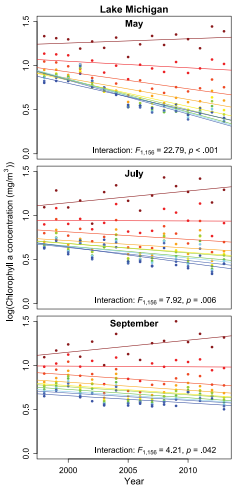
In 2018–19, Collingsworth also took part in the Indiana Climate Change Impacts Assessment, looking at how climate change would impact the Indiana waters of Lake Michigan. Researchers from several Indiana universities compiled a comprehensive assessment of potential changes and impacts on fisheries and lake stressors. They concluded that ongoing warming of Indiana's climate will accelerate over the coming century, which likely means warmer water temperatures and altered nutrient availability.

Chlorophyll mapping

Collingsworth, along with Tomas Hook, IISG director, provided guidance to Margaret Stadig, a Purdue University graduate student who used an innovative approach to assess the status of chlorophyll in Lake Michigan and Lake Huron. She studied a longtime series of satellite images of the lakes using an algorithm based on GLNPO data that analyzes colors and pixels to measure changing chlorophyll concentrations and distribution.

Since the arrival and proliferation of invasive zebra and quagga mussels, the food web in Lake Michigan has undergone immense changes—from bottom to top—in a short period of time. To assess these changes, scientists use several indicators, including monitoring chlorophyll, a green pigment found in plant and algae cells. Chlorophyll can be used as a measure of algal biomass—algae are the base of the Great Lakes food web. Stadig found that chlorophyll, which flows into the lakes from tributaries, was available in nearshore waters, but decreased or disappeared in deeper waters.



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Simply place your unwanted prescription or over-the-counter medicines into this drop box. The drugs will be disposed of properly.
OFF OF THE STREETS..
OUT OF THE WATER!
ITEMS ACCEPTED
Prescription medications (including controlled)
All over-the-counter medications
Pet medications
Vitamins & Supplements
Medicated ointments, lotions, creams, and oils
Liquid medication in leakproof containers
ITEMS NOT ACCEPTED
Needles/sharps
Syringes with needles
Thermometers
IV Bags
Bloody or infectious waste
Personal care products
Empty containers
Hydrogen Peroxide
Aerosol cans
Full Inhalers
Illegal drugs
ILLINOIS AMERICAN WATER
CITY OF URBANA

PREVENTING POLLUTION

Sources of pollution in our waterways are many. Legacy contaminants like mercury and PCBs remain long after industry is gone, but add to that, newer sources like the chemicals that help keep us healthy, ubiquitous plastic packaging, easy-to-care-for fabrics, and more.

Case in point, researchers have found traces of pharmaceuticals in waterways around the country. While the levels are not high enough to pose immediate human health concerns, negative impacts on aquatic species have been well documented. And in another example, IISG-funded research has found micro-plastics throughout the Lake Michigan food web.

Preventing pollution requires broad participation from major players to regular folks. Illinois-Indiana Sea Grant's role is to support research that helps clarify the issues, provide access to the latest results, and inform communities, professionals, residents, and youth about ways to reduce the risks that pollutants pose to the Great Lakes region.

Medicine Disposal

From time to time, we all have medicines that we no longer want or need—they expire, we get better, they don't work—the reasons are many. If you flush medicine or throw it in the trash, it's gone from your immediate world, but many of these chemicals can pass through water treatment systems or leach from landfills and turn up in local waterways, potentially affecting aquatic organisms and becoming extra ingredients in drinking water. With that in mind, what should one do with unwanted or expired medicines?

Collection programs

Sea Grant has provided guidance and resources to communities to establish collection programs since 2008, initially helping with one-day events, but then supporting permanent collection programs. Sarah Zack, IISG pollution prevention specialist, works with law enforcement to place a take back box in a location that is convenient for people to drop off medicines. She then helps the community find an environmentally responsible way for these medicines to be disposed of. It becomes a permanent resource for the community.

In 2018, this initiative to support local medicine collection programs marked its 10-year anniversary, which speaks to its longevity and its success. At that point, IISG-supported community programs in four Great Lakes states had collected and properly disposed of over 200,000 pounds, or 100 tons, of medicine. That number is now 287,000 or 143.5 tons.

The take-back program continues to grow by word of mouth—IISG regularly receives calls from law enforcement offices, inspired by success stories from neighboring communities, requesting information and support for setting up programs of their own. The demand for technical assistance is still strong. Zack also developed outreach publications to raise awareness on this issue with communities and the general public, including a fact sheet highlighting a Purdue University graduate student research project that found that societal benefits outweigh the costs of establishing community medicine collection programs.

Targeting outreach

From 2016 to 2020, IISG gave talks at 82 conferences, workshops, and outreach events and had direct contact with and provided information to nearly 7,500 people. IISG also reached out to new partners to leverage resources, assess knowledge gaps in targeted audiences, and provide needed information.

One of these audiences is veterinarians who are key players in dispensing medicine and related information. In 2016, the National Sea Grant Office (NSGO) and the American Veterinary Medical Association (AVMA) signed a 5-year renewal of the memorandum of understanding to continue their joint outreach campaign for veterinary clients with IISG serving as the NSGO's representative. Zack has informed over 800 veterinarians at annual conventions for AVMA as well as the Illinois State Veterinary Medical Association.

