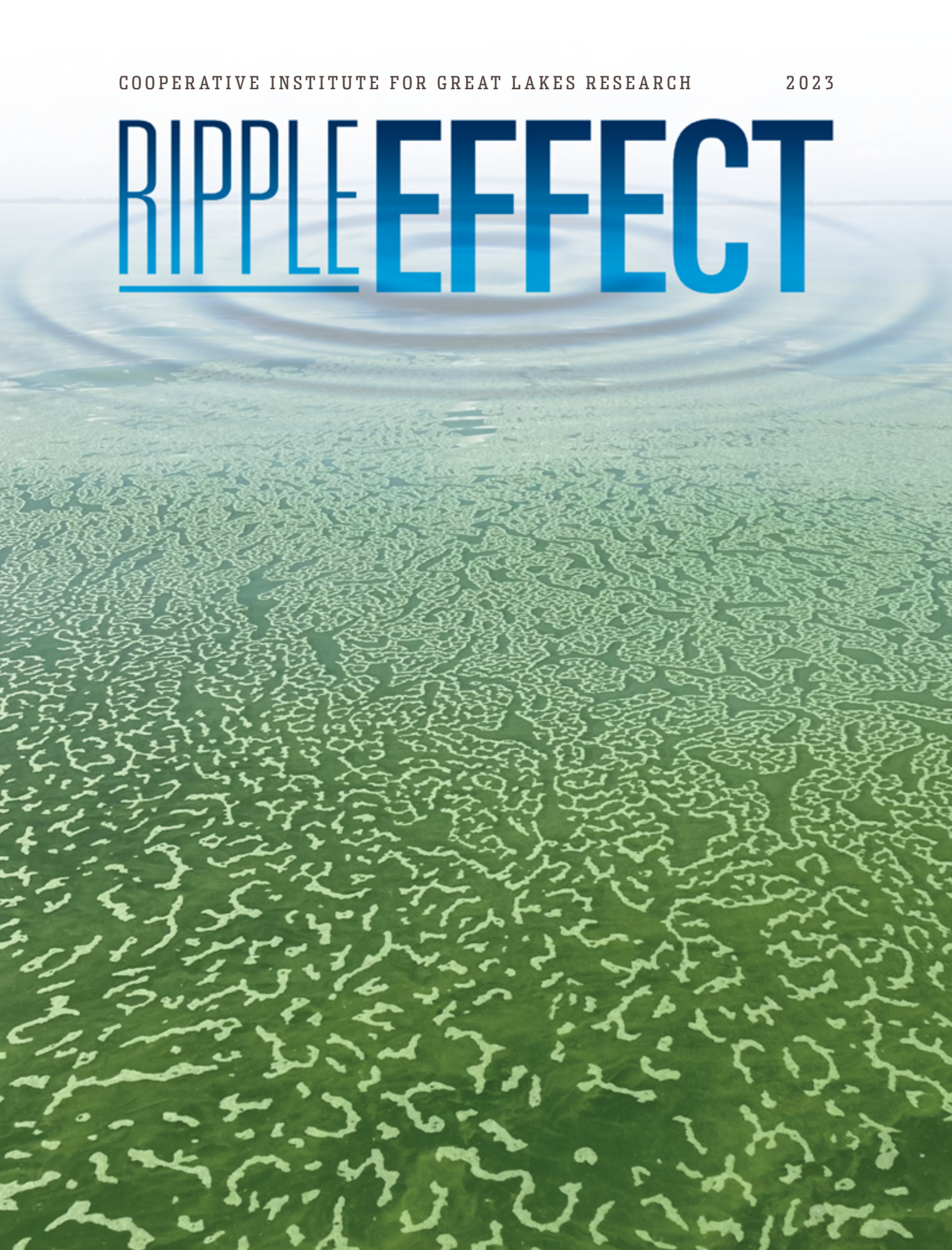
COOPERATIVE INSTITUTE FOR GREAT LAKES RESEARCH 2023

RIPPLE EFFECT

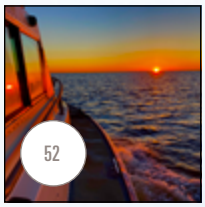


What's Inside

Mission Statement

As a NOAA Cooperative Institute, CIGLR helps NOAA accomplish its goals for research and management of the Laurentian Great Lakes by leading exciting new research efforts, training the next generation of Great Lakes scientists, expanding NOAA research in the Great Lakes through our Consortium, and translating research into actionable science to meet societal needs. The Great Lakes Environmental Research Laboratory (GLERL) is our primary NOAA sponsor and home of CIGLR research personnel.

Can Invasive Mussels Be Controlled?



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Dear Friends and Colleagues,

When I interviewed to be the Director of CIGLR, I was asked about my experience and plans for engagement. *Engagement*... I think I replied with something about outreach and some content from a book I was working on. Two years later, with what I now know about the depth, breadth, and importance of CIGLR's engagement work, I'm both embarrassed by my terrible answer and thankful that I still got the job. I now see engagement as a major strength of CIGLR's approach to research and a key element of the growth that we have undertaken in the past year. Engagement is an essential component of how we develop knowledge and products and inform policy and management actions.

CIGLR Director, Dr. Gregory Dick

CIGLR's research engagement program has grown in leaps and bounds since spring of last year when we were down to zero engagement staff. That changed when Research Engagement Specialist Megan DiCocco was hired and started rebuilding the program. Later that year, Riley Ravary joined CIGLR as an engagement lead and helped to add two more full-time engagement staff, Aubrey Arnt and John McClure, shifting our program into high gear. Together these four engagement specialists are supporting 15 current and pending projects, co-designing research and products by serving as a critical interface with stakeholders, rights holders, and end users. For example, they are working closely with the U.S. Army Corps of Engineers to co-design our development of next-generation water level predictions. The Research Engagement team has also engaged stakeholders in co-design of user interfaces for remote sensing products and updates to the Great Lakes CoastWatch node website, which went live this fall. They are beginning a new collaboration on a Michigan Sea Grant project which seeks to provide decision support and usable resources to Michigan's coastal resilience managers. They will also be working with my research group to make sure that a new database of all Great Lakes environmental genomics data is useable and accessible.

Another key piece of our engagement work is in the realm of policy. Here we were delighted to welcome Dr. Mike Shriberg, who brings his wealth of experience as the former executive director of the National Wildlife Federation's Great Lakes Regional Center to his new position as CIGLR's Director for Engagement. In this role, Mike will collaborate with scientists at our research institute and around the CIGLR Regional Consortium to align their work with key policy needs and to connect the results of our research to policymakers. Already, Mike is expanding CIGLR's networks and connections across the Great Lakes region and strengthening our existing partnerships in order to amplify CIGLR's societal impact *(see Mike's full introduction on page 6).* This past year our policy engagement activities also included a trip to Capitol Hill, hosting staff of the U.S. congressional representatives from Michigan on the University of Michigan campus, and a revitalization of interactions with regional partners such as the Great Lakes Commission, who helped co-organize a CIGLR summit on harmful algal blooms this fall.

CIGLR's broader scientific capacity is also developing quickly with the addition of three new principal investigators (PIs) in the past year. Drs. Yi Hong, David Cannon, and Dani Jones *(see introductions on page 8)* will execute two major projects funded by the Bipartisan Infrastructure Law, among others. Yi Hong is a hydrologic and hydrodynamic modeler who will address major questions and challenges regarding impacts of climate change on Great Lakes hydrology, including developing new forecasts for coastal flooding and water levels. David Cannon is a physical limnologist with deep experience in both observations and modeling of hydrodynamics. He will work to improve simulations of climate change in the Great Lakes and to develop new models of coastal flooding. Dani Jones is a physical oceanographer and data scientist who will harness artificial intelligence for applications to Great Lakes research, from designing observing systems to making sense of vast streams of data to developing next generation forecasts. The outlines of a

CIGLR Artificial Intelligence (AI) Lab, which will catalyze AI research, innovation, and training, are taking shape as I write this. Together with a new assistant research scientist in atmospheric science planned this fall, these colleagues represent the next generation of CIGLR's scientific leadership.

This year also saw major accomplishments from our established PIs. Dr. Ayumi Fujisaki-Manome, our Theme Lead for Hydrometeorological & Ecosystem Forecasting, was promoted to Associate Research Scientist. The promotion process is rigorous, with evaluative external letters and multiple levels of review within the university, so this is a major accomplishment. Ayumi also landed two major grants from the National Science Foundation, one in collaboration with postdoc (now Assistant Research Scientist) David Cannon and the other in collaboration with The University of Maryland Eastern Shore, a historically Black university. Several other major grants are pending. The effort we invested into competing for external grants reflects CIGLR's aspiration to build our research capacity and lead cutting-edge research in the Great Lakes.

As CIGLR grows, we want to retain our values and goals of conducting excellent research that is beneficial to society in a collegial and collaborative environment and with a strong community that supports principles of diversity, equity, inclusion, and justice. In this spirit, we kicked off a new annual CIGLR Staff Awards program to recognize the outstanding work done by our staff and postdoctoral research fellows. It was truly an honor to present these inaugural awards this year, to Ashley Burtner for Research Excellence, to Christine Kitchens for Diversity, Equity, Inclusion, and Justice, to Songzhi Liu for Science for Society, and to Kelly McCabe for Community.

I hope you conclude from these examples, as I do, that CIGLR is growing and evolving in exciting ways. I want to take a moment to recognize that a key force driving much of this transformation is our Program Manager, Mary Ogdahl. Mary leads many critical areas of our research institute, often behind the scenes. This includes budget administration, personnel management, reporting, proposal development and submission, U-M and NOAA compliance, and our ECO program. She also promotes partnerships across CIGLR's Regional Consortium, administers our competitive fellowship programs, and manages summits, working groups, and seminar series that engage hundreds of students, scientists, policymakers, and educators from across the Great Lakes region every year. I could go on but suffice it to say that Mary is at the center of most if not all of what we do! Thus, it was gratifying to see that Mary's tireless effort and outstanding leadership were recognized with the 2023 University of Michigan Research Leadership Recognition Award. This university-wide award recognizes distinguished service to the research community and celebrates exemplary leadership that positively impacts colleagues and advances the University of Michigan's mission. I cannot imagine a more deserving individual.

I close on an inspirational note. This past summer, three men from northern Michigan completed an 8-year quest to cross all five of the Laurentian Great Lakes on paddleboards. This year they faced one of their stiffest tests yet, with wind gusts over 16 knots, waves over 3 feet, rain, and wildfire smoke during their 35-mile, 13 hour crossing of Lake Ontario. Driven by a love for the Great Lakes (and a challenge, obviously!), this "Stand Up for the Great Lakes" team partnered with CIGLR to raise over $25,000 to help expand Lake Ontario research and restoration work and train the next generation of Great Lakes scientists. In their words, numerous little actions equal big results. We salute you, Jeff, Kwin, and Joe, for your remarkable feat and for supporting Great Lakes research. You remind us of what a privilege it is to work every day to understand and promote the health of the Great Lakes.

Sincerely,

Gregory J. Dick, PhD
Director
Cooperative Institute for Great Lakes Research

Cooperative Institute for Great Lakes Research
CIGLR
Great Lakes Science for Society

In Memoriam

REMEMBERING GREAT LAKES RESEARCHER, DR. MICHAEL FRAKER

It is with heavy hearts that we share the passing of Michigan Sea Grant (MISG) research program manager and U-M School for Environment and Sustainability (SEAS) researcher (and former CIGLR Assistant Research Scientist), Michael Fraker, PhD. Mike was a well-respected scientist and dedicated researcher, administrator, advisor, colleague, and friend. His expertise in ecological modeling contributed to improved insight and management of Great Lakes fisheries. We are so grateful for his many contributions to Great Lakes research and beyond. Our thoughts and condolences go out to Mike's family and all who knew him.

Mike earned his PhD in ecology and environmental biology at the University of Michigan with advisor Earl Werner, PhD, in 2007. He joined MISG in August 2021 as Research Program Manager, where he led projects on critical Great Lakes issues, such as sustainable fisheries, healthy coastal ecosystems and climate change adaptation. Prior to joining MISG, Mike served as Assistant Research Scientist at CIGLR, spearheading work in issues of aquatic ecology like harmful algal blooms, fisheries and ecosystem responses to multiple stressors. He also held postdoctoral research positions at U-M, Oklahoma State University and Ohio State University.

Outside of the office, Mike enjoyed running, visiting parks and watching movies. He will be terribly missed.

Donate to the Dr. Michael Fraker memorial fund

Stand Up for Great Lakes:

PADDLEBOARDERS RAISE >$25,000 IN FIFTH GREAT LAKE CROSSING

STAND UP FOR GREAT LAKES paddle boarders have finished their 8-year quest to cross all five of the Laurentian Great Lakes. Having already crossed Lake Michigan (2015), Lake Huron (2017), Lake Superior (2018), and Lake Erie (2019), Lake Ontario was all that remained. Once again, the **Stand Up for Great Lakes** team partnered with CIGLR to raise over $25,000 that is helping to expand Lake Ontario flood control and shoreline restoration work, as well as train the next generation of Great Lakes scientists.

The team includes Jeff Guy, a financial advisor with Merrill Lynch in Traverse City, Michigan; Joe Lorenz, a personal trainer in Traverse City, Michigan; and Kwin Morris, a middle school science teacher in the Elk Rapids School District and the owner of Twin Birch Golf Club.

The trio believes that many little actions yield big results. Jeff, Joe, and Kwin love the water, love the challenge, and love the Great Lakes, so why not raise awareness and resources while stand-up paddleboarding?! As each lake crossing is completed, Stand Up for Great Lakes uses the publicity surrounding their trips to raise money for a non-profit organization that conducts research and educates the public about the Great Lakes.

Jeff Guy, Kwin Morris, and Joe Lorenz are pictured here in June after paddling across Lake Ontario.

"CIGLR is doing spectacular work, and they have dedicated many research efforts to safeguard the Great Lakes ecosystem," says Lorenz. "They are experts in Great Lakes issues, and we are thrilled to have them on board our team once again."

Stand Up For Great Lakes also partnered with CIGLR in 2019 when the trio paddled 80 miles across Lake Erie, raising over $17,000. The team started at the Belle Isle State Park in Detroit, Michigan and traveled down the Detroit River before making the Lake Erie crossing to Catawba Island State Park in Ohio.

Lake Ontario was the last of the Great Lakes for the trio to cross on stand-up paddleboards, and arguably one of the toughest. Starting

Stand Up For Great Lakes presented CIGLR with a generous donation that will be used to expand Lake Ontario flood control and shoreline restoration work, as well as train the next generation of Great Lakes scientists. Pictured: Joe Lorenz, David Cannon, Yi Hong, Melissa Mattwig, Kwin Morris, and Jeff Guy.

their trip in Toronto, the team fought a barrage of 16+ knot wind gusts, 3+ foot waves, rain, and lingering wildfire smoke, making the 35-mile crossing to Fort Niagara State Park in Youngstown, New York an extremely rough 13 hours. The team's original goal was to make the paddle a roundtrip crossing, finishing back in Toronto. "When we got to shore, we looked at the forecast and saw the winds would be even higher overnight, another 7 hours of 2-5 foot waves, so we decided one way was enough," said Morris. "We made our Lake Ontario crossing, so the mission was accomplished!"

Now that their lake crossings are complete, the team would like to work on new local, community-based paddleboard experiences and projects. "We'd like to work on more youth-organizing events, as well as work with college-age students on funding opportunities for Great Lakes research," says Morris. "There are still so many challenges facing our Great Lakes and a lot of work to be done."

"Our overall goal has been to make a difference, educate, and raise awareness about Great Lakes environmental issues in the region," says Guy. "I think we've started to do that."

Check out more about the Stand Up for Great Lakes' Lake Ontario crossing by reading **CIGLR's X (Twitter) thread**.

WELCOME

Mike Shriberg

OUR NEW DIRECTOR FOR ENGAGEMENT

MIKE SHRIBERG, PhD, is a faculty member in the School for Environment and Sustainability (SEAS) at the University of Michigan and former Interim Director of Michigan Sea Grant. Shriberg joined CIGLR in 2023 as our new Director for Engagement, where he will lead the expansion of CIGLR's Engagement, Career Training and Outreach (ECO) program.

Before joining the faculty at the University of Michigan, Shriberg served as the Great Lakes Regional Executive Director for the National Wildlife Federation and as the Education Director at the University of Michigan Graham Sustainability Institute. His M.S. and Ph.D. are in Resource Policy and Behavior from SEAS. Shriberg's expertise is in water quality and access as well as environmental leadership, climate resiliency, and youth education. He is an experienced advocate and communicator of Great Lakes issues at the state, regional, and federal level. Shriberg served as a Trustee of the Great Lakes Fisheries Trust and co-chaired the Healing Our Waters – Great Lakes Coalition, which leads the effort to secure over $4 billion in funding through the Great Lakes Restoration Initiative (GLRI) and recently secured more than $1 billion for cleaning up toxic hot spots. Prior to joining the CIGLR leadership team, Shriberg enthusiastically engaged with CIGLR as a member of the Council of Fellows, a collaborator in CIGLR's partner programs such as fellowships and summits, an advisor for SEAS masters projects, and a session facilitator at CIGLR's All Partners Meeting.

"I'm thrilled to be joining the talented team at CIGLR," said Shriberg. "CIGLR is uniquely positioned to be an effective voice for the Great Lakes due to the deep scientific knowledge and strong network of relationships. I am excited to accelerate CIGLR's engagement and outreach initiatives."

As the new Director for Engagement, Shriberg joins a team of talented and dedicated ECO specialists, including CIGLR's research engagement team led by Dr. Riley Ravery. His leadership will provide strategic guidance to increase the impact of CIGLR's research and programs, including collaborating with research scientists to align their work with key policy needs, coordinating research engagement efforts around the Regional Consortium, and identifying new funding opportunities to support CIGLR's outreach and engagement work. In his role as Director for Engagement, Shriberg will expand CIGLR's networks and connections across the Great Lakes region and more broadly, thus amplifying CIGLR's societal impact.

Welcome New Research Scientists

DAVID CANNON, PhD, joins CIGLR as an Assistant Research Scientist after two years as a CIGLR Postdoctoral Research Fellow. "As a physical limnologist with more than 10 years of experience in the Laurentian Great Lakes, I am thrilled to continue working with CIGLR and studying freshwater hydrodynamics," said Cannon. "I will be working with the climate modeling team at CIGLR and NOAA GLERL to improve climate change simulations in the Great Lakes region."

David completed his PhD in Civil Engineering at Purdue University. "My thesis work at Purdue was focused on vertical mixing and nutrient cycling in Lake Michigan," said Cannon. "I planned and conducted dozens of field experiments to study the seasonal variability of hypolimnetic turbulence."

David also worked closely with Illinois-Indiana Sea Grant to deploy and maintain several meteorological buoys in southern Lake Michigan, which gave him educational outreach opportunities with local communities interested in buoy lake data.

"Before joining the team at CIGLR, I also worked as a postdoctoral researcher at the University of Central Florida," said Cannon. "I studied biophysical flows (in mangroves, seagrass and oyster reefs) in the Indian River Lagoon, a microtidal estuary on Florida's Atlantic coast. I learned a lot about hydrodynamic modeling and coastal management, but never stopped thinking about the Great Lakes. I've always wanted to work with CIGLR and colleagues at NOAA GLERL, and I'm extremely excited to start collaborating with the research team in my new role," said Cannon.

YI HONG, PhD, joins CIGLR as an Assistant Research Scientist after four years as a CIGLR Postdoctoral Research Fellow collaborating with NOAA GLERL and the National Center for Atmospheric Research (NCAR) in Boulder, Colorado to develop hydrodynamic and wave models for the Great Lakes. "I am very excited about the opportunity to join CIGLR in a more permanent role," said Hong. "I will continue to pursue my research interests in hydrological and hydrodynamic modeling, contribute to its focus on connections between decision-making and impacts on socio-ecological systems, and lead campus and professional service activities."

Before joining the CIGLR team, Yi was a postdoctoral researcher at the Ecole des Ponts ParisTech in France, where he focused on water quantity and quality modeling at various scales, as well as the development of real-time forecasting systems.

"My research journey first started as a graduate researcher and water resources engineer at a French consulting company," said Hong. "As I became more interested in environmental research, I moved to Paris to pursue a PhD in Environmental Science & Engineering at the Ecole des Ponts ParisTech in France, which really expanded my expertise in the field of freshwater management."

Now, with more than 10 years of experience in hydrologic and hydrodynamic modeling for land and freshwater systems, Yi will address even more of the major challenges in sustainable water management.

"I am eager to pursue my passion for research in hydrologic and hydrodynamic modeling," said Hong. "The Great Lakes region is an ideal test bed for developing and testing integrated and cross-scale modeling approaches to enhance sustainable water management.

DANI JONES, PhD, joins CIGLR as an Associate Research Scientist after a decade with the British Antarctic Survey (BAS), where they specialized as a physical oceanographer on the Polar Oceans Team.

During their tenure at BAS, Jones developed research programs in ocean adjoint modeling and machine learning. Reflecting on this experience, Jones shared, "I'm a big fan of tools, such as adjoint models and unsupervised clustering algorithms, that can point you towards new hypotheses and new ideas for further exploration."
"I am honored to join CIGLR - it is a truly special institute for many reasons, including its fantastic people and its integration across the university, NOAA GLERL, and the wider Regional Consortium."

Jones is establishing CIGLR's new Artificial Intelligence Laboratory, leveraging the institute's extensive observing assets, datasets, modeling capacity, interdisciplinary expertise, and numerous partnerships. "Ultimately, we are hoping to harness these techniques to address environmental challenges and hazards facing the Great Lakes and the communities they support."

"The water quality monitoring program in Lake Erie produces both up-to-date data, made available to the public just days after sampling, and a consistent long-term dataset. Those two aims place different requirements on the researchers and delivering on both would not be achievable without the professional science staff at CIGLR."

— Casey Godwin, PhD

LONG-TERM AND REAL-TIME

Water Quality Monitoring

TO SUPPORT LAKE ERIE RESTORATION AND END-USERS

WATER QUALITY MONITORING is essential for documenting the prevalence of harmful algal blooms (HABs). HABs can be scientifically complex, economically damaging, and a threat to ecosystem and human health. Stakeholders around the Great Lakes rely on CIGLR's HABs research team to provide critical and up-to-date information on HABs in the western basin of Lake Erie. With our partners at the NOAA Great Lakes Environmental Research Laboratory (NOAA GLERL), CIGLR operates a water quality monitoring program in Lake Erie that includes over a decade of water quality measurements. Weekly water quality data from western Lake Erie support HABs forecasts that inform water resource managers on the development, location, and hazards of the current bloom. CIGLR's and NOAA's monitoring work is supported by the Great Lakes Restoration Initiative.

Algal Toxin and Ecology Research Specialist Anna Boegehold, PhD, said, "The western basin of Lake Erie has a decades-long history with HABs. Aside from aesthetic concerns, these HABs are often composed of toxin-producing cyanobacteria and can be detrimental to human and environmental health."

Cyanobacteria are a natural part of Great Lakes ecosystems, but factors such as excess nutrients and warming waters can cause cyanobacteria to form large blooms, some of which can be harmful due to the production and release of toxins. In the 1960s, seasonal Lake Erie HABs and other water quality issues within the Great Lakes reached a tipping point, drawing binational attention to the need for action to protect Great Lakes water quality. To address these issues, the United States and Canada signed the Great Lakes Water Quality Agreement (GLWQA) in 1972, and the U.S. implemented its own Clean Water Act (CWA) in the same year. These legislative actions sought to reduce pollution in Lake Erie's navigable waters and regulate phosphorus inputs. As excess phosphorus was the primary factor found to be causing the HAB issue at the time, limiting this nutrient input into the lake resulted in a period of restoration and a reprieve from HABs.

"While limiting excess phosphorus was successful throughout the 1980s and early 1990s, eventually the annual HAB events resumed by the mid to late 1990s," said Boegehold. "The question then became – why was this happening?" Phosphorus pollution from sources like wastewater treatment plants and industrial effluents had been stable since the 1980s. By the late 1990s, scientists identified changes in agricultural practices, invasive species like zebra and quagga mussels, and climate change as the main causes of the HAB comeback.

The HAB resurgence led to the establishment of CIGLR's and NOAA GLERL's western Lake Erie monitoring program. This program has grown to generate real-time data, produce seasonal and near-term forecasts, create a consistent long-term dataset, and provide information for NOAA's bi-weekly Lake Erie HAB Bulletin that reaches thousands of stakeholders across Michigan and Ohio each season.

CIGLR Assistant Research Scientist Casey Godwin, PhD, said, "As the region continues progress towards Lake Erie restoration, the long-term monitoring program from CIGLR and NOAA GLERL is essential for evaluating how the lake responds to decreases in phosphorus loading and adapting our predictions and targets for the future."

Ashley Burtner, manager of the HABs laboratory and a seasoned 13-year veteran on the CIGLR HABs research team, said, "Our program uses an integrated approach to

understand the environmental drivers of HABs and to predict future events. We collect data from satellite images, buoys, and a comprehensive monitoring program. The more information we have, the more we know about the environment, the factors determining bloom growth, and ultimately, the ever-changing situation in Lake Erie."

Routine field monitoring on western Lake Erie and enhanced laboratory work begins in April and generally closes in October each year. The HABs research team is frequently navigating schedule disruptions due to weather, coordinating space for collaborators, interacting with media, and developing new and improved sampling methods. On the water, a crew consisting of several scientists and a boat captain typically carries out the routine HAB monitoring events. Everyone helps on deck to collect samples and prepare the heavy, large sampling equipment.

Aquatic Research Analyst Glenn Carter, whose responsibilities include field and laboratory sampling and analysis, said, "The HABs team is committed to collecting and analyzing a suite of samples from Lake Erie. It's all hands-on-deck for our field and laboratory crew from April to October in western Lake Erie."

Paris Schofield and Paige Williams help prepare and execute the extensive field and laboratory operations throughout the Lake Erie monitoring season. "It's fascinating to be a part of the first and last steps of Lake Erie sample collection," said Schofield. "Following water samples from the field to the laboratory to a data point is really amazing. The amount of information in a few liters of water is incredible."

The HABs team samples for over 30 different parameters including pigments, nutrients, toxins, 'omics, and others. When Lake Erie water and samples arrive at the laboratory, they are preserved and prepared for analysis in the coming days and months. The sheer volume of what the HABs team accomplishes over a given summer is a huge effort and requires an entire team of skilled laboratory scientists to process all of the samples.

Aquatic Ecology Research Analyst Jasmine Mancuso helps prepare laboratory operations throughout the Lake Erie monitoring season. She said, "A key feature of our team is how quickly we turn field samples into useful data. As soon as the field crew returns to the lab with water samples and equipment, a team of talented scientists are pulling data from instruments, filtering water or otherwise preparing samples for analysis, and collecting time-sensitive measurements. Our team quickly distributes this information to stakeholders just days after collection."

Research Lab Specialist Andrew Camilleri and Biogeochemistry Laboratory Analysts

Connor Gluck and Teige O'Brien help manage weekly Lake Erie field sampling and laboratory nutrient analyses. "Our dedicated HABs team continues to build upon the physical, chemical, and biological parameters in the western basin of Lake Erie," said Camilleri. "Our measurements help scientists better understand how nutrients, specifically phosphorus and nitrogen, influence the size, duration, and severity of HABs."

O'Brien added that, "In the nutrients lab our responsibilities include the analysis and quantification of phosphorus concentrations in Lake Erie. This involves implementing a wide range of analytical chemistry techniques that target specific phosphorus fractions."

Phosphorus is composed of a variety of physical and chemical fractions, some of which are more readily available for algal growth and energy transport.

It is critical to understand phosphorus dynamics in HAB-affected systems in order to develop management strategies that mitigate the negative impacts of HABs. Gluck said, "During the field season, our team collects thousands of phosphorus samples. Phosphorus is a limiting nutrient in Lake Erie and one of the key parameters that we study because it has such a big impact on the growth of algal blooms."

The data collected from each HAB season informs forecast models used by key Great Lakes stakeholder groups, such as drinking water managers. Effective management of Great Lakes ecosystems requires timely and continuing predictions of ecosystem change. "Year after year, we've observed variations in western Lake Erie HABs, with consistent monitoring proving to be a critical tool in discerning these changes," said CIGLR 'Omics Research Technician Paul Den Uyl, whose responsibilities included weekly Lake Erie sampling and laboratory analyses of phytoplankton genes. "This environmental monitoring program stands out as truly unique; it not only explores broad, high-level concepts but also addresses immediate concerns affecting everyday stakeholders in the region."

In 2019, a dataset from the western Lake Erie monitoring program was published online with a permanent web address thanks to massive efforts by Ashley Burtner and the entire HABs team. In addition, the team recently completed a data description paper of the western Lake Erie monitoring program titled *Routine monitoring of western Lake Erie to track water quality changes associated with cyanobacterial harmful algal blooms*. "Published datasets like this are important to give proper context to the history and methods of the program," said Boegehold, "and our routine monitoring program is essential for providing real-time data and observing long-term trends in Lake Erie water quality."