In partnership with the University of Illinois Veterinary Medical School, Zack also surveyed vets in the Great Lakes region, assessing attitudes and behaviors with regards to medicine disposal. About 600 veterinarians responded to the survey. The results will help shape the future of medicine disposal outreach to veterinarians in the region.

Reaching teachers and students

IISG has a rich history of engaging teachers and students in Great Lakes issues and through that, inspiring student stewardship projects. The need for proper disposal of medicines is no exception.

Zack connected with 75 high school students at the 2018 Prescription Pill and Drug Disposal Program (P2D2) Summit where she led a workshop on how to start a local collection program. In 2019, IISG helped fund the summit. P2D2 is a collaboration of students, communities, pharmacies, and more to educate the public about the threat of medicines in the environment.

She also engaged 80 7th–8th grade girls at the Girls Empowered by Math & Science conference, organized by Niles Township High Schools in 2018 and 2019. Zack hosted a half-day session on preventing water pollution that included watershed science and responsible disposal of household contaminants.

Terri Hallesy, IISG education coordinator, led a day-long teacher workshop at Indiana's Douglas Center for Environmental Education, providing science-based information on outreach and stewardship activities related to the proper disposal of pharmaceuticals and personal care products. She also organized a day-long teacher workshop at Chicago's Brookfield Zoo. The 17 participating teachers learned how to develop action plans with their students, start community collection programs, and collaborate with community agencies.

Emerging Contaminants

Contaminants of emerging concern includes pharmaceuticals, but also any chemical that is not regularly monitored but may pose a threat to human health. Microplastics, industrial chemicals, and personal care products that end up in the environment are emerging contaminants.

From 2016 to 2020, Zack gave invited presentations at events and conferences for professional audiences interested in more information about emerging contaminants issues—audiences included environmental lawyers, solid waste managers, water supply managers and planners, and environmental engineers. In total, she reached 724 professionals.

Sharing information

Zack works to bring scientists, educators, outreach professionals and others together to share knowledge and define issues and information gaps. In 2016, IISG and the Alabama Cooperative Extension Service coordinated a 2-day conference on pharmaceuticals and personal care products and health aspects for humans, animals, and the environment. Over 120 people from more than 25 organizations attended the conference in Huntsville, Alabama.

This success help fuel an ongoing partnership with the Illinois Sustainable Technology Center to host the annual Emerging Contaminants in the Environment Conference (2020 cancelled due to COVID-19), which continues to grow in participation, bringing together scientists and stakeholders in the U.S. and beyond to discuss microplastics, PFAS, endocrine disruptors, and more. The 2021 conference includes EPA GLNPO-funded scientists contributing a keynote speech as well as other sessions. The 2-day virtual event will highlight studies on emerging contaminants in the Great Lakes.

IISG also engaged Sea Grant programs in the Great Lakes and around the country to raise awareness of the issue of emerging contaminants. Through meeting sessions, workshops, and discussions about research, education, policy, extension, and legal efforts, a community of practice was formed. This group helped inform a National Sea Grant Office visioning process—Zack led the water resource piece that identified Sea Grant-led activities, strategic priorities, and associated action items to address current and future water resources challenges and opportunities. It also includes an implementation plan to drive the vision's actions, timelines, and resources.

Marine Debris

Marine debris, particularly plastics, is in waterbodies everywhere, as more and more research is finding. Whether floating in water or piling up along beaches, this trash can pose a threat to wildlife, humans, and the environment.

IISG was part of the team that helped NOAA develop its Great Lakes Marine Debris Action Plan. Zack helped set objectives and is taking on 10 actions in the 5-year plan that runs through 2025. For example, she will help develop a needs assessment of targeted audiences and will research and create a consistent messaging campaign for the region.

As with other emerging contaminants, Zack works to bring scientists and other experts together to share knowledge and define information gaps. In 2017, IISG led an all-day session focused on research studying plastics in the Great Lakes at the 60th annual International Association for Great Lakes Research Conference. This session was one of the largest at the conference with 18 oral presentations, a poster presentation, and a facilitated discussion. The conversation promoted collaboration and exchange of information among researchers and managers, and identified priorities and data needs related to research on Great Lakes plastic litter.


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MANAGING NUTRIENTS

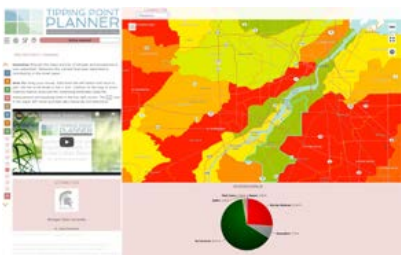
In increasingly developed environments, rainwater flows over hard surfaces, picking up various pollutants as it goes. When nutrients, such as nitrogen and phosphorus, are washed into nearby waterways from farm fields, wastewater treatment facilities, and lawns and landscapes, this can start a process that begins with an algal bloom and that ends up in hypoxia, or a dead zone.

Throughout the Great Lakes region, community leaders make long-term management decisions that affect the health of water and other environmental resources as well as residents' quality of life. Residents themselves need to consider how best to care for their own landscape while protecting nearby waterbodies.

From community planning decision support tools to outreach to homeowners, Illinois-Indiana Sea Grant helps these Great Lakes residents make informed choices.

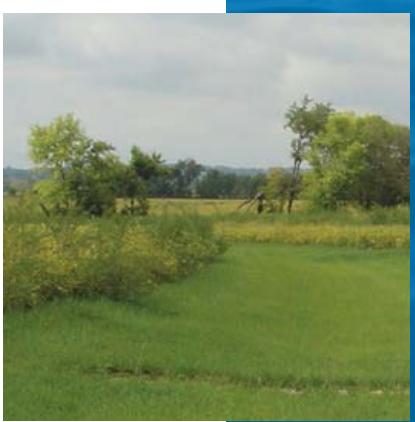
Tipping Point Planner

Protecting natural resources and enhancing resilience requires communities to understand and determine environmental tipping points, which trigger rapid, sometimes irreversible shifts in ecosystem functions.



Illinois-Indiana Sea Grant's Tipping Point Planner (TPP) is a decision support tool and a peer-reviewed curriculum for the Great Lakes region that helps communities identify land use and water quality issues affecting watershed health, and guides users through prioritizing management practices and policies.

It was created by a 22-member research team from seven universities and NOAA, Sea Grant specialists from eight Great Lakes states, and continuous input from stakeholder groups. Kara Salazar, IISG assistant program leader and Extension specialist for sustainable communities, has led community engagement activities for the TPP program since 2013.



Through TPP, Great Lakes communities can plan for sustainable futures by directly linking data to their local decision-making processes. The web tool uses the latest watershed research and technology to show planners how close their watershed is to known environmental tipping points and what the watershed will look like if land use decisions continue with "business as usual."

With help from a Sea Grant facilitator, planners can use interactive maps and simulators—along with recommended policies, ordinances, and outreach efforts—to prevent aquatic ecosystems from being degraded beyond repair.

TPP in action

Since TPP community engagement activities began in 2013, 23 communities have used the program to engage in data-driven local planning. Over the past four years, team members conducted 18 workshops with 422 natural resource manager user groups in the Great Lakes region.

Participants represented municipalities, watershed groups, government agencies, and nonprofit organizations such as the Lake Michigan Lake-wide Action and Management Plan Working group, Shiawassee National Wildlife Refuge, and Illinois and Indiana Coastal Management Programs, plus representatives from the Maumee Watershed and the National Sea Grant Network for Nutrient Reduction. The decision support tool, including its green infrastructure optimization capabilities, were featured in a workshop in Michigan City, Indiana, the Calumet Stormwater Collaborative in the Chicago region, and at a NOAA Great Lakes water quality workshop.

Community workshops consist of education and visioning sessions with local stakeholders and a series of action planning meetings with steering committees comprised of local experts.


Legal
Ex: Safety Standards
Environmental
Ex: Community Awareness
Political
Ex: Political Stability
Economic
Ex: Employment Rates
Social
Ex: Lifestyle Shifts
Technological
Ex: Research Funding
Legal
A
Natural areas conservation and management
A
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These examples from around the Great Lakes region show how TPP helps communities set priorities and develop action plans.

Michigan City, Indiana

Salazar and the TPP team worked closely with the Michigan City project team, running scenarios for the Trail Creek watershed to help in choosing the placement and type of green infrastructure best management practices. The modeling, developed by Jingqiu Chen of Purdue University, factored in cost effectiveness of several practices at six sites over 20 years and annually in terms of runoff reduction. Through this process TPP identified a land parcel that was not under consideration at the time as the top target location for cost-effective green infrastructure. All six sites were suitable for dry ponds, wet ponds, and wetlands.

Au Gres, Michigan

The TPP extension and research teams worked with Huron Pines, a Michigan-based environmental non-profit, and Michigan Sea Grant to convene regional stakeholders for a series of three meetings to support the creation of a watershed management plan for the Au Gres River and East Au Gres River watersheds along Saginaw Bay. The team guided a community visioning session to determine priorities for management in the watersheds before using the decision support system and action planning tools to better inform next steps for local and regional planners.

Perrysburg, Ohio

The TPP team worked with Ohio Sea Grant and Reveille, Ltd., in Perrysburg in the Maumee River Watershed to support the development of a city-wide, land use plan. One of the pressing environmental concerns of Perrysburg was the prevalence of harmful algal blooms in Lake Erie and other local waterways. The community worked toward improving land-management decision making by targeting nutrient loading and land use practices that impact algal blooms.

A multidisciplinary team of Purdue Extension and Illinois-Indiana Sea Grant facilitators guided this process, helping the Perrysburg team balance local values, impacts on the environment, and quality of life. Participants used the TPP decision-support tool to evaluate ecosystem services and develop action plans to guide conservation and management of ecological resources.

Going virtual

Due to COVID-19 meeting restrictions, the TPP team developed an online short course in Brightspace and an online community engagement platform that mirrors in-person activities. The new course contains four modules to train users on how to employ TPP using online community engagement techniques. It links users to videos, fact sheets, and the program curriculum.

The free, self-paced course guides users through the tool and the process of identifying land use and water quality issues, prioritizing management practices and policies, and developing an action plan. Soon after launching it online in August 2020, more than 80 participants from across Great Lakes states had completed the course.

Recognition and reviews

The TPP decision support tool, informed by research and facilitated by outreach professionals, serves as a model of experts collaborating to help communities address natural resource planning. In fact, the Tipping Point Planner program was the recipient of the 2020 Purdue College of Agriculture TEAM award, which recognizes interdisciplinary team impact and achievements of faculty and staff. In 2019, the NOAA Science Report Seminar Series featured Tipping Point Planner in their national impact report presentation series.