Scan for…

Archived Data

Recent Monitoring Data

Journal Article

CAN

Invasive Mussels

BE CONTROLLED?

INVASIVE QUAGGA MUSSELS have dramatically altered the structure and function of the Lake Michigan ecosystem. To date, research on these mussels has focused on understanding how they affect lake nutrient and food web dynamics, with the goal of guiding lake management strategies rather than remediation. There have been virtually no attempts to remove this invasive species in the Great Lakes.

While remediation is logistically impossible at the ecosystem scale, Harvey Bootsma, PhD, of the University of Wisconsin-Milwaukee, a CIGLR Consortium institution, along with doctoral student Karen Baumann (University of Wisconsin-Milwaukee) and collaborators Ashley Elgin, PhD, and Steve Ruberg from NOAA GLERL are exploring the potential of mussel removal as a method to restore critical habitats.

"Our group started experimenting with mussel removal methods in 2016," said Bootsma. "Working with colleagues from the National Park Service and the Michigan Department of Natural Resources, we've had some success removing mussels at small scales in the lake's nearshore zone." The team cleared a 40 square meter experimental plot containing close to one million mussels at Good Harbor Reef on the coast of Michigan's Sleeping Bear Dunes National Lakeshore, where the rocky bottom has remained virtually mussel-free for the last 7 years.

"We're still trying to understand why the mussels have not returned to that area," said Bootsma. "That research has really helped us to understand how these mussels affect nearshore food web structure and the growth of nuisance algae. However, at the whole ecosystem scale the effects of invasive mussels are primarily due to the trillions of quagga mussels living on deeper, soft substrate, where biological,

"When most people look at a Great Lake, they don't think about what's happening on the bottom. But, we now know that bottom-dwelling quagga mussels have dramatically altered the way these unique aquatic ecosystems function and we started wondering – is there anything we can do about it?"

— Harvey Bootsma, PhD

chemical, and physical conditions are very different from those on nearshore rocky habitat. We expect that a mussel removal project on deeper substrate will lead to new insights about the role of mussels in the lake's food web and nutrient cycles. It would also allow us to address questions that are difficult or impossible to address using more conventional experimental approaches, such as lab experiments or the interpretation of long-term data sets."

Removing mussels from a deep-water area in Lake Michigan was very different from the methods used in the nearshore zone. Scuba divers removed mussels manually in shallow areas of Lake Michigan, but that is not practical or safe in deep-water areas. After testing several options, Bootsma built a device designed to crush mussels while being dragged behind a ship. Dubbed the "mussel masher," the device, which weighs more than a half ton, was first tested in May 2023. After some small modifications, it was used in June at 40 meters depth to treat a 50 x 50 meter area of lake bottom. "Now, we're monitoring that area to see how effective the masher was, and how the sediment chemistry and the biotic community are responding," said Bootsma. "Initial sampling suggests that the treatment resulted in an 80% decline in mussel density, but we're doing more sampling to get some statistical confidence in the numbers."

Bootsma and Baumann are now collecting sediment from the study area to determine the role of sediments and quagga mussels in the lake's phosphorus cycle. "Understanding sediment phosphorus dynamics is critical," explained Bootsma, "because it has implications for plankton production and the entire food web." They are also monitoring other bottom-dwelling biota, including invertebrates and fish, to see how they respond to the removal of quagga mussels. "One of our goals is to see if we can remove quagga mussels at large enough scales to have a local positive impact," said Bootsma. "But even if we can't, we hope to better understand how biological, physical, and chemical processes on the lake bottom affect Lake Michigan as a whole, and how these processes are altered by the presence of quagga mussels in the lake. That understanding will allow us to better predict the lake's response to factors such as nutrient inputs and climate change, and will help guide decisions related to management of the lake's fish populations."

Bootsma's work has caught the attention of a film company, Inspired Planet Productions. His pioneer research into lake mussel removal is expected to be showcased in the documentary "All Too Clear" which highlights how invasive species have changed Great Lakes ecology. "Our research team is excited to be a part of this documentary and we look forward to future collaborations that inform the public about the role science plays in understanding and caring for these precious lakes," said Bootsma.

More about documentary

Image 1. Harvey Bootsma, PhD, and Captain Max Morgan discussing deployment of the "mussel masher". (Photo Credit: Charles Carignan)

Image 2. The "mussel masher" on deck. (Photo Credit: Harvey Bootsma)

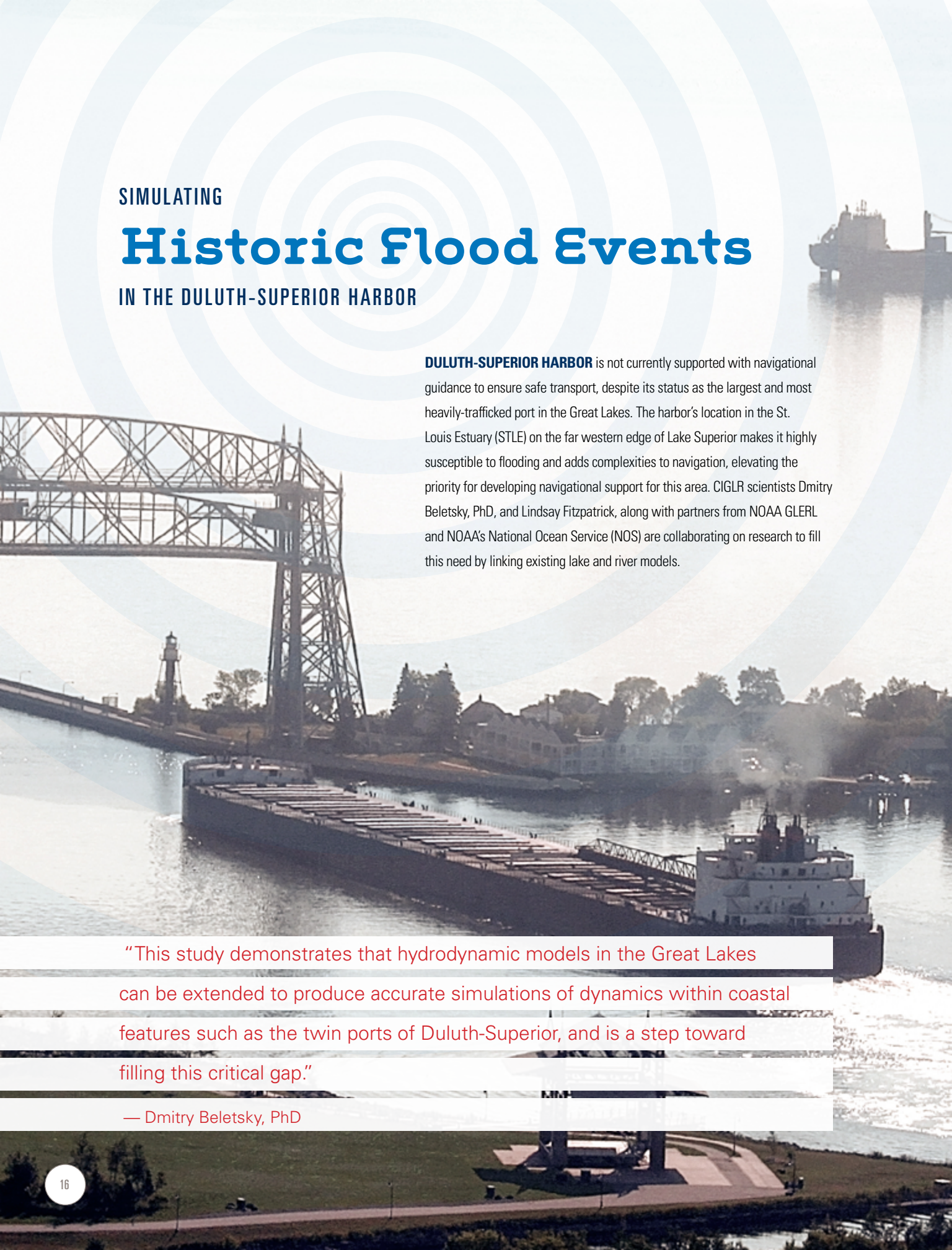
Background Image: A swath of Lake Michigan bottom after deployment of the "mussel masher". (Photo: Zach Melnick, Inspired Planet Productions)

SIMULATING

Historic Flood Events

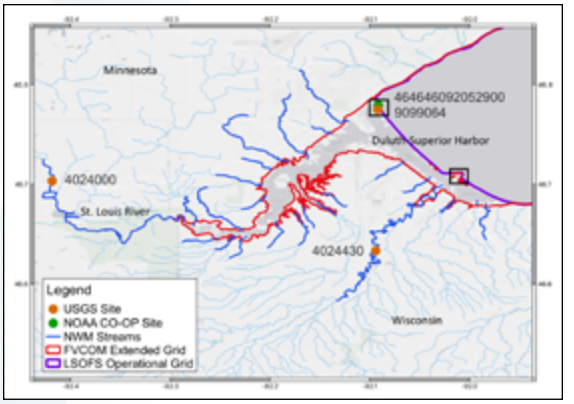
IN THE DULUTH-SUPERIOR HARBOR

DULUTH-SUPERIOR HARBOR is not currently supported with navigational guidance to ensure safe transport, despite its status as the largest and most heavily-trafficked port in the Great Lakes. The harbor's location in the St. Louis Estuary (STLE) on the far western edge of Lake Superior makes it highly susceptible to flooding and adds complexities to navigation, elevating the priority for developing navigational support for this area. CIGLR scientists Dmitry Beletsky, PhD, and Lindsay Fitzpatrick, along with partners from NOAA GLERL and NOAA's National Ocean Service (NOS) are collaborating on research to fill this need by linking existing lake and river models.



"This study demonstrates that hydrodynamic models in the Great Lakes can be extended to produce accurate simulations of dynamics within coastal features such as the twin ports of Duluth-Superior, and is a step toward filling this critical gap."

— Dmitry Beletsky, PhD



St. Louis estuary (STLE), including the St. Louis River and Duluth-Superior harbor. The purple outline shows the extent of the operational grid from the Lake Superior Operational Forecast System. The red outline shows the extent of the extended high-resolution grid that covers the upstream portion of the STLE and floodplain.

On the lake side, NOAA's Great Lakes Operational Forecast System (GLOFS) is a hydrodynamic model that provides information on lake water levels, water temperatures, currents, and ice, but that coverage does not extend all the way into the harbor. On the river side, the National Water Model (NWM) is a hydrologic model that provides streamflow data across the continental United States, including the St. Louis River, but stops just short of the harbor. The result is a "blind spot" within the STLE where guidance is not available for water levels, flooding potential, or currents. "Due to its unique geography, the region is extremely susceptible to flooding events from heavy rain and storm surge," said CIGLR Research Scientist Dmitry Beletsky, PhD. "We have already seen the catastrophic ramifications of this blind spot in recent years." In June 2012, a low-pressure system dropped 5-10 inches of heavy rain over a two-day period, creating over $100 million in damage and causing extreme upstream flooding. In October 2019, the region again experienced heavy flooding, this time driven by a rapid drop in air pressure, strong winds, and storm surge from the lake into the harbor.

To fill the coastal flood-forecasting gap for this area, the NOAA-CIGLR research team created a high-resolution model extension into the harbor and across the floodplain. They accomplished this by inserting streamflow from the NWM into the hydrodynamic lake model using a linked framework. "Next, our team worked on simulating past extreme flood events and evaluating the model output," said CIGLR Hydrological Modeler Lindsay Fitzpatrick. "Simulations were created for the 2012 heavy rainfall event and the 2019 storm surge event. Model results for both events compared well against the time-series of water level and streamflow at observational gauges, but the inclusion of NWM-simulated streams improved accuracy."

The researchers conducted a flood extent survey, which evaluates flood risk and how that risk can be managed, in response to the 2012 event. Modeled flood extent and depths matched well with the observational inundation maps from the survey. The addition of the NWM tributary streamflow improved the accuracy of modeled water levels and increased simulated surface current speeds by up to 0.5 meters per second inside the harbor. "The ability to accurately simulate and predict current changes within the harbor is an important step toward improving the safety of commercial shipping vessels and other watercraft, as well as our response time to environmental disasters such as oil spills," said Fitzpatrick.

"This study demonstrates that hydrodynamic models in the Great Lakes can be extended to produce accurate simulations of dynamics within coastal features, and is a step toward filling this critical gap," said Beletsky. "Future work includes extending research and development to other coastal infrastructures within the Great Lakes, such as the Keweenaw Waterway in Michigan, which is currently unresolved in GLOFS."

40 Years of Warming

IN THE LAURENTIAN GREAT LAKES

Using a Hydrodynamic Model to "Fill the Gaps" in a Sparse Observational Data Record

OBSERVATIONAL STUDIES in the Laurentian Great Lakes show dramatic changes in lake surface conditions over the last several decades. Warming surface temperatures and dramatic ice cover declines exacerbate a range of risks to the Great Lakes, including changes in the range and distribution of some species, increases in invasive species and harmful algal blooms, and declines in beach health. However, understanding the water dynamics below the surface is more complicated and challenging. Whereas lake surface water conditions can be observed remotely using satellites, measurements at depth need to be collected manually using instrumented buoys and moorings, which can be expensive and dangerous, especially during winter. Very little subsurface data is available for long-term trend analysis, with only a single mooring in existence ever recording more than a decade of measurements in the entire Great Lakes basin.

"This is a serious problem for natural resource management," said CIGLR Assistant Research Scientist in Hydrodynamics David Cannon, PhD. "Subsurface temperatures and thermal structure act as a critical control on many ecosystem processes, with implications for dissolved oxygen, fisheries habitat, water quality, and even contaminant transport. Understanding how subsurface conditions are changing is crucial for managing the lakes under continued climate warming. Direct observations are the gold standard for climate change research, but we just do not have the observations we need to understand how the Great Lakes are changing, especially over large spatial scales. You can't go back in time to invest in better long-term monitoring, but you can try to simulate changes using hydrodynamic models."

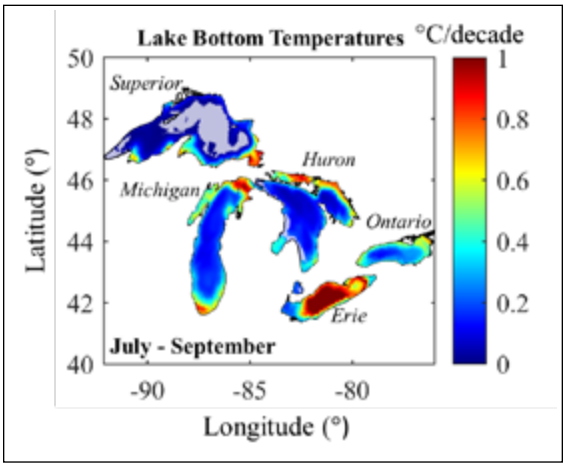
"Simulations suggest that subsurface temps in the Great Lakes have risen rapidly over the last 40 years, with important implications for water quality and fisheries management. The changing lake climate is driven by a combination of global warming and natural multidecadal variability, which makes it difficult to project changes into the future."

— David Cannon, PhD

In collaboration with Ayumi Fujisaki-Manome, PhD (CIGLR), Jia Wang, PhD (NOAA GLERL), and James Kessler (NOAA GLERL), Dr. Cannon helped develop a hydrodynamic model to hindcast thermal structure in the Laurentian Great Lakes. In doing so, the team was able to estimate historical lake-wide temperatures and ice cover going back to 1979, essentially "filling the gap" in the observational record.

Model results suggest that temperatures below the lake surface have increased significantly over the last 40 years, with all five Great Lakes warming at 50 meters depth by between 0.2 and 0.4 degrees Celsius per decade. "A 0.25 degree Celsius increase in temperature every 10 years might not seem like much," said Cannon, "but it can really add up. The deepest waters in the Great Lakes are almost 1 degree Celsius warmer now than they were 43 years ago."

This study also detected significant decreases in ice cover (between -1% and -10% per decade) and ice thickness (between -1 cm and -4 cm per decade) across the region, along with a general lengthening of the stratified summer season (between 4 and 14 days per decade) when surface waters are warmer than 4 degrees Celsius. "Together, these seemingly small changes in lake temperature and ice cover can have a large impact on lake ecosystems," said Cannon. "For example, increasing bottom-water temperatures can drive fish out of their preferred habitats, effectively restructuring food-web dynamics in the lakes. This is especially concerning for historically productive fisheries like Green Bay in Lake Michigan and Saginaw Bay in Lake Huron, where model simulations showed near-bottom warming in excess of 1.4 degrees Celsius since 1979. One of our concerns is that increasing temperatures at the lake bottom may affect fish spawning habitats or the quality and viability of fish eggs. We're hoping that these data might be useful for lake managers as they set fishing regulations and plan habitat restoration initiatives moving forward."



Spatial map of modeled trends in lake bottom temperature.

The Great Lakes have changed considerably over the last several decades, but the climatic processes driving these changes are still unclear. "Our research was designed to investigate the root cause of warming in the region," said Cannon. "When working with climate data, it's really difficult to separate global warming driven by human activities from multi-decadal climate variability, which occurs naturally. The longer lake records produced by our simulations provide a great way to start separating natural and human-induced trends. In fact, preliminary analysis suggests that as much as 30% of the surface warming trends described in this study may be linked to naturally occurring climate oscillations, like the Atlantic Multi-decadal Oscillation. Does this mean global warming is not important? Absolutely not. It means that global warming does not tell the whole story. Long-term climate oscillations play an important role in regulating temperatures and ice cover in the Great Lakes, and they should not be ignored as we move forward with climate projections. Next step, modeling the future!"

UNDERSTANDING THE CHANGING PATTERNS OF

Great Lakes Ice Cover and Winter Weather

ICE COVER is an important part of the experience of coastal communities in the Great Lakes, from being an obstacle to vessel navigation to providing an opportunity for winter recreation. Ice plays a key role not only in regional weather but also in environmental quality and economic prosperity. This year, ice coverage on the Great Lakes was at a near record low, and the impacts were felt across the region.

"Warmer lake surface temperatures and low ice coverage in the Great Lakes can trigger lake-effect snowstorms, such as the December 2022 severe lake-effect snowstorm that gripped the majority of the Great Lakes region and included 41 deaths in Buffalo, New York," said CIGLR Associate Research Scientist Ayumi Fujisaki-Manome, PhD. Dr. Fujisaki-Manome leads CIGLR's ice and snow research program that aims to improve the predictability of hazardous weather, ice, and lake/ocean events to support preparedness and resilience in coastal communities. "Typically a lake-effect snow season ends by early-to-mid February, as ice covers the surface of the lakes. However, with less ice, more late-season lake-effect snowfalls can be anticipated, such as the late March 2023 lake-effect snow event that impacted west Michigan, leaving 18 inches of snow in just a few days. Larger open water areas during the windy winter season also pose concern for high waves, which can damage the shoreline when it loses protection of stable ice cover along the coast."

"It's so important to understand changes in ice cover and winter severity, how they can be attributed to climate variability and warming, and ultimately be able to make better predictions from our continued data collections and observations."

— Ayumi Fujisaki-Manome, PhD

Air temperature is the main factor affecting ice cover on the Great Lakes. Alarmingly, scientists recorded warmer-than-average temperatures this winter, especially in the month of January. A recent study by NOAA GLERL reports that Great Lakes ice coverage is on a downward trend, demonstrating a 70% decline in the lakes' ice cover between 1973 and 2017. To many, this seems like quite a different story from the recent 2019 winter. "In January 2019, a cold blast that closed schools, state offices, and other businesses is clearly remembered as one of the coldest, most extreme ice-covered winters in recent years," says Fujisaki-Manome.

So what's the story behind this variable ice coverage and winter weather?

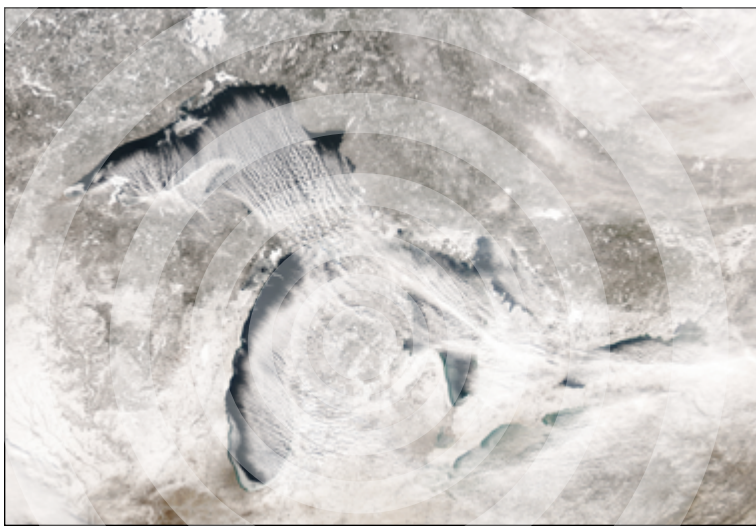
"The year-to-year fluctuations of Great Lakes ice coverage became larger in the past two decades," said Fujisaki-Manome. "Long-term patterns of climate variability over the Pacific and Atlantic Oceans are key factors that are contributing to the reduction of ice. There was an interesting shift in the patterns during the winter of 1997/1998. Before this shift, the Great Lakes annual maximum ice cover significantly correlated with a couple of well-known climate indices, the El Nino–Southern Oscillation and North Atlantic Oscillation. However, after this shift, these climate indices no longer presented significant correlations with the Great Lakes annual maximum ice cover. Instead, the Eastern Pacific Oscillation and the sea surface temperature anomaly over the North Pacific presented significant correlations."

Dr. Fujisaki-Manome looks for process-based evidence that supports the relationship between Great Lakes winter severity and the sea surface temperature anomaly over the North Pacific.

"So far we have found that notable wave energy emanating from the warm sea surface temperature in the North Pacific contributes to the meandering of the jet stream, which can ultimately contribute to the Great Lakes winter severity and warming," said Fujisaki-Manome. "In addition to the ice cover, we are also investigating changes in winter storm tracks, storm intensity, and frequencies."

Dr. Fujisaki-Manome and her team are focused on understanding what large-scale patterns control regional climate variability and extreme weather event occurrences in the Great Lakes.

"Year-to-year fluctuations of ice cover and winter severity are expected to remain high, if not increase further, and extreme weather events can be anticipated, such as the historic ice storm that struck southeast Michigan in late February 2023," said Fujisaki-Manome.



DIFFERENTIAL IMPACTS OF

Storm Surge Flooding

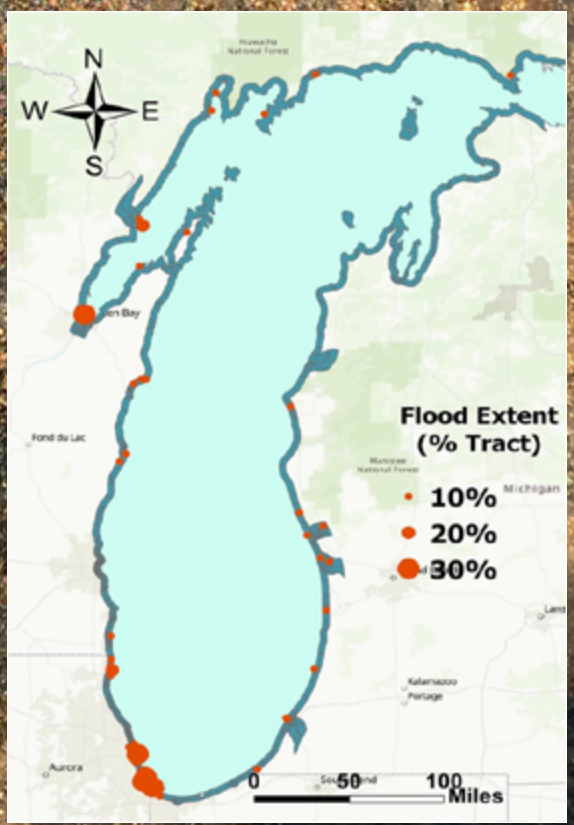
ON COASTAL COMMUNITIES OF THE GREAT LAKES

STORM SURGE FLOODING throughout the Great Lakes region has become more frequent in recent years, causing significant property damage to coastal homes and exacerbating public health issues such as injuries, hypothermia, disease, undernutrition, mental health problems, and more. The adverse impacts of flood exposure are amplified for socially vulnerable populations who disproportionately reside in flood-prone areas. Socially vulnerable populations include those with special needs, such as, but not limited to, people without vehicles, people with disabilities, older adults, low income households, and people with limited English proficiency. In order to improve flood resiliency, it is essential to accurately identify both the flood hazard extent for Great Lakes coastal communities and the exposure of different socio-demographic groups to flooding. However, neither of these crucial factors have been comprehensively evaluated in relation to the Great Lakes region.

A research team led by Assistant Research Scientist Yi Hong, PhD (University of Michigan, CIGLR) and collaborators Eric Anderson, PhD (Colorado School of Mines) and Sara Hughes, PhD (University of Michigan, CIGLR) are using a coastal flood model combined with a social vulnerability analysis to examine the differential impacts of storm-surge flooding on Great Lakes coastal communities. "Climate change and its associated effects such as rising water levels, warming water temperatures, more intense weather events, and coastal flooding disproportionately impact coastal communities, including populations who are already vulnerable due to social or economic factors," said Hong. "Our team is looking more intentionally and specifically at the negative effects that Great Lakes coastal flooding has on vulnerable communities."

From 2018 to 2021, the Great Lakes experienced a period of historically high water levels, pushing water further inland and raising concerns over more extreme storm-surge flooding of coastal communities. "Using a recently-developed hydrodynamic lake model, our team is working to simulate coastal flood extent from 2018 to 2021 for all Great Lakes," said Hong. "But first, we focused on Lake Michigan because all of the coastal regions are within the United States, and at the time we did not have data (e.g., census tracts, demographic data) for Canadian coastal regions. We looked at the relationship between the proportions of flood-prone areas and key social vulnerability indicators at census tract scale." Census tracts are subdivisions of counties for which the United States Census Bureau collects statistical data. "Our results highlighted specific census tracts and populations that need help and intervention to mitigate the impacts of storm-surge flooding. For example, Green Bay, Wisconsin and Chicago, Illinois are in extreme flood zones on Lake Michigan's coast. Both areas have had up to 30% of census tracts flood in the last 3 years, causing life-threatening situations for many."

"As we continue this research, our team is working to embed these results into a real-time flood forecasting system," said Hong. "This would help reduce disparity and provide advanced flood warning to socially vulnerable populations, ultimately enhancing coastal management strategies for the Great Lakes region."



"Storm surge flooding throughout the Great Lakes region has become more frequent in recent years and it is essential we look more intentionally and specifically at the negative effects of coastal flooding on vulnerable communities."

— Yi Hong, PhD

ALUMNI SPOTLIGHT

Olivia Anderson

2020-2021 CIGLR Graduate Research Fellow

OLIVIA ANDERSON was a 2020-2021 CIGLR Graduate Research Fellow recipient from Central Michigan University (CMU). Anderson, advised by Donald Uzarski, PhD (CMU) and co-mentored by Casey Godwin, PhD (University of Michigan, CIGLR), graduated with a master's degree in biology focused on Great Lakes wetlands and vegetation. Currently, Anderson is pursuing a PhD at the Swedish University for Agricultural Sciences, where she is developing a decision support tool to help manage ditches in forests across Sweden.

While at CMU, Anderson and her team published a study about how Great Lakes coastal wetlands shift in tandem with extreme changes in water levels. "Recent decades saw unprecedented (for recorded history) dynamics in Great Lakes water levels: 2000–2015 experienced an extended low-water level period, which was followed by record highs in 2017–2020," said Anderson. "The **Great Lakes Coastal Wetland Monitoring Program** has a growing database of coastal wetland vegetation surveys, which began in 2011. We used these data to investigate how coastal wetlands extent (i.e., wetland length perpendicular to the shoreline) changed with the extreme increase in water levels from 2011–2019, using data from 342 sites across all five Great Lakes. A better understanding of how coastal wetlands migrate with shifts in water levels enables decision makers to better predict where Great Lakes coastal wetlands are at risk of being lost and thus where to prioritize management efforts."

Uzarski, Anderson's advisor at CMU, leads the Great Lakes Coastal Wetland Monitoring Program. "Olivia's work is gaining a lot of attention and has contributed substantially to our understanding of Laurentian Great Lakes' coastal wetland dynamics," he said. "While never approached in such a robust way, I believe that her results have surprised many coastal wetland scientists and have changed the way that we think about these systems. Olivia is an extremely talented student and I am certain that she will continue to be very successful through her career."

Q & A WITH OLIVIA ANDERSON

Q: Which is your favorite Great Lake and why?

Lake Superior is my favorite Great Lake since it borders Minnesota - where I grew up, and is the Great Lake that I've lived by for the majority of my life including for my undergraduate work at Northland College in Ashland, Wisconsin. In addition, I like that it is the deepest, least populated, and most northern of the five Great Lakes, giving way for abundant beauty and many unique ecosystems.

Q: What led you to pursue this career path?