Throughout TPP implementation, the team has sought insights on the tool's effectiveness through evaluation surveys and interviews of those who have gone through the training workshops. Repeatedly, participants indicate a willingness to recommend the program to others and express an intent to integrate what they have learned into planning efforts. Furthermore, participants consistently indicate a greater awareness of issues impacting their water quality and watershed management approaches.

One participant reflected on how the program "presented a disciplined approach to leading a group through contentious environmental issues to arrive at consensus and develop an action plan."

With the switch to virtual engagement, a workshop participant commented, "TPP team, your information was great. I've definitely learned more from you all on using online interactive tools than anyone else I've worked with."

Going forward: Cedar Creek

For its newest project, the TPP team is bringing different interest groups together to plan the future of Cedar Creek in Indiana, which is located in the western Lake Erie basin. It flows about 32 miles from northwest DeKalb County into Allen County, where it joins the St. Joseph River.

The Indiana Department of Natural Resources in 1976 designated a portion of Cedar Creek that crosses county lines as one of only three in the state's natural, scenic, and recreational river systems. But two counties govern and manage their sections of Cedar Creek differently, and environmental, agricultural, and recreational groups have long debated its use.

Although the parties involved are all looking to preserve the integrity of the designated area, TPP will be there to provide guidance on how to best to move forward with respect to different priorities. Through online programming, the TPP team is helping the Cedar Creek Collaboration begin addressing the region's many and varied priorities.

Lawn to Lake

IISG also strives to protect waterways from nutrient and pesticide pollution through its Lawn to Lake program. The focus of this effort is homeowners that take care of their lawns and landscapes. This program promotes natural, low-input lawn care practices to reduce the use of chemicals and water for irrigation.

In 2019, with funding from the University of Illinois Extension, state residents were surveyed to obtain baseline information about their practices, knowledge, attitudes, behaviors, and information needs regarding lawn care. IISG's Sarah Zack and Allison Neubauer held three focus groups.

Of the 849 survey participants, 72% responded positively about environment-friendly lawn care practices. And through the focus groups, the Lawn to Lake team received valuable feedback on outreach materials, in addition to further insight into participants' lawn care practices and preferences. The resulting peer and audience reviewed outreach brochures and factsheets will be used in Illinois and throughout the Great Lakes region.

GREAT LAKES CLEANUPS

The Great Lakes Legacy Act helps communities reconnect with once thriving waterways that over time have become degraded by toxic chemicals and other pollutants from long-gone industries. Since 2002, the Legacy Act has provided opportunities to clean up contaminated sediments in sites designated as Great Lakes Areas of Concern (AOC). These projects help to revitalize local waterfront economies through strong partnerships with states, municipalities, and businesses.

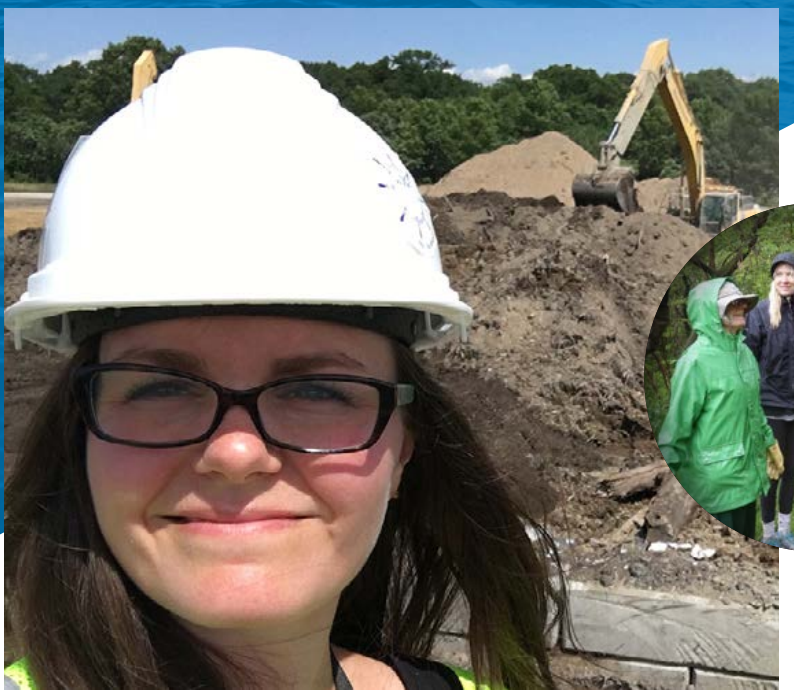
Throughout the cleanup process, IISG works closely with many of these communities undergoing remediation. From 2016 to 2020, Caitie Nigrelli, IISG's environmental social scientist, engaged with residents, stakeholders, government officials, and even school children to ensure that their questions are answered and concerns are heard or addressed, and to help the community make the most of this chance to turn the waterfront environment and economy around.

Here are some on-the-ground outreach stories from AOCs around the Great Lakes that are undergoing Legacy Act cleanups.

The Muskegon Lake AOC: The Zephyr Oil Refinery

In the early 1900s, Muskegon County experienced a mini oil boom and the Zephyr Oil Refinery set up shop overlooking the Muskegon River, converting crude oil into gasoline and naphtha. Over its lifetime, the company spilled hundreds of thousands of gallons of oil and built a ditch from the wetlands below to bring water closer to put out fires. During oil-based fires, water mixed with oil, ash, and smoke—this mucky water was then returned to the wetlands.

Through the Great Lakes Legacy Act, the Muskegon Lake Area of Concern took one step closer to a clean bill of health. At the former Zephyr Oil Refinery, one of the last sites slated for cleanup in this AOC, 50,000 cubic yards of sediment contaminated with petroleum, lead, and other heavy metals were removed from an adjacent wetland that has now been restored with native plants.



Community questions and concerns

Before the cleanup, Nigrelli and her intern Carly Norris interviewed residents to understand people's perceptions of the remediation. What they learned in this needs assessment was that some residents were confused about what the cleanup entailed and that many were very concerned about possible odors released from digging up petroleum-soaked sediment. These findings helped shape how the public was informed as well as the cleanup process itself.

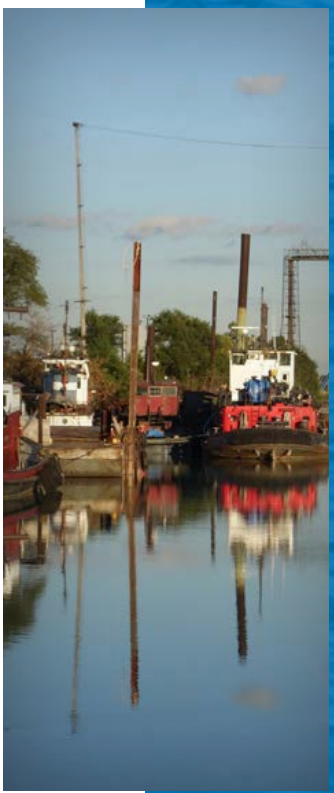
To address these concerns, EPA installed an air monitoring system and established a hotline for residents to report odors. The process was also timed to take advantage of cooler months when people typically have closed windows. Onsite, dredgers used odor suppressing foam and quickly trucked away the smelliest sediment.

To help facilitate community involvement and ownership of this cleanup, Nigrelli arranged a public meeting, designed posters, created webpages, led a teacher workshop and site tour, and sent out mailings to update stakeholders on the cleanup process.

Bringing remediation to the classroom

The cleanup also provided an opportunity to engage local students in learning about the impact of pollution in their community. To give students in the Reeths-Puffer School District a glimpse of the environmental restoration happening near their schools, IISG's Ben Wegleitner brought drone video footage of the site to their classrooms and talked to students about sediment remediation. About 250 Muskegon area students and their teachers were encouraged to ask questions and take part in discussions of Great Lake issues.

The Rouge River AOC: The Lower Rouge River Old Channel



Like a number of Michigan waterways, the Lower Rouge River in Detroit has a long and rich industrial past. This kicked off in the early 1900s when Henry Ford enlarged a shipping canal to the Detroit River to allow freighters to move through the Rouge. Over time, a flood of contaminants flowed into the river and remain in the sediment of the Old Channel. A Great Lakes Legacy Act project is underway to remediate up to 70,000 cubic yards of sediment near an environmental justice community.

Connecting with the community

To improve outreach efforts, Nigrelli and Wegleitner talked with residents and stakeholder groups to understand their perceptions of the river and the remediation process. The results were shared with EPA and community leaders. Among many findings, the assessment revealed that information should be available in multiple languages.

To help facilitate community involvement and ownership of this cleanup, in 2017 Nigrelli helped plan a meeting for industrial property owners and other shipping industry stakeholders. She also participated in local environmental organization meetings and through the Great Lakes Mud website provided updates for stakeholders and the public on the cleanup process. Nigrelli produced a trilingual fact sheet (English, Spanish, and Arabic), and ensured that posters, presentations, and a press release used plain language.

After school learning

IISG funded and mentored a graduate student from Wayne State University to deliver the Helping Hands curriculum at an after-school program through the People's Community Services of Metropolitan Detroit. Through this program, 20 low-income students and four educators serving low-income districts were provided the opportunity to connect with an urban waterway and learn about cleanup efforts. The students grew native plants, created a mural of the Rouge River ecosystem, and engaged in critical thinking discussions about how cleanup projects help fish and wildlife. IISG also provided resources

for teachers to attend a Friends of the Rouge teacher workshop to learn about the Rouge River cleanup.

The St. Louis River AOC

The St. Louis River is the largest tributary flowing into Lake Superior and, geographically, this Area of Concern is the largest in the Great Lakes. Sitting between Minnesota and Wisconsin, the St Louis River has been a center of shipping and industry, with hydrocarbons and other pollutants remaining in the sediment long after industries have left.

The Duluth waterfront

In the St. Louis River in Duluth, Minnesota, a number of sites have been slated to undergo remediation through the Legacy Act. Two projects in 2018 cleaned up 148,000 cubic yards of sediment contaminated with dioxins, PCBs, PAHs, and heavy metals. This remediation took place at Minnesota Slip and Slips 3 & C, in the heart of Duluth's tourism sector, heightening the need to keep the public informed.

Nigrelli coordinated an information session for the Canal Park Business Association, recruited a speaker from EPA for the St. Louis River Alliance annual boat tour, and organized a site tour for 50 high-level agency and elected officials, including the Duluth mayor. To inform the public, both tourists and locals alike, she convened an outreach team to develop a fact sheet and press release. The team also created signs to enable downtown visitors to reach the Duluth Entertainment Convention Center safely during remediation by using the alternative walking path.