When pursuing my bachelor's degree at Northland College, I realized that I really enjoy working in wetlands and with wetland plants. After graduating with a bachelor of science in Sustainable Community Development and Natural Resources, I worked as a research assistant for the Mary Griggs Burke Center for Freshwater Innovation, where I got a taste of sampling for the CMU Coastal Wetland Monitoring Program. That experience led me to pursue a master's degree focused on Great Lakes wetlands and vegetation at CMU. As a student at CMU, I was part of

CIGLR's Regional Consortium and eligible to apply for a CIGLR Graduate Research Fellowship, which I received for the 2020-2021 academic year. This fellowship helped me complete my graduate research and gave me additional resources and mentorship opportunities from a CIGLR research scientist. My research interests broadened after I completed my master's degree. I wanted to continue working with land-water interfaces and improve my programming skills, but in a new environment and abroad. This led me to Scandinavia and the Swedish University for Agricultural Sciences. This university campus specializes in forest research, with my PhD work focused on the development of a decision support tool to help manage ditches in forests across Sweden.

Q: What was your favorite part about being a CIGLR Graduate Research Fellow?

My favorite part about being a CIGLR Graduate Research Fellow was getting more time dedicated to work on my master's project. Graduate students often have to participate in side research projects, be teaching assistants, etc., to get their research projects and degree funded. However, the CIGLR Graduate Research Fellowship gave me the funding I needed for my first year and an opportunity to focus specifically on my research, allowing for a better and more focused start. Also, I am very grateful for my CIGLR co-advisor, Casey Godwin, PhD (University of Michigan, CIGLR) and that he introduced me to using Bayesian statistics, which I am now frequently using for my PhD work.

Q: What advice would you give to current graduate students?

As a new graduate student, I found it very helpful to focus on what the end goal/objective of my project was going to be and what questions I wanted to answer. I created a general time-table of when I wanted to complete certain steps of my project. For example, during the first semester it was figuring out my objective, why it's important, and how I'll get there - all put into a prospectus. Then, second semester and in the summer I was working on cleaning up data and GIS work to generate variables. This helped me feel like I was progressing and using my time well. I also intentionally included "wiggle room" in my schedule, in case I needed to backtrack or redo parts of my research, and to better understand my statistical approach and results.

Q: What was your favorite part about studying Great Lakes coastal wetlands?

Easy answer. Now that I've had my first summer without field work, I realize that my favorite part was vegetation sampling with the Great Lakes Coastal Wetland Monitoring Program — I miss it a lot. I really enjoyed the diversity of wetland sites and finding my favorite wetland plants in them. I also found learning about the hydrologic dynamics of the Great Lakes and how they influence vegetative communities (e.g., zonation of wetland communities in response to differing levels of stress, etc.) to be super fascinating.

To read more about Anderson's work, scan the QR-Codes below.

Journal Article

Research Highlight

LAKE SUPERIOR STATE UNIVERSITY AND SOO LOCKS ENGINEERS DAY

Making a Great Lakes Impact

Every year on the last Friday of June, Michigan's oldest city, Sault Ste. Marie, Michigan, is bustling with thousands of people interested in Great Lakes history, engineering, natural resources, fisheries, and more. Those in attendance for Soo Locks Engineers Day have the opportunity to view mammoth freighters and the "Soo Locks" in operation, a remarkable feat of engineering and human inventiveness that connect Lakes Superior and Huron. Engineers Day is also an opportunity for CIGLR and the local Lake Superior State University (LSSU) to share fun activities and engage with visitors about Great Lakes science.

LSSU is uniquely positioned at the intersection of the St. Marys River and Lakes Superior and Huron in Sault Ste. Marie. LSSU joined CIGLR as a Regional Consortium member in 2022, expanding its long tradition as leaders in Great Lakes fisheries management, aquatic science, and education with the new Center for Freshwater Research and Education (CFRE). The state-of-the-art CFRE facility features a mesocosm laboratory, teaching labs for undergraduate students, office spaces, and a Great Lakes Discovery Center that is open to the public. Capitalizing on its extraordinary location and success in Great Lakes research, LSSU announced in July 2023 the creation of the College of Great Lakes Ecology and Education. The new College will train the next generation of conservationist leaders and teachers, deliver high-impact student resources, partner with the public and private agencies on environmental causes vital to the area, and more.

Kevin Kapuscinski, PhD, joined LSSU in 2014 and serves as an Associate Professor and Assistant Director of Research for the CFRE. "Being a member of CIGLR's Regional Consortium has enhanced our research collaborations across the basin, and the ability to engage new partners has been a tremendous benefit," said Kapuscinski. "As an example, the CIGLR-funded summit focused on oil spills under ice helped us kick-start research efforts in this area as CFRE prepared to house the United States Coast Guard's Great Lakes Oil Spill Center of Expertise. And now, another tremendous resource for our students and the Great Lakes community is LSSU's new College of Great Lakes Ecology and Education. As we continue to build research infrastructure at CFRE, collaborations fostered by CIGLR will be essential for maximizing research productivity and benefits gained by our faculty, students, and partners."

CIGLR's Abigail Goodman (Communications Assistant) and Aubrey Lashaway (Communications Specialist) visited LSSU's CFRE and

A ship going through the Soo Locks in Sault Ste. Marie, Michigan.

Aubrey Lashaway and Jacob Heck attending Soo Locks Engineers Day in June at Sault Ste. Marie, Michigan.

LSSU mesocosm facility.

facilities while representing CIGLR at the 2023 Soo Locks Engineers Day. "We were treated to a private tour by Dr. Kapuscinski and CFRE's Education and Outreach Specialist, Ms. Beth Christiansen," said Goodman. "The Great Lakes Discovery Center is full of hands-on learning activities including tanks full of invasive sea lampreys and mysterious, prehistoric lake sturgeon. The in-house mesocosm lab is another amazing asset and teaching resource. Water is delivered straight from the St. Marys River, purified in biological filter tanks fitted with degassing units, and sent to round tanks with controlled heating, offering a controlled environment for experiments that replicate the natural world. There are large sunlit classrooms and laboratories with views of the beautiful St. Marys River and a student-run fish hatchery. LSSU CFRE's location and facilities make it a prime resource for Great Lakes research and community interaction."

CIGLR presented with our partners from LSSU at the 2023 Soo Locks Engineers Day. "Canceled in 2020 due to the pandemic, re-engineered in 2021 to ensure social distancing, and opened with restrictions in 2022, the 2023 annual Soo Locks Engineers Day was ready to celebrate the Great Lakes again," said Goodman. "More than anything, this event was a reminder that we don't work in a bubble. CIGLR's research efforts are aided by a complex and sophisticated network of learning centers that include LSSU and span across not only geographic locations, but also fields of study and institutional levels. We spoke with thousands of people from varying backgrounds and interests in Great Lakes science."

One of CIGLR's and LSSU's highest priorities is making our science accessible to the public. Goodman spoke with fellow Engineers Day presenter Rebecca Kilponen – Academic Assistant for both the LSSU School of Engineering and Technology and the School of Computer Science and Mathematics – as she handed out miniature 3D-printed anchors to delighted children. Kilponen said, "My job is to guide and inspire LSSU students as they embark on careers in freshwater conservation, fisheries management, and environmental sustainability. What better place for the engineering department to be than at Engineers Day?! Lake State loves the community. Lake State loves Sault Ste. Marie. Anytime there's a community event, we try to get out there."

CIGLR's Regional Consortium, including our LSSU partners and research institute, strives to unite scientists and communities across the Midwest under the common cause of protecting the Great Lakes. CIGLR Communications Specialist Aubrey Lashaway said, "At special events like Engineers Day, we love to entertain a diverse group of visitors who share their favorite Great Lakes stories, take educational materials with them, and are looking for swag to share their Great Lakes pride."

"The 2023 Soo Locks Engineers Day was my first experience sharing CIGLR science and meeting with the greater Great Lakes community," said Goodman. "It's inspiring to see the region and our partners growing, thriving, and working together."

Postdoc Fellows

Do Organisms that Kill Cyanobacteria Release Toxins?

Cyanobacteria produce a number of harmful substances, including toxins that are a concern to the environment, human health, and economy. Two cyanobacterial harmful algal bloom (cHAB) species of concern in the Great Lakes region are *Microcystis* and *Planktothrix*, both of which are known to produce the cyanotoxin microcystin, among others. *Microcystis* is a colony-forming cyanobacteria species that dominates in the open waters of Lake Erie, whereas *Planktothrix* dominates in more shallow, eutrophic freshwater ecosystems such as embayments, ponds, and rivers. Both *Microcystis* and *Planktothrix* blooms are complex ecosystems containing many interacting players and are host to a number of organisms that "feed" off them to survive, including viruses, parasitic fungi, and amoeba grazers.

Katelyn McKindles, PhD (formerly University of Michigan, currently an Assistant Professor at Baylor University) along with mentors Timothy James, PhD (University of Michigan), S. Rao Chaganti, PhD (University of Michigan, CIGLR) and Hank Vanderploeg, PhD (NOAA GLERL) and collaborators Anders Kiledal, PhD (University of Michigan), Laura Reitz (University of Michigan), Ava Tackabury (University of Michigan) and Samantha Schrodel (University of Michigan) worked to identify organisms feeding on these two harmful algal bloom species. "Our goal is to understand how the organisms that feed on *Microcystis* and *Planktothrix* affect toxin dynamics in a bloom," said McKindles. "During the 2022 Lake Erie bloom season we tested and monitored several variables associated with these two cHAB species. We (1) monitored the presence of feeding cyanophages (viruses) to track any toxin release; (2) identified a new fungal parasite on *Microcystis* colonies which has implications for nutrient recycling within the bloom ecosystem; (3) tested the effects of a parasite presence on its host using a previously-established *Planktothrix*-fungal parasite system to better understand toxin release and potential toxin transfer to grazing organisms; and (4) isolated 3 families of *Microcystis*-consuming amoeba that will help us understand mechanisms behind how organisms adapt to consuming toxic cyanobacteria. Together, this work will help our understanding of toxin release and potential toxin remediation within cHABs."

Currently, there are very few practical solutions for large-scale cHAB control and mitigation. More research is being conducted on the viability of using viruses and fungal parasites as biological control methods for cHABs. "We are also using an omics approach to evaluate how parasitic infections on cyanotoxin-producing hosts can affect the whole ecosystem," said McKindles. "Targeting individual potential parasites and viruses of cHAB species to determine prevalence of infection as well as infection outcome (e.g., death of host) will address knowledge gaps in microbial food web models to achieve quantitative assessment of host-pathogen-toxin interactions."

"My work as a CIGLR postdoctoral fellow was novel and made an impact on my research field. I've started many meaningful relationships and partnerships throughout this project that will last a lifetime."

— Katelyn McKindles, PhD

Icy Challenges and Renewable Resilience

HOW ICE LOADS IMPACT OFFSHORE WIND TURBINES IN THE GREAT LAKES

Offshore wind turbines (OWTs) offer a promising solution for meeting the increasing demand for renewable and clean energy. However, the impact of drifting ice on OWTs in ice-covered coastal areas is a critical issue affecting their serviceability, particularly in the Great Lakes. For example, since ice is pervasive throughout shallow Lake Erie in the winter, offshore wind infrastructure must be resilient to the combined loading of lake ice, waves, and wind, while also accounting for the unstable glacial till lakebed on which the tower is founded.

Pengxu Zou, PhD (University of Michigan) along with mentors Jeremy Bricker, PhD (University of Michigan) and Ayumi Fujisaki-Manome, PhD (University of Michigan, CIGLR), are working to better understand the ice-induced vibrations (IIVs) and ice-structure-soil interactions (ISSIs) of OWTs in Lake Erie. Ice moving against a bottom fixed structure such as an OWT can cause significant IIVs and ISSIs that can lead to extensive structural damage and erosion of the bond between the lakebed and the OWT structure. Since combined ice-wave-wind loading is exceedingly difficult to recreate in the laboratory, integrated modeling was applied to determine OWT foundation and tower loading, structural response, and fragility.

"We are employing high fidelity numerical simulations to better understand the dynamics of OWTs and ice-OWT interactions," said Zou. "The dynamic response of the OWT changes with varying ice properties, and the ice loading demonstrates a noticeable local effect at the elevation where ice collides with the OWT."

"Our goal is to create an innovative modeling tool that can determine how to optimize wind turbine design for maximized lifespan in the Great Lakes, so that future construction projects in the lakes can also benefit from the project," said Zou. "The integrated model will be applicable to future offshore wind farms, as well as pipelines, bridges, shipping locks, and shoreline defense structures like seawalls and levees. This open source model suite will promote smart design of offshore, coastal, and hydraulic structures in regions with combined ice, wave, and wind loading, and contribute to renewable energy transition by assisting the buildout of OWTs and other infrastructures in regions where this technology has not yet expanded."

Graduate Research Fellows

What Does an Invasive Mussel Look for in a Lake?

Just as in the world's oceans, it is likely that accumulation of carbon dioxide (CO_2) in the Earth's atmosphere is driving a period of acidification and a lower calcium carbonate ($CaCO_3$) saturation state in the Laurentian Great Lakes. Invasive mussels in the Great Lakes rely on $CaCO_3$ to build their shells and are at risk of disintegration in acidic environments. In contrast to the open ocean, the Great Lakes possess acid buffering capacities that complicate our understanding of $CaCO_3$ shifts and how they may impact invasive mussel establishment and survival. Lakes Erie, Huron, Michigan, and Ontario have sustained large populations of invasive mussels for several decades and also possess greater acid-buffering capacity from limestone ($CaCO_3$) bedrock surroundings. However, Lake Superior, which lacks the buffering capacity of limestone bedrock and is colder, more oligotrophic, and acidic than the other lakes, remains nearly untouched by these mussel invaders. Investigating the connection between $CaCO_3$ saturation state and invasive mussel habitat in the Great Lakes is under-explored and would be a valuable addition to future model forecasting of these species.

Daniel Sandborn is a Limnology and Oceanography PhD candidate at the University of Minnesota Duluth (UMD) and a 2022-2023 CIGLR Graduate Research Fellow. Daniel is working with his advisor Elizabeth Minor, PhD (UMD) and co-mentor Reagan Errera, PhD (NOAA GLERL) to explore $CaCO_3$ saturation state as a driver of invasive mussel habitat in the Great Lakes. "The connection between invasive mussel habitat and inorganic carbon chemistry is an exciting and novel hypothesis because it combines invasive species ecology and "The Other CO_2 Problem" [ocean acidification] in the context of important freshwater resources," said Sandborn. "While $CaCO_3$ saturation state is a well-understood ecological driver in oceans, its application to inland waters is totally novel."