Spirit Lake

Spirit Lake is a large open area in the St. Louis River near the former U. S. Steel Duluth Works site. The cleanup of Spirit Lake is $75 million Legacy Act project agreement between U. S. Steel and EPA. One of the largest PAH contamination sites in the nation, the cleanup will remediate 2.65 million cubic yards. This project will increase total cubic yards remediated through the Legacy Act over its 16 years by 65%.

Spirit Lake plays an important role for local people, including those who live in Duluth's Morgan Park neighborhood, which began as a company town for the plant workers. Additionally, Spirit Island, a sacred place for the Fond du Lac Band of Lake Superior Chippewa, is located in the lake. The cleanup will have a tremendous impact on many stakeholders with conflicting needs.

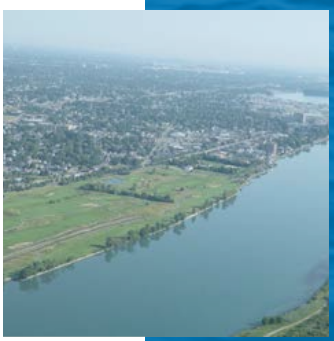
Nigrelli created and led an outreach team of stakeholder representatives in conflict to find common ground and forge consensus building. The team worked together on public meetings, fact sheets, and presentations. In 2018, the team announced the project agreement through a variety of channels.

Other Projects

The Milwaukee Estuary

In this AOC where much cleanup work has already taken place, plans are in the works to remediate the approximate 1–2 million remaining cubic yards of contaminated sediment. The only economically feasible way to conduct the Legacy Act project is to construct a new dredge material management facility (DMMF) on Lake Michigan, where the sediment will be placed. This plan has some hurdles to jump because in past projects, community opposition to nearby containment locations has significantly altered plans and costs.

Nigrelli joined with local, state, and federal stakeholders to create an outreach team to communicate with a range of audiences about the DMMF. She advocated for a strategic, structured, and stepwise approach to explain the costs and benefits of these often controversial facilities. As a result, everyone was informed in a prescribed order, first technical stakeholders, then elected officials and community leaders, and finally the public. IISG also created a panel of key stakeholders to help introduce the DMMF concept in an informal, accessible way.



Upper Trenton Channel of the Detroit River

U.S. EPA in is the design phase for a cleanup to remediate 240,000 cubic yards of sediment in the Upper Trenton Channel of the Detroit River. The design process is taking much longer than is typical, creating the need for updates with important stakeholders who are not on the technical project team, as well as a need for communication and outreach to communities and stakeholders about the cleanup and impacts to the area. Nigrelli held meetings to provide updates and answer questions on this project—participants included municipal leaders, city engineers, city lawyers, and the mayor of Riverview.

The Grand Calumet River: a sense of place

The Grand Calumet Stewardship Day is an annual event that takes northwest Indiana school children out of the classroom and immerses them in nearby nature along the river at Roxana Marsh or Seidner Dune and Swale. Hosted by IISG, along with The Nature Conservancy, the field trip provides an opportunity for the students to participate in education and stewardship stations—from bird watching to tree planting.

As remediation and restoration projects continue in this AOC, cleaned up environments offer these young stewards and scientists an opportunity to experience a 'sense of place' for the Grand Calumet River. Nigrelli uses this well-established social science concept to capture the students' place attachment, which is predictive of future environmental stewardship at that place. Between 2016–2019, 220 students clearly increased their sense of place after their day of learning along the Grand Calumet River.

Outreach and education resources

Nigrelli developed other outreach products and campaigns to reach Great Lakes audiences—from school children to potential Legacy Act partners to the general public. She also helped outreach teams on the ground in AOCs do their job better.

Nigrelli recruited AOC communities to submit their best management practices for outreach and communication related to the remediation process, particularly the use of visual media technology. She created a portal for local AOC community leaders that included the best examples. This compendium of outreach and communication tools and practices was shared at the 2019 AOC Conference.

For educators, IISG expanded its Helping Hands curriculum so it can be used in communities with sediment remediation projects throughout Areas of Concern in the Great Lakes. The corresponding website serves as a teacher companion for Helping Hands, and provide additional resources for carrying out lessons, including PowerPoints and diagrams.

To explain what it means to be a Legacy Act cost-share partner with EPA, Nigrelli directed and produced, “A Seat at the Table: Great Lakes Legacy Act.” Through partner interviews, the video describes the benefits and challenges of cost sharing, the cost-sharing mechanism, examples of in-kind services, and the flexibility of partnerships. The video was released with a Twitter campaign, #22SedimentStories, and was shared at three state AOC meetings.

The #22SedimentStories campaign starred #SedimentSam, a paddle-boarding sediment sample shaped as a core tube, who described 22 Great Lakes remediation projects using facts, photos, maps, and jokes, and invited others to share local stories. During the Twitter campaign, @Gr8LakesLady gained 300 followers, a 50% increase. The #22SedimentStories campaign created more than 285,000 impressions with 4,950 engagements, including 1,499 likes and 670 retweets.