The results of the proposed research will both inform invasive species study and policymaking, and generate new paths of scientific inquiry into the fate of the Laurentian Great Lakes ecosystems. "Our work focuses on observation and modeling of lake water chemistry as a driver of mussel survival," said Sandborn. "We are presently combining our chemical analysis of Great Lakes waters with publicly-available water quality monitoring data and mussel invasion reports to explore the hypothesis of $CaCO_3$ saturation state control of mussel habitat. Our preliminary results reinforce the utility of $CaCO_3$ saturation state as an ecological variable in fresh waters. This work will be explored further in a forthcoming publication."

Measuring $CaCO_3$ saturation state in fresh waters such as the Great Lakes is an under-utilized tool for the prediction of ecological impacts from climate change and invasive mussels. A better understanding of the drivers of $CaCO_3$ saturation state throughout the Great Lakes will inform researchers about the limits of invasive mussel habitat and help models predict distribution, potential management strategies, and Great Lakes ecosystem resiliency. "We hope our research enables future experimental and monitoring efforts at the intersection of inorganic carbon chemistry and freshwater ecology," said Sandborn.

"This CIGLR graduate research fellowship helped me develop my skills as a scientist leading collaborative research into important unexplored questions of chemical limnology."

— Daniel Sandborn, University of Minnesota Duluth

A Meteotsunami Case Study in Lake Erie

USING SATELLITE ALTIMETRY AND WATER LEVEL GAUGE DATA TO IMPROVE FORECAST POTENTIAL

Meteotsunamis are large waves caused by atmospheric conditions and are frequently observed across all five Great Lakes, averaging over 100 events per year. Many are too small to notice, but large meteotsunamis can have devastating coastal impacts (e.g., damaging waves, flooding, strong currents), often resulting in the tragic loss of life and inflicting severe economic damage. A standout event showcasing the Great Lakes region's vulnerability to weather extremes was the 1913 meteotsunami. From November 7 to 10, this catastrophic storm, fueled by colliding low-pressure systems, unleashed hurricane-like conditions and giant waves (>35 feet high) claiming up to 250 lives, sinking 12 large ships, and damaging another 31 vessels, marking it as one of the deadliest disasters in Great Lakes history. More recently, the "Chiclone" storm on October 26, 2010, comparable to a category three hurricane, profoundly impacted the Great Lakes region, setting record low pressures in Wisconsin and Minnesota, spurring tornadoes in several regions and generating exceptionally high waves in Lakes Superior and Michigan. Under future climate change scenarios, extreme meteostunami events will become more frequent, underscoring the region's pressing need for effective and predictive meteotsunami preparation.

Shengdao Wang is a Geodetic Science PhD candidate at Ohio State University (OSU) and a 2022-2023 CIGLR Graduate Research Fellow studying Great Lakes meteotsunamis. "Observations and early detection of these fast-moving meteotsunami waves have been difficult to identify using the existing NOAA Great Lakes water level network due to lags in spatial coverage," said Wang. "While meteotsunamis can be a significant threat to Great Lakes coastal communities, a reliable warning system for forecasting these hazards has yet to be developed. These large wave events are driven by atmospheric pressure disturbances under extreme, fast-moving weather conditions, such as severe thunderstorms, squalls, and other storm fronts. If conditions are right, the storm or disturbance could generate a large wave that moves towards the shore and is amplified by shallow coastlines, bays, inlets, or other coastal features."

Wang is working with his advisor C.K. Shum, PhD (OSU) and colleague Yuanyuan Jia, PhD (OSU) to use satellite data, specifically from radar altimetry, to track, detect, and measure lake surface height and the formation of Great Lakes meteotsunamis. Radar altimetry is a remote sensing technique that uses satellites to bounce thousands of radar pulses per second off Earth's surface, providing contours, shapes and other useful environmental mapping information. "Our team has combined over three decades of multi-mission satellite radar altimetry data and water level gauge data for a meteotsunami case study in Lake Erie, with hourly spatiotemporal scales and 10-20 km resolution," said Wang. "Data from December 6-7 and 11-12, 2021, detected the genesis and evolution of large meteotsunami waves that swept from eastern Lake Erie across to the western coast. Our methods are now helping us track the evolution of meteotsunamis across the other Great Lakes as well. Our team believes that these study results could improve assimilated lake modeling and help improve the potential for future meteotsunami forecasting."

"Many meteotsunamis go unrecorded for a variety of reasons," said Shum, PhD. "For instance, some may be so localized that the affected area lacks sufficient monitoring equipment, such as water gauges, anemometers, and others. As a result, the records we currently possess represent only a fraction of the events that have occurred, with many going undocumented. Our goal is to continue to improve our use of satellite radar altimetry to better understand the frequency and formation of meteotsunamis and help inform future forecasts."

Great Lakes Summer Fellows

In partnership with NOAA GLERL, the Great Lakes Summer Fellows Program is the cornerstone of CIGLR's efforts to train the next generation of scientists. Each year, CIGLR has the pleasure of hosting a group of bright, upcoming scientists to participate in a 12-week fellowship that exposes them to an in-depth research project. These projects typically include computer-based modeling, marine engineering, field research, and laboratory analyses.Their research projects were complemented by weekly career development seminars and research discussions, exposing them to the many dynamic individuals in our collaborative research environment and equipping them with skills to help shape their career paths. The Fellows, mentors, and CIGLR ECO (Engagement, Career Training, and Outreach) team truly demonstrated just how much can be accomplished in a short 12-week period. We applaud everyone involved for their flexibility, creativity, and positivity that shaped a meaningful, career-building experience.

We offer an enthusiastic thank you and congratulations to the 2022 and 2023 Great Lakes Summer Fellows:

Maya Casey (2022)
Haverford College

Maya worked with Drs. Reagan Errera (NOAA GLERL), Hank Vanderploeg (NOAA GLERL), and Cody Sheik (University of Minnesota-Duluth) to explore the buoyancy potential of *Microcystis* using metagenomic data.

Ryan Glassman (2022)
Valparaiso University

Ryan was mentored by Drs. Ayumi Fujisaki-Manome (CIGLR) and Abby Hutson (CIGLR). He worked to understand long-term trends of the winter storm frequency and intensity over the Great Lakes.

Shaun Laurinaitis (2022)
SUNY Oswego

Shaun worked with Drs. Jia Wang (NOAA GLERL) and Brent Lofgren (NOAA GLERL) to investigate connection patterns between Great Lakes and Arctic ice cover in response to teleconnection forcing.

Emilia Lepe (2022)
California State University, Monterey Bay

Emilia worked with Drs. Reagan Errera (NOAA GLERL), Hank Vanderploeg (NOAA GLERL), and Jim Hood (Ohio State University) to investigate pigment-specific identification methods of phytoplankton in Lake Erie.

Marion Martyres (2022)
University of Michigan

Marion worked with Sarah Waters (NOAA ONMS) and Ellen Brody (NOAA ONMS) to support the Great Lakes Bay Watershed Education and Training (B-WET) program by connecting with staff

and engaging with grant recipients leading place-based education projects.

David Rose (2022)
University of Michigan

David worked with Drs. Ashley Elgin (NOAA GLERL) and Rochelle Sturtevant (Michigan Sea Grant, Michigan State University) to expand the Great Lakes Aquatic Nonindigenous Species Information System (GLANSIS).

Luke Skowronek (2022)
University of Michigan

Luke worked with Drs. Casey Godwin (CIGLR), Reagan Errera (NOAA GLERL), and Tim Maguire (CIGLR) to model harmful algal blooms' (HABs) vertical distribution in Lake Erie.

Amy VanZanen (2022)
University of Michigan

Amy worked with Dr. Craig Stow (NOAA GLERL) and Steve Ruberg (NOAA GLERL) to explore the status and trends of Saginaw Bay time-series observations.

Tait Algayer (2023)
Washington State University

Tait worked with Drs. S. Rao Chaganti (CIGLR) and Edward Rutherford (NOAA GLERL) on the development of genetic assays for Great Lakes larval fish identification.

2022 CIGLR Great Lakes Summer Fellows.

Naomy Aviles-Diaz (2023)
University of Puerto Rico Mayagüez

Naomy worked with Drs. Greg Dick (CIGLR), Anders Kiledal (University of Michigan), Sara Rivera (University of Michigan) and PhD candidate Lauren Hart (University of Michigan) to study interactions of *Microcystis* and associated bacteria on bloom control and proliferation.

Kristin Huelsbeck (2023)
University of Wisconsin – Milwaukee

Kristin worked with Drs. Casey Godwin (CIGLR) and Reagan Errera (NOAA GLERL) to explore microcystin production by benthic communities in western Lake Erie.

Michael Meng (2023)

Boston University

Michael was mentored by Drs. David Cannon (CIGLR) and Jia Wang (NOAA GLERL). Along with Jessica Middleton, their fellowship research focused on understanding the connection between Great Lakes and Arctic ice cover in response to teleconnection forcing.

Jessica Middleton (2023)

University of Michigan

Jessica was mentored by Drs. David Cannon (CIGLR) and Jia Wang (NOAA GLERL). Along with Michael Meng, her fellowship research focused on understanding the connection between Great Lakes and Arctic ice cover in response to teleconnection forcing.

Chase Pheifer (2023)

University of Minnesota Duluth

Chase worked with Drs. Yi Hong (CIGLR) and Lauren Fry (NOAA GLERL) to evaluate hydrologic modeling over the Great Lakes domain for sub-seasonal to annual forecasts.

Heather Truong (2023)

Eckerd College

Heather worked with Maddie Tomczak (CIGLR), Drs. Edward Rutherford (NOAA GLERL), Doran Mason (NOAA GLERL) and Mark Rowe (NOAA GLERL). Her research investigated recruitment bottlenecks in larval stages of key Great Lakes prey fishes.

2023 CIGLR Great Lakes Summer Fellows.

Karen Weldon (2023)

University of Michigan

Karen worked with Lara O'Brien (NOAA Office for Coastal Management), Jennifer Day (NOAA GLERL), Chiara Zuccarino-Crowe (Michigan Sea Grant), and Dr. Kate Quigley (NOAA Office for Coastal Management) to explore Great Lakes ecosystem services valuation.

Hear about the program from the fellows themselves!

Scan for fellows profile videos.

Summits, Seed, & ECO Funding

The Defining Baseline Ecosystem Conditions in Dynamic Great Lakes Ecosystems Summit was led by Christopher Winslow, PhD, Ohio State University. Photo: Aubrey Lashaway.

CIGLR Summit:

Defining Baseline Ecosystem Conditions in Dynamic Great Lakes Ecosystems

Defining a baseline ecosystem condition, or ecosystem objective, is a critical step in management and conservation, including mitigating anthropogenic stressors, managing fish populations, and measuring progress toward restoration. However, a baseline condition can be defined in many ways and the chosen definition can have multiple implications. Because of their size, history, and dynamic ecosystems, the Great Lakes present many obstacles to effectively and efficiently defining baseline conditions. All of the Lakes have experienced both natural (e.g., fluctuating lake levels, variable fish hatches) and human-induced (e.g., invasive species; climate-related changes in ice cover, runoff, and temperature) disturbances that have shifted biotic and abiotic conditions.

A team of experts led by scientists from Ohio Sea Grant, CIGLR, Michigan Sea Grant, and NOAA GLERL convened to discuss how to best define baseline conditions within the context of ecosystem-based management, a long-standing goal of the Great Lakes research and management community. To ensure varied perspectives and contributions to the summit, participants from several federal, academic, binational, and non-profit entities were invited to share their unique expertise on how best to monitor and assess each of the Great Lakes' ecosystems.

The summit group is preparing a summary of the meeting outcomes for submission to a peer-reviewed journal. The publication will identify baseline data gaps, the various approaches being used to define baseline ecosystem conditions, and the group's recommended changes to current monitoring and assessment practices.

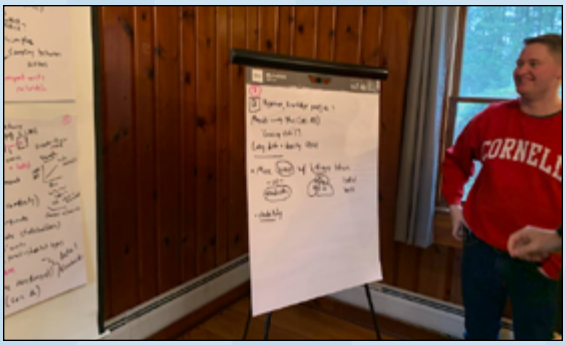
CIGLR Summit:

Improving the Science and Policy of Great Lakes Ecosystem-based Fisheries Management

Assessing the State of Knowledge and Investigative Approaches

Across the world, there is a recognized need to consider the entire ecosystem when studying management decisions and policies. For fisheries, this research approach has been expressed as "ecosystem-based fisheries management (EBFM)," which considers social, economic and ecological trade-offs across multiple fisheries and habitats. Recent research has listed knowledge gaps and made recommendations for food web investigations that are relevant to Great Lakes EBFM. These investigations are critical to linking complex ecosystems with changes in water quality, habitat, fish stocking, recreational fishing, and commercial fishery management. However, Great Lakes food web investigators are not yet fully exploiting the integration of these areas or methods and data sets available to meet ecosystem and societal information needs. As such, the EBFM approach has not been fully realized in practice in the Great Lakes.

A team of experts from Cornell University, University of Windsor, U.S. Geological Survey Great Lakes Science Center, NOAA GLERL, Great Lakes Fishery Commission (GLFC), University of Toronto, University of Guelph, Ontario Ministry of Natural Resources, and Forestry and Royal Netherlands Institute for Sea Research led a summit and webinar series to evaluate various tools and methodologies for implementing an EBFM approach. To promote the summit and familiarize participants with the current state of food web investigative methods, summit leadership developed and presented two webinars. The webinars consisted of 12 presentations from fisheries managers and food web investigators from across North America and Europe. To facilitate focused discussion groups, summit participants were surveyed about their goals for the meeting and what the biggest challenges are to applying



The Ecosystem-based Fisheries Management Summit was held at the Cornell Biological Station, Bridgeport, NY. Photo Credit: Nicholas Boucher.

food web science to fisheries management. The summit group worked to understand the interconnectedness of ecosystem components and changes in the physical, chemical, biological, social, and economic drivers. Using this information, they examined the historical trends, status, and future predictions of food web and fisheries response to management decisions.

Next steps for the summit organizers include sharing the insights gained from the summit and leveraging this knowledge to develop new investigative approaches for Great Lakes food webs. A comprehensive report was prepared that will serve as a blueprint for food web scientists and includes proceedings from the summit and webinar series, serving as a valuable resource for understanding the state of knowledge, data needs, and future research directions for EBFM. Excitingly, a group of workshop participants used information from this summit to develop a research proposal titled "Restoring Great Lakes Food Web Function," which is currently under consideration for funding through the GLFC's Fishery Research Program. The summit report is available through request at frp@glfc.org (project code: 2021_STE_460021).