Also a source of online information, Great Lakes Mud is a website created by IISG in 2014 that provides history as well as up-to-date information on Great Lakes Legacy Act projects. In 2017, the site coverage expanded from eight to 28 projects. Descriptions and definitions of several legacy contaminants were added as well as information about emerging remediation technology.

GREAT LAKES LEARNING

The Great Lakes face many threats—invasive species, pollutants, and climate change, among others. However, local decision makers managing a large ecosystem may come to the task unprepared. They, along with the general public, may not have a good grasp of the characteristics, functions, and value of these waterbodies.

These lakes are also woefully underrepresented in school textbooks and other educational resources. A more Great Lakes-literate public could better contribute to the environmental, economic, and social sustainability of the Great Lakes.

Center for Great Lakes Literacy

Sea Grant's strength is in translating and delivering cutting-edge, science-based information to address complex issues so it is well suited for filling this literacy gap. Increasing literacy across the basin can be accomplished in many ways, though one of the most effective and efficient ways is through working with educators. These efforts can also help grow future scientists who conduct aquatic research, and resource managers who guide the responsible use and conservation of the Great Lakes ecosystem.

The Center for Great Lakes Literacy (CGLL) brings together the Sea Grant education specialists in the region, establishing basin-wide coordination of hands-on professional development workshops, educational resources, and networking opportunities among educators, scientists, and residents. Kristin TePas, IISG community outreach specialist, as a liaison to EPA GLNPO, has provided guidance since CGLL's inception.

Through workshops, curricula, and other resources, CGLL provides opportunities for educators and their students to learn about Great Lakes science, pressing concerns in these waters, and stewardship ideas. Plus, teachers can join a network of fellow educators, scientists, and Sea Grant specialists for more opportunities to grow in knowledge and confidence and bring that to their students.

The CGLL team continually strives to expand the reach and impact of the center's work. Cultivating a community of practice, CGLL now has more opportunities for educators to work together and mentor and help each other. And today's technology is offering avenues to make learning available to a wider audience.

The CGLL community is also growing to include the culture and knowledge of underrepresented Great Lakes residents. For example, New York Sea Grant led the effort in 2020 to develop a new curriculum collection called Freedom Seekers: The Underground Railroad, Great Lakes, and Science Literacy Activities. The lessons acknowledge the enslaved Africans who had to rely on environmental science principles in their quest for life and liberty.

Workshops, Resources, and More

CGLL connects educators with scientists, both onboard research vessels, and in their local watersheds. Also, at the heart of CGLL educator resources is a rich supply of curricula on the Great Lakes, as well as hot topics in the region, such as aquatic invasive species and medicine disposal. These resources are showcased in workshops and are available online. And what can't be downloaded, can be borrowed. For example, educators can borrow the Aquatic Invader Attack Pack, filled with materials about aquatic invasive species, the problems they cause, and what can be done about them. Educators who are introduced to CGLL workshops and curricula have opened a door to many more resources, ideas, and support.

All aboard science workshops

Each summer, on one of the Great Lakes, Sea Grant and GLNPO facilitate a weeklong workshop aboard the *R/V Lake Guardian*, providing educators in the region the opportunity to actually "do" science alongside aquatic researchers, learn strategies to successfully integrate Great Lakes science into their curriculum, and develop a network of like-minded teachers and scientists.

From 2016 to 2019, 59 educators participated in these Great Lakes science immersions (with the ability to reach more than 3,500 students annually), and cruises set sail on four of the five lakes.

A survey of workshop participants in 2016–19 led by Michigan Sea Grant revealed themes that resonated with the educators. Common takeaways from their time aboard included an awareness of the problem of harmful algal blooms, the importance of food webs, and the issues of microplastics and other contaminants. The responding educators also highlighted their increased understanding of the process of scientific data collection, as well as its importance.

Many teachers implemented school initiatives following their time aboard the *Lake Guardian*. In follow up, educators described connecting students and scientists through videocalls, bringing real-world Great Lakes science to the classroom. Some incorporated new curriculum, including Nab the Aquatic Invader and the Watershed Game, providing a venue for student debates. Other educators described organizing field trips—for example, Lake Guardian tours and beach clean-ups.

Minnesota and Wisconsin Sea Grant programs have regularly hosted an onboard workshop on the *S/V Denis Sullivan*, a 3-masted schooner in the Great Lakes. In 2019, 16 educators focused on Lake Superior ecology and experienced water sampling, but they also learned about Chippewa treaty rights and tribal approaches to resource management. Sea Grant educators teamed up with Fond du Lac Tribal and Community College education/outreach specialists to foster awareness of the tribal relationship with the lake.

Local watershed workshops

Shoreline workshops, which range from one day to a week, employ the same best professional development practices as the shipboard workshops, including experiential education and opportunities to interact with scientists. What makes the shoreline workshops distinctive is that they are typically place-based—classroom and stewardship activities are brought home as local educators learn about issues in their watershed. Curriculum is often the focus as it relates to hot topics in the region.

From 2016 through 2020, Sea Grant education specialists organized 77 land-based workshops for 1,267 educators. Altogether, these teachers brought new knowledge, skills, and resources to more than 175,826 learners.

In 2019, Illinois-Indiana Sea Grant provided support for teachers who had participated in CGLL workshops to develop stewardship and other student projects. The students focused on writing letters to elected officials, recycling, trash collecting, planting, and reducing use of single-use plastics. Students created art, informational campaigns, and Earth Day events.

As life went virtual in 2020 due to the pandemic, CGLL workshops were no exception. Sea Grant programs quickly rerouted training online. For example, Michigan Sea Grant converted its 3-day summer place-based stewardship education institute to eight weeks of self-paced online learning. Participating teachers were also engaged in a variety of virtual learning tools they could use in the coming school year, from Google Classroom to Flipgrid to Jamboards. Since the program started in 2015, more than 70 educators have participated in Michigan's placed-based training—in person or virtual—leading to more than 2,000 youth taking part in Great Lakes stewardship projects.

Going forward, as normal life resumes, virtual workshops will continue to play a role, even as on-site events are back on the schedule. The convenience and availability that online workshops provide will be weighed against the benefits of engaging in on-site learning.

Students doing real science

The Limno Loan program, which is coordinated by IISG in partnership with GLNPO, is an opportunity for educators to borrow monitoring equipment actually used by scientists in the field.

With the Hydrolab data sonde, students can collect water quality data from their local waterways and analyze characteristics such as pH, conductivity, and dissolved oxygen. Teachers have found that bringing the Hydrolab into the mix engages students to investigate real-world problems and provides an opportunity to discover answers.

It also draws students into the experience, both because they can operate high tech equipment, and they can read the data immediately. Educators have commented that their students say using the Hydrolab makes them feel like "real scientists."

Between 2016 and 2020, 14 workshops were conducted to introduce educators to the Limno Loan program. Of those trained (some shipboard, some shoreline), 48 educators have borrowed the Hydrolab (with many now borrowing it annually)—reaching over 5,800 students.

Scientists visit virtually

The work of scientists can seem like another world for many middle and high school students so TePas developed the Scientists Ask Students (SAS) program to connect students with Great Lakes scientists on board the Lake Guardian, via videocasts. While out on the lakes collecting samples, scientists visit classrooms virtually and talk with students about aquatic science, water quality monitoring, careers, and life on a ship.

Since the program's inception, over 25 scientists, 33 teachers, and more than 3,400 students throughout the Great Lakes have participated.

In some cases, students caught the crew while they were on board collecting and analyzing samples. Others talked with GLNPO scientists from their offices. But for many students, it was a once-in-a-lifetime chance to discuss everything from water quality to food webs to what it's like to live and work on a ship. Many of these students have experience with the Hydrolab and can therefore discuss water quality issues with the scientists. They asked scientists about the health of the Great Lakes, how research is conducted offshore, and careers in the environmental field, and got a tour of the ship.

This spring, due to COVID-19, as with most events, SAS videocasts needed to be rethought, if the program happened at all. Working with several teachers, TePas and IISG's Allison Neubauer refashioned the get-togethers with everyone in their homes, both scientists and students alike. This new approach has been beneficial in encouraging participation from different types of learners, ranging from those who feel comfortable directly asking the scientists questions to those who would prefer to type in a chat box.

Community of Practice

CGLL envisions a community of Great Lakes literate educators, students, scientists, environmental professionals, and local volunteers dedicated to improved Great Lakes stewardship. This requires a strong, vibrant, and self-sustaining community of practice to reduce the barriers that make it difficult to integrate Great Lakes literacy into classrooms in new and empowering ways.

Curricula and workshops get the ball rolling, but CGLL is also there for teachers to take their involvement in Great Lakes literacy efforts further. From 2016–2020, CGLL supports educators to attend and present at state, regional, or national professional education conferences. And, the CGLL team facilitates place-based stewardship events for students and adults throughout the watershed; many experiences were related to coastal, stream or watershed clean ups, but also storm drain stenciling and removing invasive species.

Looking for other ways to expand the community of practice and the impact of the center's work, the CGLL team developed a mentoring program. With funding from GLRI, mentors were recruited from educators who had previously participated in CGLL workshops to advise and train novice Great Lakes educators. CGLL's workshop participants represent some of the most enthusiastic, creative, and motivated educators from across the basin

The mentoring program provided additional training to teachers to prepare them as mentors and it supported educators who

wished to extend Great Lakes learning and stewardship beyond the classroom. Through this project, 46 mentors and upwards of 102 mentees participated in professional learning, which included techniques for integrating Great Lakes materials into their classrooms, examples of successful stewardship activities, strategies for interacting with the Great Lakes research community, and methods for overcoming barriers to incorporating Great Lakes science into K-12 education.

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A wide range of mentoring activities and projects were documented across the Great Lakes basin, with program participants reporting significant impacts for themselves, their students, and their communities.

For example, in Pennsylvania, a mentor-mentee team empowered their middle school students to be stewardship leaders in the school through research projects on plastic bags, straws, and single use plastic bottles. Students met with a local scientist to learn about the issue, they developed a survey and collected data on why their peers drink water from single use plastic bottles. The students created presentations and hands-on activities and shared their work with 150 students at the 2019 Penn State Children's Water Festival.

In follow up evaluations of the mentor program, many participating educators described learning and growing in areas of content expertise or local community partnerships. In Ohio, the mentor-mentee pair teamed up with Ohio Sea Grant and the Cleveland Museum of Natural History to conduct a workshop for educators in the region on the threat of aquatic invasive species, how invaders are introduced, and their impacts in the Great Lakes. They were provided new instructional strategies, games, lessons, and resources for teaching about this issue in their classrooms.

The mentor project empowered educators to become leaders, which is further growing and strengthening the CGLL network and the community of practice.