For more on the "Ecosystem-based Fisheries Management" summit and associated products, please visit the SWG webpage: **ciglr.seas.umich.edu/opportunities/summits-and-working-groups/ecosystem-based-fisheries-management**

CIGLR Summit:

Coordinated Experiments Across the Great Lakes Basin: Great Lakes Integrated Mesocosm Research

From June 22-23, 2022, a team of experts led by scientists from Grand Valley State University, CIGLR, Wayne State University, Central Michigan University, and NOAA GLERL convened to discuss the potential development of a Great Lakes Integrated Mesocosm Research (GLIMR) network that would develop and implement a coordinated and standardized approach for the use of experimental mesocosms across the Great Lakes basin. A mesocosm is a large tank used for controlled experiments that is larger than an aquarium but smaller than a pond, allowing researchers to bridge the gap between the laboratory and the real world. Several institutions have mesocosm or mesocosm-type facilities around the Great Lakes, presenting an opportunity for coordinated research. During the interdisciplinary summit, participants took inventory of existing Great Lakes mesocosm facilities and identified specific coordinated experiments that can serve as the basis for future grant proposals. Although mesocosm research has inherent limitations owing to their relatively small volume and over-simplification of natural systems, they are useful for simulating a wide range of environmental conditions in controlled and replicable experimental units. Mesocosms allow for the assessment of ecosystem processes and testing of mechanisms driving ecological structure and function, thus improving our understanding of how systems operate. They are very useful for testing hypotheses and predictions from ecological or biogeochemical models. A basin-wide mesocosm approach that uses the same design, same instrumentation, and same analytical procedures, but in different areas of the Great Lakes, would give researchers a powerful tool to study the degree to which Great Lakes respond to applied stressors.

The Robert B. Annis Water Resources Institute's (AWRI) Mesocosm Facility. Mesocosms are experimental units (tanks) that are larger than aquariums (microcosms) but smaller than natural ponds (macrocosms). Photo Credit: Grand Valley State University's AWRI.

The summit group produced a **white paper** that describes the summit and summarizes its findings, which is available on the CIGLR website.

Mesocosm Summit information

Seed Funding:

St. Marys River Oil Spill Response

In June 2022, over 5,300 gallons of refined oil was accidentally released from a steel producer in Sault Ste. Marie, Ontario. The oil quickly entered the St. Marys River, causing oil sheens to accumulate near the North Channel of Sugar Island. This spill was particularly destructive because the North Channel of Sugar Island is known to support lake sturgeon populations and serves as critical wetland habitat that underpins nursery areas for valuable sport fishes. Additionally, members of the Sugar Island community often use river water directly for municipal purposes. The effects of this oil spill generated tremendous concern among the local and scientific communities about potential impacts of future oil spills in the region.

In response, LimnoTech and Lake Superior State University (LSSU) used CIGLR Seed Funding to integrate sensor systems into a new monitoring network in the St. Marys River at locations that are likely to be impacted by any current or future oil spills. "The St. Marys River is home to one of the busiest shipping lock systems in the world," said Ed Verhamme, LimnoTech Senior Engineer. "This region is highly susceptible to freighter strandings and oil spills, making it an ideal location to pilot a pollution monitoring network. The installed sensor system provided assurance to community members that oil from this spill was not affecting coastal areas."

The sensor systems use state-of-the-art cellular technology that allows for real-time data availability on LSSU's **MiWaterNet** from a cloud server hosted by LimnoTech.

"In addition, a new U.S. Coast Guard National Center of Expertise focusing on freshwater oil spills opened at LSSU's Center for Freshwater Research and Education in August 2022, and our initial sensor system deployment is helping to leverage an even larger-scale project to develop real-time monitoring networks for oil spills throughout the Great Lakes," said Verhamme.

Scan for sensor data

A sensor system being prepared for deployment in the St. Marys River. Photo: Ed Verhamme

"CIGLR Seed Funding allowed LimnoTech and LSSU to respond to an oil spill in the St. Marys River within 24 hours, filling a critical need for both the local and scientific communities."

— Ed Verhamme, LimnoTech

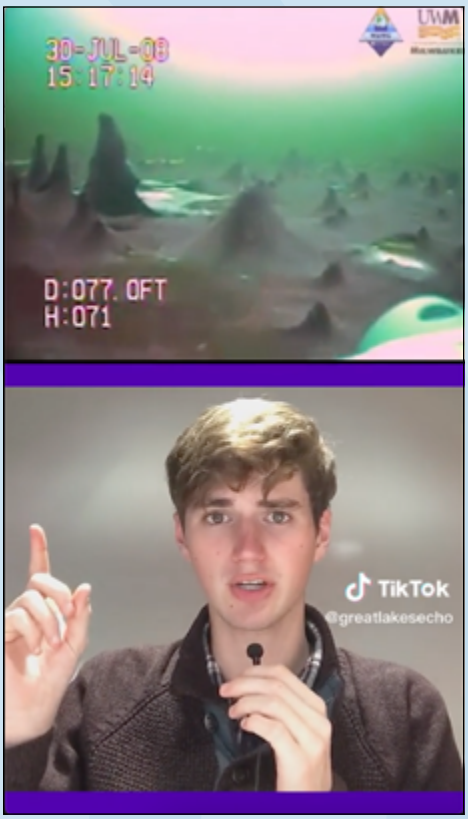
ECO Funding:

Environmental Reporting for the Great Lakes Region

Countless intriguing stories about the Great Lakes environment often remain trapped in labs, fieldwork, journals and in the minds of science researchers. However, quarantining information away from the public eye ignores the real-life impact scientific discovery makes on the world. Once publicly shared, these stories can ignite significant interest, understanding, and support throughout communities around the Great Lakes and beyond.

Michigan State University's (MSU) **Great Lakes Echo** is an environmental news service produced by the Knight Center for Environmental Journalism that translates Great Lakes research into journalism for the public. With funding from a CIGLR Engagement, Career Training, and Outreach (ECO) Award, MSU's Great Lakes Echo trained 11 undergraduate journalism students who produced, distributed, and broadly shared 52 news stories that highlighted the work of CIGLR's research institute and regional Consortium.

"Funding from CIGLR's ECO Award was vital for helping our team significantly expand our reporting about research created by Great Lakes scientists around the region," said David Poulson, Senior Associate Director of MSU's Knight Center for Environmental Journalism. "News organizations, nonprofit and government agencies, and others use stories directly from Great Lakes Echo, including MSU's **Capital News Service** wire that distributes relevant Great Lakes news to 40+ newspapers around Michigan. They range from large, high impact publications to smaller, weekly periodicals. Our team also developed new text and radio partners, extending our regional reach, and created a TikTok channel to showcase Great Lakes research to a wider, more diverse audience. CIGLR's support helped our newsroom inform the public around the Great Lakes region about environmental challenges, solutions, and important science research stories."



Scan for more about ECO Funding

2023 Program Winners

CIGLR AWARDS $467,000 IN 2023 PARTNER PROGRAMS

Each year, CIGLR offers competitive programmatic funding for Consortium partners to build collaborations with NOAA. Through these partnerships, recipients provide early career training to graduate students and postdocs, delve into big Great Lakes issues in multidisciplinary summits, translate research to the public, research emerging issues, and respond to emergencies and other time-sensitive needs in the Great Lakes. The recipients of the 2023 partner awards will advance important areas of Great Lakes research and form connections between our partners and NOAA. Thank you to all who applied and congratulations to the winners!

POSTDOCTORAL FELLOWSHIP AWARDS

- **Sara Hughes, PhD, University of Michigan:** Monitoring and Measuring Resilience in the Great Lakes: An Analysis of the Region's Science, Policy and Funding Frameworks
- **Zack Spica, PhD, University of Michigan:** Monitoring Lake Ontario Using Distributed Fiber-Optic Sensing
- **Don Uzarski, PhD, Central Michigan University:** Assessing Drivers of Spatial and Temporal Greenhouse Gas Dynamics in Laurentian Great Lakes Coastal Wetlands

GRADUATE RESEARCH FELLOWSHIP AWARDS

- **Rose Cory, PhD, University of Michigan:** Does Hydrogen Peroxide in Lake Erie Sediments Influence the Toxicity of Microcystis Blooms?
- **Naomi Levin, PhD, University of Michigan:** Constraining Evaporative Fluxes on Lake Erie Using a Bayesian Isotope Mass Balance Model
- **Elena Litchman, PhD, Michigan State University:** *Dolichospermum* in the Great Lakes: A Comparison of Trait and Genetic Diversity Across Lakes

SUMMIT AND WORKING GROUP (SWG) AWARDS

- **Robin DeBruyne, PhD, USGS Great Lakes Science Center:** Developing a Conceptual Framework and Vision for Coordinating Great Lakes Connecting Waters Research and Monitoring
- **Heather Raymond, PhD, Ohio State University:** Disturbance Ecology: Effects on Great Lakes Harmful Algal Blooms and Phycology
- **Paul Seelbach, PhD, University of Michigan:** Discerning the "Bricks and Mortar" Required to Implement the Societal Components of Comprehensive Great Lakes Restoration

ECO AWARDS

- **Meha Jain, PhD, University of Michigan:** Empowering Underrepresented Students with GIS
- **Mike Shriberg, PhD, University of Michigan:** Building a Community-Driven Model for Drinking Water News Coverage

SEED AWARDS

- **Zack Spica, PhD, University of Michigan:** Distributed Acoustic Sensing in Lake Ontario

Congratulations to CIGLR's 2023 Award Recipients and Finalists

The CIGLR Staff Awards program recognizes the outstanding work done by our staff and postdoctoral research fellows. Please join us in congratulating Ashley Burtner, Christine Kitchens, Songzhi Liu, and Kelly McCabe!

The **Research Excellence Award** was given to **Ashley Burtner** (Aquatic Ecology Laboratory Manager) and recognizes outstanding performance in laboratory research, fieldwork, computer modeling, data analysis, scientific achievements, and innovative work. **David Cannon** (Postdoctoral Research Fellow, currently Assistant Research Scientist) was runner-up.

The **Diversity, Equity, Inclusion, and Justice Award** was given to **Christine Kitchens** (Research Lab Specialist Intermediate) and recognizes exceptional activities or accomplishments that advance CIGLR's interest in diversity, equity, inclusion, and justice (DEIJ).

The **Science for Society Award** was given to **Songzhi Liu** (Programmer/Analyst Lead, NOAA CoastWatch Great Lakes Node Operations Manager) and recognizes exceptional activities or accomplishments that support the link between science and public service. **Megan DiCocco** (Research Engagement Specialist) was runner-up.

The **Community Award** was given to **Kelly McCabe** (Biogeochemistry Laboratory Analyst) and recognizes exceptional contributions to building the CIGLR community, encouraging teamwork, and excellence in mentoring.

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RESEARCH INSTITUTE

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Assistant Research Scientist
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Assistant Research Scientist
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Melissa Mattwig
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Ronald Muzzi
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Miye Nakashima
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Srikar Nelakuditi
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Erica Pillar
Aquatic Chemistry Laboratory Technician
Tongyao Pu
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Heidi Purcell
Research Area Specialist Intermediate
Riley Ravary
Lead Research Engagement Specialist
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Aquatic Ecology Laboratory Technician
Meredith Seibold
Engagement Assistant
Yang Song
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*Indicates personnel transitions

Underlined names indicate profile links

Jonathan Overpeck, Samuel
A. Graham Dean, School for Environment and Sustainability, University of Michigan

*Steven Thur
Director, National Centers for Coastal Ocean Science, NOAA National Ocean Service (currently Assistant Administrator for NOAA Oceanic and Atmospheric Research)

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Donald Uzarski
Director, Biological Station and Institute for Great Lakes Research, Central Michigan University

Chris Winslow
Director, Stone Laboratory, Ohio Sea Grant, Ohio State University

SONGZHI LIU RECEIVES 2022 NESDIS COLLABORATION AWARD

Congratulations to CIGLR's Songzhi Liu (Programmer/Analyst Lead, NOAA CoastWatch Great Lakes Node Operations Manager) on earning the 2022 National Environmental Satellite Data and Information Service (NESDIS) Collaboration Award! This award recognizes outstanding work in making step-change advances to the **CoastWatch Satellite Data Training Courses**.

"It is my privilege to work with a team that cares about their work deeply and executes it professionally," said Veronica Lance, NOAA CoastWatch/OceanWatch/PolarWatch Program Manager. "The CoastWatch training, Learning Portal and other outreach efforts have reached at least hundreds of people directly and likely many times more than that indirectly, undoubtedly contributing to the success of missions across all of NOAA."

"It was a great honor to receive this special award," said Liu. "I want to express my gratitude and thanks to all of my collaborators who supported this important work."

CIGLR welcomes new team members!

Aubrey Arnt is a Research Engagement Specialist working with Riley Ravary, PhD (CIGLR) and Megan DiCocco (CIGLR) to facilitate the co-design of research to produce socially useful research products.

Alain Isabwe, PhD, is a Postdoctoral Research Fellow working to understand how global warming and changes in land cover affect freshwater algae at different spatio-temporal scales.

Jasmine Mancuso is an Aquatic Ecology Research Analyst working with Casey Godwin, PhD (CIGLR) and the harmful algal bloom research team to help further our understanding of algal bloom ecology in western Lake Erie and Saginaw Bay.

John McClure is a Research Engagement Specialist working with Riley Ravary, PhD (CIGLR) and Megan DiCocco (CIGLR) to facilitate the co-design of research to produce socially useful research products.

Connor Gluck is a Biogeochemistry Laboratory Analyst working with Casey Godwin, PhD (CIGLR), Ashley Burtner (CIGLR) and Teige O'Brien (CIGLR) on nutrient analysis in support of the harmful algal blooms (HABs) research program.

Shay Keretz, PhD, is a Postdoctoral Research Fellow working with Casey Godwin, PhD (CIGLR) and the NOAA GLERL Ecosystems Dynamics group. Her research focuses on dynamic energy budget modeling of invasive dreissenid mussels to understand their individual and population dynamics in the Great Lakes.

Melissa Mattwig is an Earth System Modeler working with Dmitry Beletsky, PhD (CIGLR) and David Cannon, PhD (CIGLR) on spatial analysis to support the development of inland and coastal flooding predictions.

Teige O'Brien is a Biogeochemistry Laboratory Analyst working alongside Casey Godwin, PhD (CIGLR), Ashley Burtner (CIGLR), and Connor Gluck (CIGLR) on nutrient analyses supporting the HABs monitoring program.

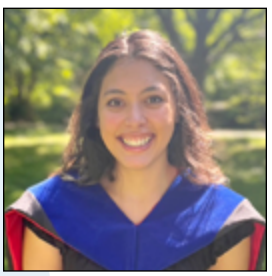
Brooke Odstrchel is an Earth System Modeler working on development, testing, and deployment of coupled integrated Earth system models.

Justin Riley, PhD, is a Postdoctoral Research Fellow working to predict coastal and inland flooding by coupling 3D hydrodynamic and hydrologic models.

Margaret Throckmorton is CIGLR's Administrative Project Coordinator. She is integral in organizing CIGLR programming events, such as coordinating the Summer Fellows Program, the Great Lakes Seminar Series, and summits and working groups.

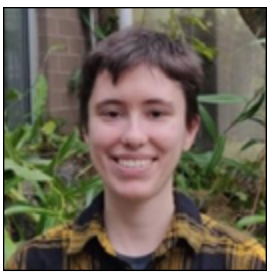
Jamie Ward, PhD, is a Postdoctoral Research Fellow working with Yi Hong, PhD (CIGLR), Ayumi Fujisaki-Manome, PhD (CIGLR), and Lauren Fry, PhD (NOAA GLERL) to better understand atmospheric influences on Great Lakes water supply.

Sophie Orendorf is a Data Analyst working to help acquire and analyze data, improving sub-seasonal to annual forecasts of the Great Lakes.



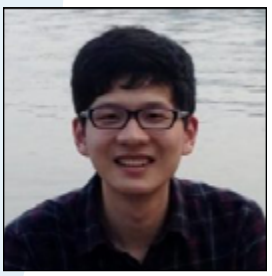
Kyla Semmendinger-Raney, PhD, is a Postdoctoral Research Fellow working to advance decision support tools for Lake Ontario outflow regulation using advanced many-objective optimization approaches.

Lucas Vanderbilt is an Environmental Genomics Specialist working with S. Rao Chaganti, PhD (CIGLR) and the HABs research team to manage the genomic parameters for both western Lake Erie and Saginaw Bay, Lake Huron.



Paige Williams is an Aquatic Field Research Technician working with Casey Godwin, PhD (CIGLR) on the HABs research team to collect data on field cruises, sample processing, and data analysis.

Tongyao Pu is an Ecological Modeling Data Analyst working to develop a Great Lakes energy budget model for quagga mussels.



Yang Song, PhD, is a Hydrodynamic Modeler working to advance our understanding of oil spill processes in the Great Lakes.

In the Media

CI UPDATES

OVPR Awards 12 Staff Members for Research Service, Leadership,
The University Record

Mike Shriberg Named CIGLR's Director for Engagement,
University of Michigan School for Environment and Sustainability News

Remembering Mike Fraker,
Michigan Sea Grant Upwellings

Spotlight: Dr. Benjamin Kramer,
Great Lakes HABs Collaborative Newsletter

HARMFUL ALGAL BLOOMS

Scientists Hope SHARC System Takes a Bite Out of Harmful Algæ,
Detroit Free Press

Scientists Are Learning Just How Complicated It Will Be to Reduce Toxic Blooms in Lake Erie,
Michigan Radio

President Ono's Monthly Message for July 2023,
University of Michigan

Combining Algæ, Plastic Has 'Scary' Implications for Great Lakes, Experts Fear,
Detroit News

Harmful Algal Blooms Appearing on Lake Erie Earlier Than Usual,
Michigan Radio

ICE, WATER LEVELS & INVASIVE SPECIES

Nearly $1.2 Billion Spent at One Site to Deter Invasive Carp from Great Lakes; Other Entry Sites Still Possible,
Michigan Radio

Research Brief: The Development of Lake-/Sea-Effect Snowstorm Forecasting,
Lake Scientist

It's Never Been This Warm in February. Here's Why That's Not a Good Thing,
CNN

Great Lakes Ice Cover Plummets to Record Mid-February Low,
The Washington Post

Low Ice on the Great Lakes This Winter,
NOAA Research News

Record-Low Great Lakes Ice Coverage: U-M Experts Can Discuss,
Michigan News

It's Mid-January and the Great Lakes are Virtually Ice-Free. That's a Problem,
Milwaukee Journal Sentinel

Research Briefs: Winter Satellite Data Collection in the Great Lakes,
Lake Scientist

Climate Change Yields Uncertain Future for Great Lakes Water Levels,
Wisconsin Public Radio

Climate Change Remains a Wild Card for Great Lakes Water Levels,
The Toledo Blade

OTHER STORIES

New Database Offers Comprehensive Picture of Municipal Drinking Water Systems Nationwide,
University of Michigan School for Environment and Sustainability News

A Climate Laggard in America's Industrial Heartland Has a Plan to Change, Fast,
The New York Times

New Guiding Principles Urgently Needed for Great Lakes Stewardship, U-M Researchers Say,
Michigan News

The Future of Great Lakes Stewardship,
University of Michigan School for Environment and Sustainability News

Wolverine Caucus: Michigan's Climate Future – What It Means to be a Climate Refuge and How to Prepare,
Government Relations, University of Michigan

Wolverine Caucus Gathers to Address Climate Change in Michigan,
WILX News 10

Meet the Team Who Crossed all 5 Great Lakes by Paddleboard,
CTV News Windsor

Success! Three Guys Cross Lake Ontario on Stand-Up Paddleboards —$25,000 Raised for CIGLR,
Expert Click

Crossing the Great Lakes: Three NoMi Men to Complete Final SUP Journey Across Lake Ontario,
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Trio to Paddle Across Lake Ontario for Nonprofit,
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The North Shore Weekend

'Stand Up For Great Lakes' Brings An 8 Year Journey To An Epic Finale,
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These 3 Guys Plan to Paddle Across Lake Ontario on Stand-Up Boards,
New York Upstate

State of the Strait Report Highlights Urgent Need to Clean up Detroit River,
University of Michigan School for Environment and Sustainability News

Collaborative Project to Help Improve Coastal Community Resilience in Michigan, Wisconsin,
Michigan News

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MARY OGDAHL RECEIVES UNIVERSITY OF MICHIGAN RESEARCH LEADERSHIP RECOGNITION AWARD!

CIGLR Program Manager Mary Ogdahl received the 2023 University of Michigan Research Leadership Recognition Award that celebrates distinguished service to the research community, exemplary leadership that positively impacts colleagues, and excellence in advancing the University of Michigan's mission.

"Every day, in laboratories, studios and workspaces across the University of Michigan, staff are working vigorously to catalyze, support and safeguard important activity that impacts so many aspects of our society," said Rebecca Cunningham, University of Michigan Vice President for Research.

Gregory Dick, Mary Ogdahl, and Thomas Johengen celebrate as Mary receives the 2023 University of Michigan Research Leadership Recognition Award. Photo: Aubrey Lashaway

"What's truly remarkable about Mary is her versatility," said Gregory Dick, CIGLR Director. "She excels in the many dimensions of her job. She's an outstanding scientist, contributing substantially to our research planning, science strategy, and proposal writing. She's a wonderful people person which is essential in managing staff, navigating a complex relationship with federal agencies, identifying and recruiting talent, and building and maintaining cohesion among our staff as well as a strong and inclusive culture. To me, it's unbelievable that one person can do so much, so well. In many ways, she is the heart and soul of our institute."

"Every day, I feel fortunate to not only work with people that inspire and motivate me, but also for the future health and sustainability of the greatest freshwater resource on Earth. From developing the next generation of scientists to facilitating the forefront of Great Lakes research, I am driven by the purpose behind my work. It is an incredible honor to be selected for the 2023 Research Leadership Recognition Award and I thank my mentors and colleagues who supported my nomination," said Ogdahl.

Scan for more

Peer-Reviewed Publications

Anderson, O.; A. Harrison; B. Heumann; C. Godwin; D. Uzarski. 2023. The Influence of Extreme Water Levels on Coastal Wetland Extent Across the Laurentian Great Lakes. *Science of The Total Environment*. 885:163755. (DOI:**10.1016/j.scitotenv.2023.163755**).

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Baer, M.M.; C.M. Godwin; T.H. Johengen. 2023. The Effect of Single Versus Dual Nutrient Decreases on Phytoplankton Growth Rates, Community Composition, and Microcystin Concentration in the Western Basin of Lake Erie. *Harmful Algae*. 123:102382. (DOI:**10.1016/j.hal.2023.102382**).

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Lehmann, M.K.; D. Gurlin; N, Pahlevan; K. Alikas; T. Conroy; J. Anstee; S.V. Balasubramanian; C.C.F. Barbosa; C. Binding; A. Bracher; M. Bresciani; A. Burtner; Z. Cao; A.G. Dekker; C.D. Vittorio; N. Drayson; R.M. Errera; V. Fernandez; D. Ficek; C.G. Fichot; P. Gege; C. Giardino; A.A. Gitelson; S.R. Greb; H. Henderson; H. Higa; A.I. Rahaghi; C. Jamet; D. Jiang; T. Jordan; K. Kangro; J.A. Kravitz; A.S. Kristoffersen; R. Kudela; L. Li; M. Ligi; H. Loisel; S. Lohrenz; R. Ma; D.A. Maciel; T.J. Malthus; B. Matsushita; M. Matthews; C. Minaudo; D.R. Mishra; S. Mishra; T. Moore; W.J. Moses; H. Nguyễn; E.M.L.M. Novo; S. Novoa; D. Odermatt; D.M. O'Donnell; L.G. Olmanson; M. Ondrusek; N. Oppelt; S. Ouillon; W.P. Filho; S. Plattner; A.R. Verdú; S.I. Salem; J.F. Schalles; S.G.H. Simis; E. Siswanto; B. Smith; I. Somlai-Schweiger; M.A. Soppa; E. Spyrakos; E. Tessin; H.J. van der Woerd; A. Vander Woude; R.A. Vandermeulen; V. Vantrepotte; M.R. Wernand; M. Werther; K. Young; L. Yue. 2023. GLORIA – A Globally Representative Hyperspectral In Situ Dataset for Optical Sensing of Water Quality. *Scientific Data.* 10:100. (DOI:**10.1038/s41597-023-01973-y**).

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2022 Photo Contest Winners

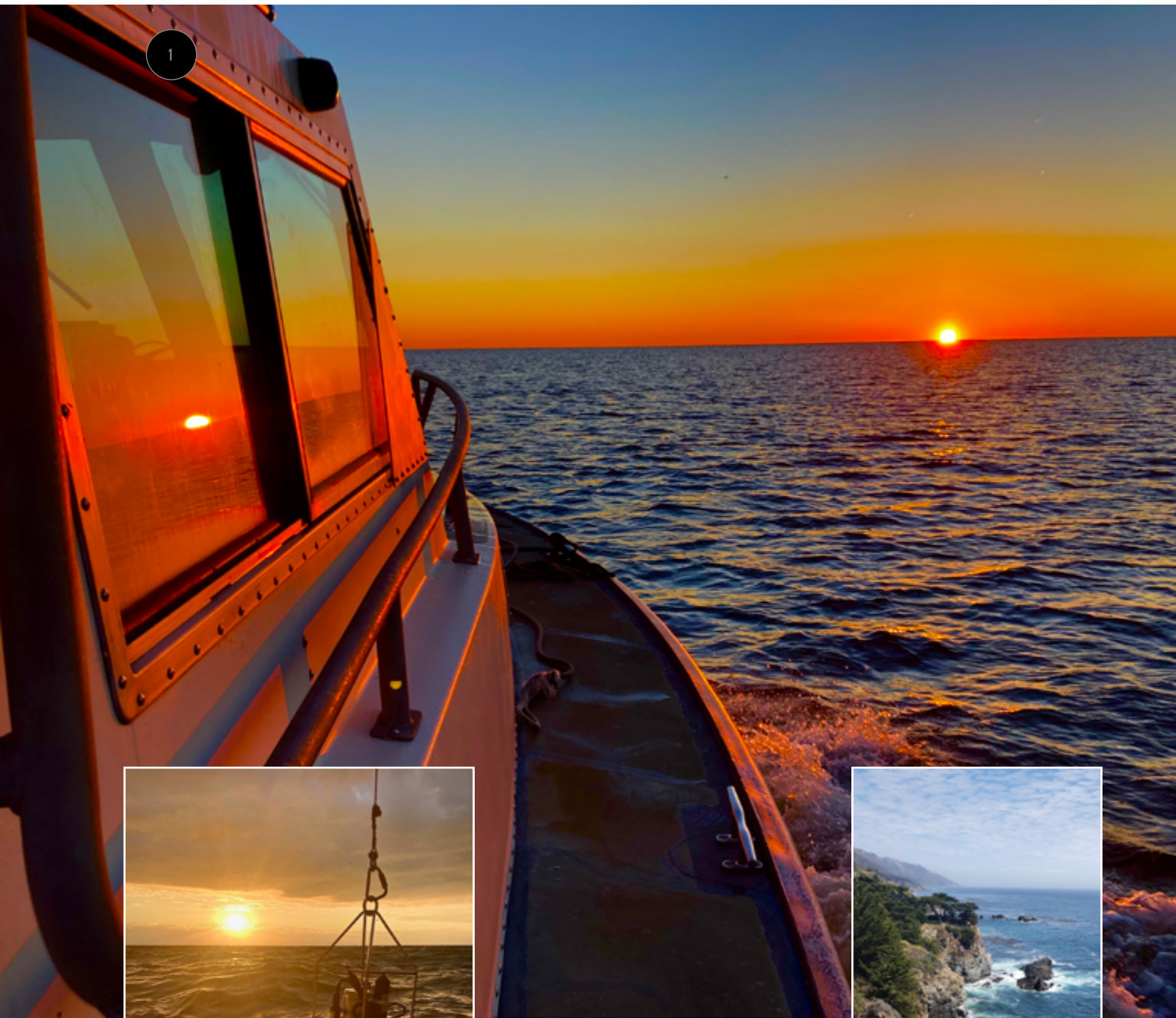
CIGLR IN ACTION With a shared passion for water, the Great Lakes, and science, photographers from the Cooperative Institute for Great Lakes Research seek to tell their stories through the lens. For the sixth year in a row, the CIGLR Photo Contest entries feature images that inform, inspire, and amaze.

1st place: *I Spy Mysis,* Madeline Tomczak

2nd place: *HABs and Drones,* Heidi Purcell

3rd place: *Sample at Sunset,* Madeline Tomczak

Explore more photos



CIGLR SCENERY

Viewing scenery through CIGLR lenses is always an inspiration. The creative stories that emerge offer shared experiences and adventure through our Great Lakes research.

1st place: *Hi Ho, Hi Ho, It's Off To Work We Go,* Holly Kelchner

2nd place: *Early Morning Fieldwork,* Holly Kelchner

3rd place: *Big Sur,* Heidi Purcell

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